



IoT Community

Digital Twin Technology as an Enabler of 5G

Company cluster analysis:

Autonomous air traffic
Consultancy
Digital twin for communication towers
Telecommunications
Test automation

Powered by:

 Valuer



Table of Contents:



page 3.

Foreword



page 4.

**Clusters of Companies That
Develop Digital Twins for 5G**



page 6.

**Ranking the Clusters
of Companies**



page 7.

Data Insights



page 13.

**Five Case Studies of
Innovative Companies**



Foreword

This report aims to explore the innovation ecosystem in the area of digital twins for 5G by mapping trends, business models, and technologies.

To get familiar with both the “big picture” and specific solutions, the publication includes data analysis of clusters of companies that develop similar technologies, as well as five case studies of companies.

The magazine takes an in-depth look at five areas of innovation relevant to digital twins for 5G: Autonomous air traffic, Consultancy, Digital twin for communication towers, Telecommunications, and Test automation.

To identify the companies most suitable for inspiration or potential collaboration with the IoT Community, the selection favored those with already-existent practical solutions and proof of concept.

Clusters of Companies That Develop Digital Twins for 5G



Autonomous air traffic



Consultancy



Digital twin for communication towers



Telecommunications



Test Automation

Identifying companies relevant to digital twins for 5G

The process starts with Valuer processing its database of more than 600,000 companies to identify all potentially relevant to the topic “digital twin technology as an enabler of 5G.”

The relevant company descriptions were then processed by Natural Language Processing (NLP), which finds patterns impossible to recognize with tags and regular search mechanisms. At this point, the number of organizations was narrowed down to around 1,000 most-relevant ones.

The platform then referenced the companies to five focus areas deducted from the IoT Community’s request (listed below.) By choosing the ones nearest to a projected point, it selected roughly 200 most relevant to each of the five clusters.

Grouping companies from different focus areas

The illustration shows the clusters of companies (represented with dots) which are colored depending on their projection area. Their proximity to other companies depends on the commonalities of the products or solutions they provide.

Even though the platform processes the clusters in 1,024 dimensions, we’ve included a 2D interpretation for demonstration purposes (this is also why some dots may seem very distant from their projection areas). The rendered image lets us make several straightforward interpretations.

Observations and company trends

We can draw several insights from the company clustering image:

- Overall, there is considerable overlap between these clusters, with the exception of the **“Digital twin for communication towers”** and **“Autonomous air traffic”** clusters, which may indicate similarities in market approach and technologies.
- The **“Telecommunications”** cluster is scattered around the map but has the most overlap with the **“Consultancy”** cluster. This might indicate that these clusters are solving similar problems or using similar technologies.
- Despite the considerable spread, there are two more distinct cluster groupings - **“Autonomous air traffic”** and **“Digital twin for communication towers”**. These (mostly standalone) clusters may be solving specific problems or using unique technologies.
- The **“Test automation”** cluster is mainly concentrated within one area on the map but also spreads into the overlap between the **“Telecommunications”** and **“Consultancy”** clusters, which may indicate similarities in market approach between the clusters.



Cluster Sectors:

- Digital twin for communication towers
- Test automation
- Telecommunications
- Autonomous air traffic
- Consultancy

Ranking the Clusters of Companies

The platform uses four parameters to assess the clusters' potential, market opportunity, degree of fit, and innovativeness:

Success potential

The AI platform uses historical data from each company to evaluate the group's overall chance for future success.

Degree of fit

The AI platform uses Natural Language Processing (NLP) to grade how well a cluster of companies aligns with the customer's challenges.

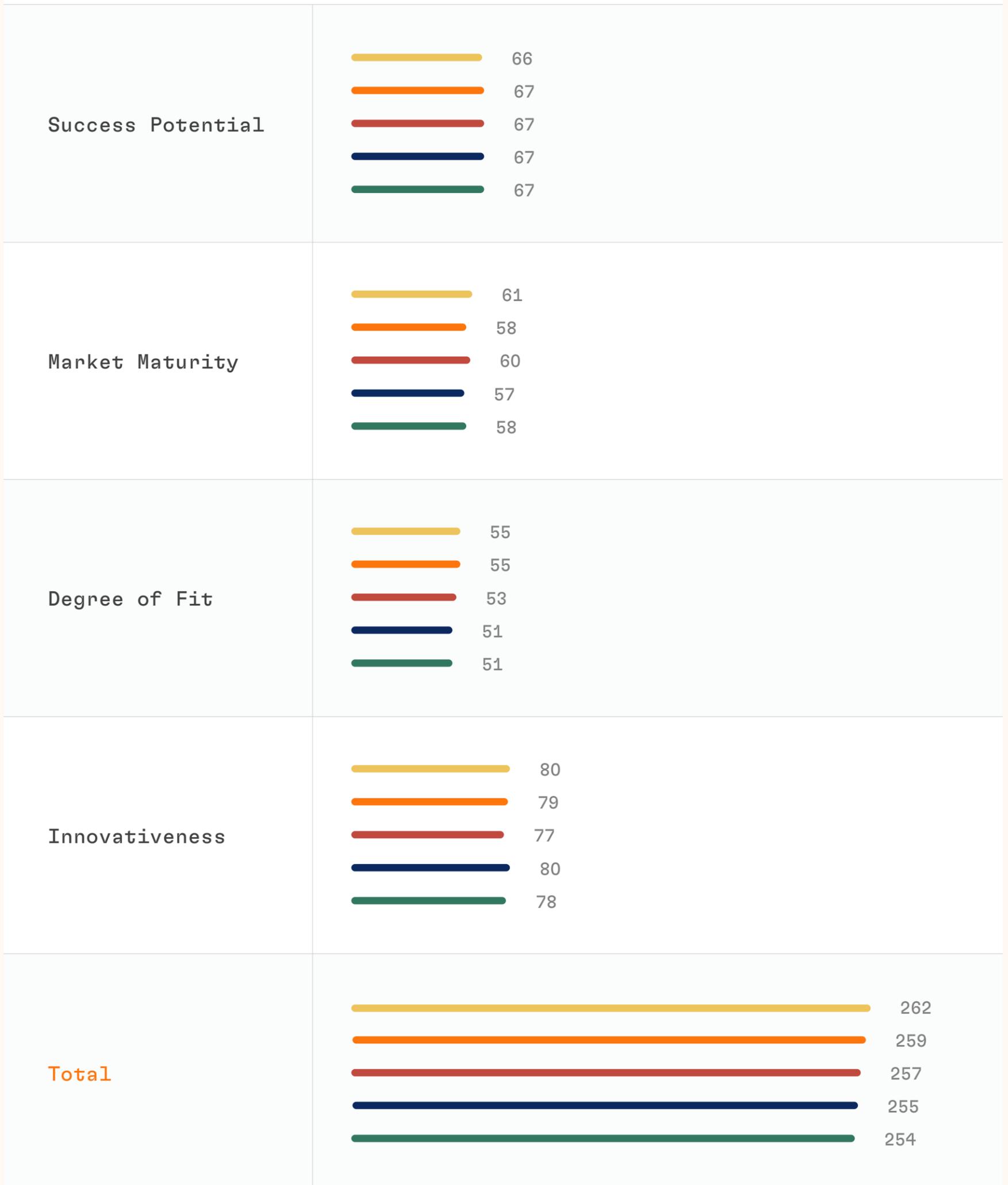
Market maturity

The AI platform analyzes companies' technologies to estimate the group's overall potential to generate profit. The algorithm analyzes the companies' financial history, the potential of attracting customers, and the maturity of their technology to compare it to the market's general development and trends.

Innovativeness

The AI platform looks for original and previously unseen combinations of business models and technologies to grade how generally innovative a cluster is.

Ranking the Clusters of Companies



- Digital twin for communication towers
- Test automation
- Telecommunications

- Autonomous air traffic
- Consultancy

Data Insights

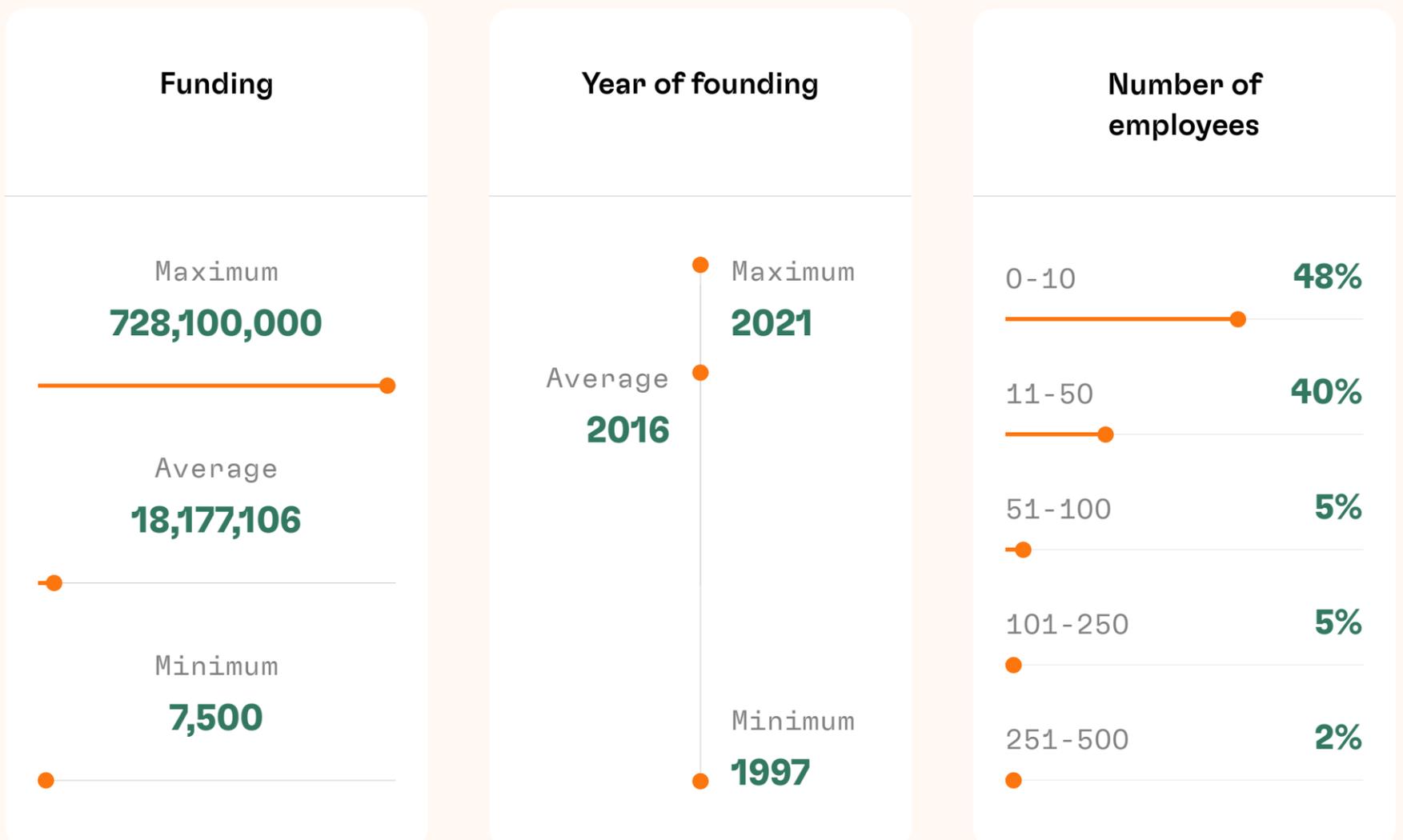
General Data Observations:

The average funding of all companies covered in the cluster analysis is \$18,177,106. The average minimum funding is \$7,500, while the average maximum funding is \$728,100,000.

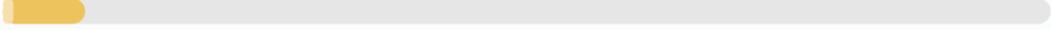
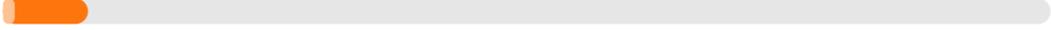
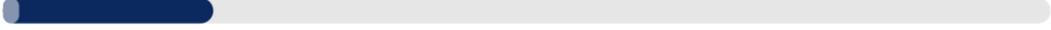
All the companies covered in the cluster analysis were founded between 1997 and 2021, with the average year of founding being 2016.

Most of the companies (on average, 58 out of circa 200 in each cluster) are based in the United States. The second most common geographical location is India, and the third is the United Kingdom.

Data Summary for All Company Clusters:



Funding

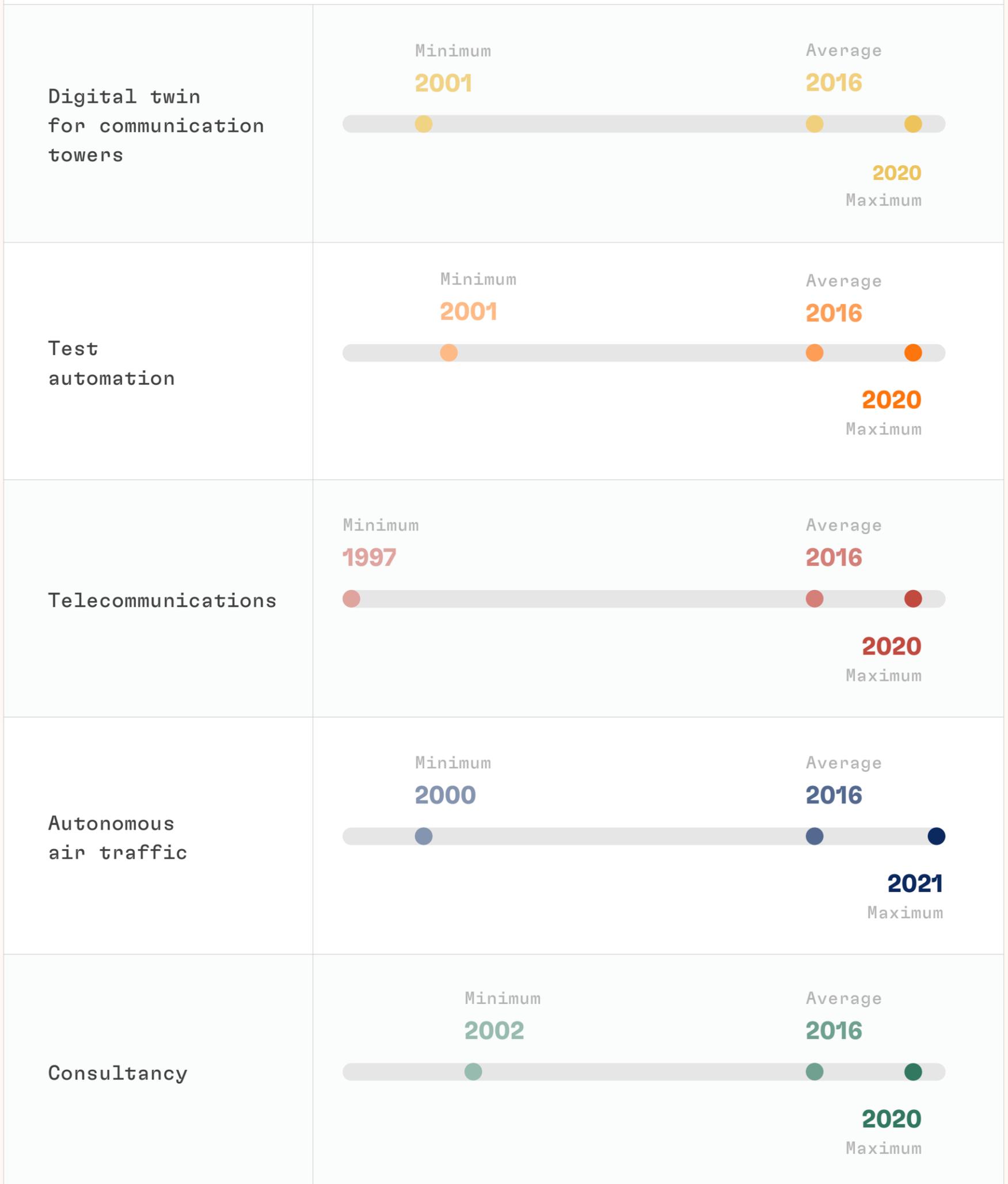
<p>Digital twin for communication towers</p>	<p>Average 7,200,530.33</p>  <p>\$57,449,991.00 Maximum</p>
<p>Test automation</p>	<p>Average \$5,368,306.05</p>  <p>\$59,800,000.00 Maximum</p>
<p>Telecommunications</p>	<p>Average \$36,554,073.90</p>  <p>\$728,100,000.00 Maximum</p>
<p>Autonomous air traffic</p>	<p>Average \$11,908,983.50</p>  <p>\$146,160,628.00 Maximum</p>
<p>Consultancy</p>	<p>Average \$29,853,637.26</p>  <p>\$728,100,000.00 Maximum</p>

● Average funding received by the companies in the cluster

● Maximum funding received by the companies in the cluster

For reference, all numbers are compared to the largest funding sum (\$728,100,000 in “Consultancy” and “Telecommunications”)

Year of Founding



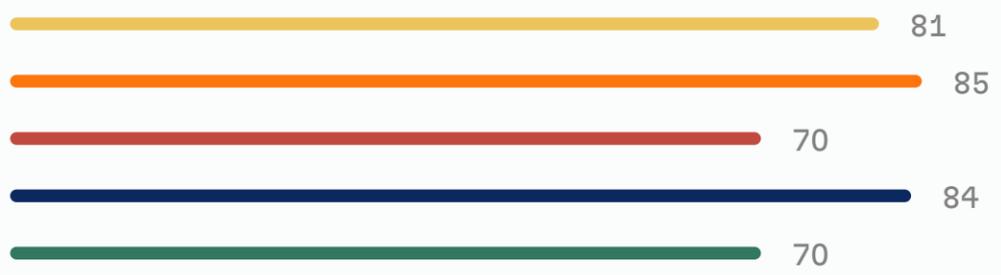
● Minimum year of founding

● Average year of founding

● Maximum year of founding

Number of Employees

0-10



11-50



51-100



101-250



251-500



- Digital twin for communication towers
- Test automation
- Telecommunications

- Autonomous air traffic
- Consultancy

Geographical Distribution

Area	Most frequent country and number of employees	Second most frequent country and number of employees	Third most frequent country and number of employees
Digital twin for communication towers	United States 57	India 29	United Kingdom 15
Test automation	United States 55	India 30	United Kingdom 12
Telecommunications	United States 66	India 26	United Kingdom 17
Autonomous air traffic	United States 57	India 38	China 20
Consultancy	United States 55	India 26	United Kingdom 19



Five Case Studies of Innovative Companies

Arup

Digital Twin Sim

OpenTower

SCALABLE Network Technologies

Spirent Communications



Featured Company:

Arup

Hardware

Science & Engineering

Sustainability

IoT

Civil Engineering

Environmental Engineering

Year of Inception:
1946

Current Stage:
Established

Team:
16,534

Location:
London, United Kingdom

Website:
arup.com

Arup Group Limited is a multinational professional services corporation with expertise in engineering, planning, design, project management, and consulting services. Founded in London in 1946 by Sir Ove Nyquist Arup, the company has worked on many notable projects, including the Sydney Opera House, the Centre Pompidou, the London Eye, and many others. As of October 2021, Arup employs more than 16,000 people in over 90 offices across 35 countries.

Executive Team



Paul Coughlan
COO & Chairman

Paul Coughlan joined Arup in 1997 as a senior engineer and has worked on projects in the highways, rail, and aviation sectors. In his professional career there, he served as a Director in Ireland and an Arup Group Leader in the Netherlands, before being appointed Arup's COO and Chair of the Management Board in April 2019. Prior to Arup, Coughlan spent nine years at Robert West as a civil engineer and director. He is a member of the Institution of Engineers of Ireland and a member of the Institution of Civil Engineers. He obtained a BEng in Civil and Structural Engineering from University College Cork.



Rob Boardman
CFO

Robert Boardman joined Arup in November 2019 to lead the company's finance function globally and engage with leaders to drive and optimize the financial health of the firm. He brings board-level finance experience from over 20 years working with international professional services firms, such as Herbert Smith, Ingenium Archial Ltd, Panmure Gordon, and Altium Capital. Before joining Arup, Boardman held the position of CFO at Hakluyt & Company for six years. He holds a BA from Manchester University.

Business Model

Arup operates on a B2B and B2G model, helping companies and governments deliver solutions and services locally, nationally, and globally. Even though the company's focus is the construction industry, it offers a broad project portfolio,

such as the UK Government's heat decarbonization program, the design of new cancer treatment centers, and engineering a more resilient rail network. The company's revenues are tailored on a per-project basis.

Value Proposition

Managing modern buildings comes with challenges such as getting real-time data on assets, verifying the accuracy of operation and maintenance manuals, checking equipment status, and reliably calculating the building's performance and energy consumption. With the increasing convergence of building systems, a central analysis platform that can offer insight from integrated data is of great importance. For that reason, Arup has developed Neuron, an integrated BIM and IoT platform

for smart buildings which uses 5G to gather real-time "sense-data" from equipment and systems.

In addition to digital services, Arup's expertise covers buildings and infrastructure, planning, consulting, and advisory services. Moreover, the company takes pride in its commitment to climate change, with its primary goal being sustainable development. To that end, the company consistently contributes to achieving net-zero carbon emissions throughout its projects.

Product Portfolio

Arup's product portfolio includes a plethora of solutions for healthcare, education, aviation, advanced manufacturing, intelligent mobility, renewable and net-zero energy and decarbonization, and many other segments.

Most recently, the company launched Neuron, an integrated BIM (Building Information Modeling) and IoT platform for smart buildings harnessing 5G and digital twin technologies. The Neuron Digital

Hub Platform is a centralized, cloud-based management platform that can connect disparate building systems and equipment, facilitate their operation and maintenance, and make them easily accessible. It consists of four applications, (1) Neuron Building, (2) Neuron Health, (3) Neuron Carbon, and (4) Neuron City. The platform represents a novel approach to how smart buildings are constructed, managed, designed, and maintained.

Technology Overview

Arup developed Neuron as a 5G digital twin to offer centralized asset management and performance control across complex systems. The platform combines machine learning and AI to analyze real-time data and optimize any asset. It integrates with BIM systems to display data sets through a cloud-based, centralized management console. Also, Neuron can learn from historical data, allowing for predictive maintenance and helping the BMS adjust automatically to achieve better energy savings and building performance.

Neuron allows facility managers, building owners, and city authorities to make smarter, data-driven decisions. The app helps control energy use, health, well-being,

and carbon emission with its four applications: (1) Building, (2) Health, (3) Carbon, and (4) City.

The first application of the digital platform is Neuron Building. An example of use case for smart decision-making for buildings is an HVAC system, which is generally a costly energy consumer. Operators traditionally use building automation and control systems to monitor and react to changes within those systems, but Neuron can help turn that data into predictive control for greater efficiency. The platform features allow energy forecasting to better match cooling loads to occupancy and offer predictive maintenance for early fault detection in equipment. Neuron Building has self-learning abilities that continually

refine and improve its forecasts, translating into energy efficiency of the systems it controls.

Neuron Building was incorporated into One Taikoo Place in Hong Kong, making it its first AI-enabled and data-driven smart building. It uses the platform as a flexible digital visualization tool for energy monitoring and optimization and access to real-time performance data from anywhere within the Taikoo Place complex. The Neuron system is fully integrated with the existing BIM model, allowing the company to optimize its facility management further. According to Arup, Neuron's cooling load predictions help reduce energy consumption by 15%.

Neuron Health is designed for healthier buildings. It monitors the temperature, humidity, and levels of pathogens in the air to identify the correlations between health and indoor air quality. Its predictive modeling gives operators visibility of the risks and identifies measures to mitigate them. Neuron Health has been implemented in Beijing's Water Cube building, where a network of IoT sensors continuously monitor air pollution and collect data to optimize the building system operations.

According to Arup, Neuron Health helped the building reach energy savings of up to 25%.

Neuron Carbon is aimed at intelligent sustainability and reducing the environmental impact. It captures a record of emissions from the whole building's ecosystem, such as onsite generators and cooling systems, company cars, and energy and material purchasing and recycling. Its algorithms provide analysis that helps set targets and implement plans to reduce carbon emissions and provide an evidence base for carbon credits.

The insights Neuron's digital platform creates are not limited to individual buildings. The last application—Neuron City—allows asset owners to monitor, control, and compare performance across a whole campus or portfolio of buildings. Arup is working with authorities to bring insight and control to entire city networks. One example is Hong Kong's electrical and mechanical services department, where Neuron City integrates the government's IoT with a geographic information system to visualize the whole city's performance and help authorities plan a response in case of an accident.

Market Opportunities

The IoT and 5G networks offer connectivity opportunities that facilitate information extraction from the most complex assets. Regardless of the industry, Arup aims to ensure high performance, optimal maintenance, and the longest possible asset life for business partners. The company targets both the 5G and the global digital twin market with its digital asset management solutions.

A recent report by Research and Markets projected the global digital twin market to reach \$63.5 billion by 2027, rising at a CAGR of 41.7% over the

2021-2027 forecast period. Significant growth factors are the worldwide adoption of Industry 4.0 and the increasing automation for streamlining processes.

The world's access to 5G networks is also advancing rapidly. According to a recent report by Research and Markets, the global 5G technology market is expected to reach \$65.49 billion by 2026. The market was valued at \$4.1 billion in 2020 and is expected to grow at a CAGR of 58.7% over the forecast period.

Achievements and Future Plans

Over the years, Arup has won numerous awards and certifications. In 2020, Neuron was awarded the Gold Award at the Hong Kong ICT Awards for Smart Business in Big Data and Open Data Application. Also, the product won a Certificate of Merit in Category II, for an Innovative Application of Engineering Theories at the HKIE Innovation Award in 2020.

“We’re pleased to receive these awards, which recognize our efforts in pursuit of excellence. Creativity, innovation, and technical excellence are, in our view, inherent to the design process. We continuously explore new technologies and provide the best engineering solutions to challenging and complex technical problems, making possible what others think impossible,” stated Michael Kwok, Arup’s Region Chair for East Asia.

Moreover, Arup and its digital twin solution support the UK’s National Digital Twin program, providing clients with new levels of business intelligence in many performance-critical contexts.

As governmental climate change and decarbonization commitments move from policy development to implementation, the role of businesses is also becoming pivotal. As a business with extensive strategic and technical expertise in climate change services, Arup is working with its clients to accelerate such actions. The company is working with the UK Government COP26 Presidency team as a lead sustainable event consultant for the 26th United Nations Climate Change Conference, which will take place in Glasgow in November 2021.

DIGITAL TWIN SIM

Featured Company:

Digital Twin Sim

Hardware

Information Technology

Communications Infrastructure

Network Hardware

Telecommunications

Penetration Testing

Year of Inception:
2018

Current Stage:
Product/ Prototype

Team:
2

Location:
San Diego, CA, United States

Website:
digitaltwinsim.com

Digital Twin Sim is a San Diego-based company that advises telecommunication companies around the globe on financial, technical, and strategic decisions regarding various communication technologies. The company offers an analytical framework for consulting, leveraging big data, GIS, finance, machine learning, RF planning, and network economics. It was founded in 2018 by telecommunications expert Sameer Lalwani and strategy and finance consultant David J. Morgan.

Executive Team



Sameer Lalwani

Co-Founder

Sameer Lalwani is an experienced telecom industry professional who advises clients in the telecom industry on technology and network deployment strategies. Before co-founding Digital Twin Sim, he worked at Qualcomm for 22 years, holding various positions and progressing to Director Technology Valuation (Qualcomm Economic Modeling). Lalwani also briefly worked as Senior Network Planner at Facebook. He holds an MBA and an MSc in Electrical Engineering from the University of Southern California and a BSc in Electronics & Communication from Gulbarga University in India.



David J. Morgan

Co-Founder & Consultant

David J. Morgan is a growth-focused strategy and finance consultant in the telecom, media, and technology sectors. Prior to Digital Twin Sim, Morgan held several different roles at Qualcomm for nearly 15 years, the last one being Strategic Finance Manager of Global Business Development. Additionally, Morgan is the co-founder and Managing Director of HyperFocus and Associate Vice President, Strategic Finance & Analysis at Ultra Mobile. He holds an MBA in Finance and Strategy from the University of California, Irvine, and a BBA in Business Economics from the University of San Diego.

Business Model

Digital Twin Sim is a B2B consultancy offering tools and advisory services to clients in the telecom industry, targeting wireline, fixed wireless, and mobile operators, infrastructure vendors, OEMs, investors, regulators, and industry associations around the world. Its services are present internationally in emerging and

developed markets, enabling clients to make well-informed decisions on technologies ranging from 2G to 5G to IoT and mmWave. The company generates revenue based on subscriptions, licenses, and consulting fees, with different models applying for specific tools and services.

Value Proposition

The launch of 5G comes with some significant challenges and opportunities regarding infrastructure. Digital Twin Sim offers its tools and know-how to help telcos bridge the gap between technology and economics. It provides tailored expertise in financial modeling, economics, market forecasts and research, strategy, business plan support, and due diligence. Its

consultancy leverages big data, GIS, finance, machine learning, RF planning, and network economics, offering a comprehensive advisory service. Digital Twin Sim has experience of working with operators (wireline, fixed wireless, and mobile), manufacturers (infrastructure and device manufacturers), and governing bodies (investors, regulators, and industry associations).

Product Portfolio

Digital Twins Sim's portfolio comprises various tools that help advise on the financial, technical, and strategic implications of technological decisions. Their offering includes Terragraph and microwave planning, los & view shed, market dynamics, and capex & opex. It provides clients with a cohesive view of their networks by offering network deployment, a proprietary digital twin network model that leverages big data, machine learning, 5G, GIS,

and RF planning. Moreover, by building a detailed digital twin, the company enhances the decision-making process related to spectrum. The company also generates profiles that enable relevant demand forecasts for voice and data traffic by device and technology to analyze network traffic at a busy hour. Finally, it offers modeling of proposed changes in network architecture and device procurement.

Technology Overview

Digital Twins Sim offers a service that enables the planning of large-scale Terragraph and point-to-point microwave backhaul networks. Terragraph allows WISP to offer Hbps data rates with rapid deployment at a low cost while bringing in planning challenges inherent in 60GHz. Planning mmWave network brings challenges of working with high-resolution GIS data and access to tools to allow planning networks with thousands of links.

The company also developed tools that work seamlessly with 6-inch resolution DSM (Digital Surface Model), offering licenses to their tools in the form of a Docker Image named los & view shed. The market dynamics tool refers to developing robust models of specific target markets to provide an intelligent view of the total addressable opportunity. To create these models, the company uses geodemographics, helping companies understand subsets of population distribution for customer targeting, develop a network deployment strategy, plan campaigns, and perform site-location analysis.

Most of the 5G deployments will occur at high-frequency bands, including 3.5GHz in Sub6GHz frequencies and 12GHz/49GHz band in mmWave. The massive increase in site density, expected to follow the deployment of 5G, cannot be supported with the traditional site selection methods. Digital Twins Sims's network deployment tool enables infrastructure providers and

operators to have a clear overview of their networks at city scale, leveraging the capabilities of big data, machine learning, GIS, and RF planning.

Other tools offered by Digital Twin Sim are related to spectrum decisions that can heavily influence the coverage, capacity, user experience, and network cost. Additionally, the company develops subscriber and device profiles considering churn and device replacement rates to model the diffusion of technology and network features. Those, in turn, provide companies with a relevant demand forecast on voice and data traffic. They also enable them to assess the impact of subsidies on device adoption and the trade-off between enhanced device features and band support on network capacity. The company offers its know-how and tools in model development through network performance modeling, which reduces the risk in strategic decisions regarding complex technology.

Lastly, the capex & opex tool offers economic support to companies building or upgrading telecommunication networks and developing services. Integral projections of market trends, market share, and traffic growth lead Digital Twin Sim's financial models and business case analyses, enabling clients to make unbiased and well-balanced investments.

Market Opportunities

Driven by the rapid pace of innovation concerning virtualization in the networking domain and the increasing number of applications that require latent-free connection, the transformation of the 5G ecosystem is projected to witness a 3-4 times faster growth rate than other connectivity transformations. The global 5G services market is expected to grow at a CAGR of 29.4% between 2020 and 2026, reaching \$249.2 billion by 2026. Two significant restraints in the market development are the high costs required for 5G network deployment and delay in spectrum harmonization

across geographies, challenges where Digital Twin Sim's solutions could be of use.

The global digital twin market was valued at \$3.1 billion in 2020 and is projected to reach \$48.2 billion by 2026. It is expected to grow at a CAGR of 58% during the forecast period. Other than the 5G network deployment, some major drivers of this market are the increasing demand for digital twins in the healthcare and pharmaceutical industries, the changing face of maintenance, and the growing adoption of digital twin solutions for coping with the COVID-19 pandemic.

Achievements and Future Plans

Since its inception in 2018, Digital Twin Sim has extensively researched several significant fields related to 5G. The most recent ones explore the economics, the practicality, and the overall importance of Terragraph backhaul in the process of 5G deployment. To this end, the company tested its assumption that in high-density implementations, the most significant challenges for the operators will be site selection and backhaul. While the fiber backhaul accounts as the main cost driver of 5G, Terragraph offers potentially significant backhaul savings.

Digital Twin Sim also investigated 5G mmWave coverage. Its study demonstrates the type of coverage operators should expect from street light-based mmWave deployments through a propagation model that enabled them to determine path loss in line of sight (LOS), non-line of sight (NLOS), and indoor conditions.

Additionally, Digital Twin Sim has completed several other major research projects, including investigations into fixed wireless access, microwave LOS qualification, geodemographics, and spectrum auctions.



Featured Company:

OpenTower

Hardware

Telecommunications

Year of Inception:
2019

Current Stage:
Go to Market

Location:
Exton, PA, United States

Website:
opentower.com

OpenTower is a provider of purpose-built lifecycle management software applications for telecom towers. The applications are designed to support all critical aspects of lifecycle management, including tower design, structural analysis, inspections, change detection, planning, and creating a digital twin of the infrastructure. The OpenTower brand was developed by Bentley Systems (Nasdaq: BSY) to support 5G rollouts and accelerate the digitization of tower infrastructure with 3D representation and digital twin technology.

Executive Team



Apurba Tribedi

Senior Product Manager

Apurba Tribedi is a civil engineer with over two decades of experience in the field. Before his appointment at Bentley Systems, he held a senior position as Product Manager at Net Guru. Tribedi holds a BA in Civil Engineering from the Indian Institute of Engineering Science and Technology in Shibpur.



Santanu Das

Senior VP & CBO

Santanu Das joined Bentley Systems in 2006, where he progressively climbed the ladder to Chief Business Officer and Senior VP in 2020. Before Bentley, he held several senior positions, namely President at Research Engineers International and Web4 and COO at netGuru. Next to his post as CBO, Das is an active Board Member and Treasurer at the MATHCOUNTS Foundation.

Business Model

OpenTower operates on a B2B basis, targeting stakeholders in the telecom infrastructure vertical. Its AI-powered software solutions are designed to enable tower engineers, owners, carriers, and operators an end-to-end digital transformation, encompassing design, deployment, operation, and maintenance of towers, and transition to the 5G

market. OpenTower's primary revenue source encompasses practitioner software licenses offered through Virtuosity, Bentley's eCommerce store. With a 12-month practitioner license, the user can access the software, training sessions, expert services, and custom mentoring.

Value Proposition

The software enables a comprehensive lifecycle management overview consisting of digital twin projections, performance analysis, infrastructure inspections, and report generation. By collecting near real-time data, the solution generates insight that helps tower owners and operators conduct monitoring and prediction, essentially

leading to prompt reaction if a modification across the tower is required. With the three-application pack, OperTower aims to optimize the cost, quality, and performance efficiency of telecom towers and accelerate the modernization of communication towers through purpose-built tower applications at the same time.

Product Portfolio

OpenTower's product portfolio encompasses three applications:

1. **OpenTower Designer:** software for designing and analyzing communication towers, featuring tools for 3D model projections with appurtenances so users can understand the exact positioning of equipment and feedlines;

2. **OpenTower IQ:** a digital twin software for communication infrastructures that enables end-to-end automation of the tower lifecycle; and,

3. **OpenTower Mount Analysis:** an analysis solution with access to a collection of antenna replicas and pre-built mounts, avoiding the modeling from scratch.

Technology Overview

Bentley's OpenTower applications have been designed to translate high-precision tower data into engineering-grade digital twin projections, leveraging AI and predictive analysis to advance current industry practices for designing and analyzing telecom infrastructure. To comprehensively capture all critical aspects of tower lifecycle management, the company has developed three products: (1) OpenTower Designer, (2) OpenTower IQ, and (3) OpenTower Mount Analysis.

OpenTower Designer is purpose-built software for tower design and analysis that connects to the equipment databases to generate automatic wind and seismic loadings, inspect the structure, and create data insight based on the analysis. The solution enables users to design and model various towers, including lattice towers, guyed masts, and equipment parts such as antennas, mounts, and linear appurtenances. The software also supports features for scenario management, layer modification, wind and ice load generation, etc. Moreover, it can capture real-life workflows, namely tower modification, multiple scenario evaluations, foundation checks, and connection designs. Empowered by advanced graphics, the application can also generate a realistic view of the tower, including 3D projection with appurtenances of the equipment and feedlines.

The second product, OpenTower IQ, is a digital twin software that

accelerates 5G rollouts and enhances decision-making with advanced 3D visualization and comprehensive tower lifecycle automation. Combining AI and patented dual-sensor drone technology, the tool provides high-accuracy digital twin modeling, enabling tower companies to virtually inspect towers, scrutinize their construction, and examine the structural integrity and vitality of the infrastructures.

With OpenTower IQ, tower engineers can modify existing towers, automate repetitive tasks related to as-built model production, and analyze critical components to determine the robustness of the towers. The software also features tools for cost-benefit analysis, revenue assurance, smart inventory management, and improved accuracy of tower inspections. The OpenTower IQ software is powered by Bentley's iTwin platform for digital twin visualization.

Lastly, the OpenTower Mount Analysis software is an add-on module to OpenTower Designer and provides access to realistic 3D graphics, antenna, and mount databases. The solution encompasses an extensive library of pre-built mounts for sector frames, platforms, T-arm structures, and a database of antenna models. It also features a wind load generator that automatically creates load combinations, cohesively applying wind at intervals around the mount to conduct prompt and elaborate analysis.

Market Opportunities

The telecom industry's progressive transition to 5G technology, along with the accelerated infrastructure digitization, effectively contributes to the advancement of the smart city concept. To further stimulate these efforts, tower companies seek software solutions that can inspect infrastructure vitality via digital solutions and resilient connectivity, essentially leading to enhanced safety, reduced risks, and lower maintenance costs. Digital twin visualization is among the most pursued solutions in this direction, allowing telecom engineers a comprehensive

overview of the tower's lifecycle to utilize the full potential of the infrastructure.

Bentley Systems targets the digital twin market by promoting OpenTower as a global provider of digital twin services to telecom infrastructure organizations. According to Markets and Markets, the market was valued at \$3.1 billion in 2020 and is projected to reach \$48.2 billion by 2026. The market will register a CAGR of 58% during the forecast period due to the rising demand for digital twin solutions in the healthcare and pharmaceutical industries, credited to the COVID-19 pandemic.

Achievements and Future Plans

Bentley Acceleration Initiatives (BAI), Bentley Systems' strategic investment fund, launched OpenTower IQ in March 2021 as a joint venture with Visual Intelligence, a Houston-based sensor technology company, and Aeroprotechnik, an aerial inspection engineering solutions provider from Viseu, Portugal. The partnership aims to "bring together ecosystem partners in digital co-ventures" to speed the commercialization of iTwin-based creative cloud-based services.

In an effort to accelerate the launch of the product, BAI pursued AI-enabled digital twin technology from Aeroprotechnik, an aerial inspection engineering company specializing in aerial inspection with expertise in automated asset data capture and digitalization solutions. Visual Intelligence, as a third stakeholder in the joint venture, contributed with patented dual-sensor drone technology. The technology enables OpenTower

IQ to digitize physical structures with millimeter accuracy, essentially empowering the software to deliver engineer-grade asset intelligence. After it endures a successful market launch, the co-venturers expect the product to significantly help tower companies accelerate the rollout of 5G technology.

"Our next step is to invite additional interested ecosystem partners to kick start new digital integrator services to capture huge emerging opportunities for enterprise integration and implementation for towers. The telecom industry is going through a rapid transformation as multi-network operators are expanding their portfolios through consolidation and moving from a 4G platform to 5G. Without a doubt, digital twin solutions like OpenTower IQ, 'powered by iTwin,' will help tower owners make the most of the industry's burgeoning opportunities," emphasized Santanu Das, Senior VP at Bentley.



Featured Company:

SCALABLE Network Technologies

Software

Hardware

Privacy & Security

Simulation

Wireless

Cyber Security

Year of Inception:
1999

Current Stage:
Established

Team:
38

Location:
Culver City, CA, United States

Funding:
Acquired

Website:
scalable-networks.com

SCALABLE Network Technologies provides network digital twin modeling and simulation solutions for the defense, infrastructure, and autonomous technology sectors. The company was founded in 1999 by Dr. Rajive Bagrodia, a Professor of Computer Science at UCLA, to translate his and the academic work of his research group into commercial simulation and modeling products. The company is based in Culver City (CA) and as of October 2021 operates as a part of Keysight Technologies' portfolio.

Executive Team



Rajive Bagrodia, PhD

Founder & CEO

Dr. Rajive Bagrodia is an expert in computer science and electrical engineering. Prior to founding SCALABLE, he was a full-time Professor of Computer Science at UCLA, where he and his research team published over 150 research papers on the topics of high-performance computing, wireless networking, and parallel simulation. In 2012, Dr. Rajive Bagrodia briefly stepped down from the CEO position and took up the CTO role, before returning to his former position in 2016. He holds a BTech in Electrical Engineering from the Indian Institute of Technology in Bombay and a PhD in Computer Science from the University of Texas at Austin.

Business Model

SCALABLE is a B2B and B2G company, targeting commercial, government, military, and educational organizations. The client categories can be divided according to the sectors they service, such as (1) the Army, the Navy, Marine Corps, and Air Force under the defense

sector; (2) critical infrastructure entities, such as telecommunications, emergency services, utilities, and financial services; and (3) the autonomous technology industry, specifically the automotive, positive train control, flight, and mining sectors.

Value Proposition

SCALABLEs' simulation and modeling tools address numerous challenges faced by businesses and governments globally. The company offers design, analysis, and testing of network-centric devices and systems, which is to reduce the time, cost, and risks of developing and deploying new technologies for its clients. Since simulations are being run in "virtual time", the processing is reduced from hours to seconds without affecting

precision. As a provider of network digital twin solutions, SCALABLE provides the inherent benefits of the technology, namely, it enables testing of numerous networks against highly realistic scenarios in a low-cost and low-risk lab-based setting with a small hardware footprint, thus improving operational planning while eliminating the need for building physical infrastructure.

Product Portfolio

SCALABLE offers an extensive product portfolio consisting of skews and scenario-dependent versions of its two base products:

1. **QualNet** is a network simulator used to create network digital twins in commercial, military, government, and educational organizations.
2. **EXata** is a network emulator utilized for replicating live networks with

high-fidelity software models. It is available in several varieties, including EXata Lite, EXata Cyber, EXata 5G, and others.

Furthermore, in terms of security, SCALABLE offers a cybersecurity training platform which has a live-virtual-constructive (LVC) system for simulating different kinds of threat ensuing environments.

Technology Overview

SCALABLE's product portfolio kickstarted with QualNet in 2001 as its first network simulation product. The generated digital twin refers to a computer simulation model of the communication network, its operating environment, and the application traffic that the network carries, typically used to study the behavior of its physical counterpart under various circumstances. SCALABLE provides three different operational modes: (1) a design mode for designing virtual network models and inputting environment parameters; (2) a visualization mode for performing visualization and analysis of the scenarios created in design mode; and (3) an analyzer mode for displaying metrics and comparing different experiment results. As such, it offers an efficient and cost-effective way to analyze application and network performance, identify potential problems, understand the root cause, and assess alternative mitigation strategies.

The portfolio expanded with the EXata network emulator, which allows the user to create a network digital twin. It uses a software virtual network (SVN) to represent the entire network, the various protocol layers, antennas, and devices digitally. It can integrate with real radios and devices at single or multiple protocol layers and be connected to other systems on the SVN.

SCALABLE has developed a specialized version of the EXata network emulator for 5G networks, which includes 5G model libraries designed to help users evaluate

the performance and behavior of their 5G cellular networks. EXata's 5G model libraries support two deployment modes, the first being the non-standalone (NSA) mode. It uses the new 5G frequency spectrums for radio access and the Evolved Packet Core (EPC) of existing LTE networks enhanced to support 5G NSA. This allows for a quick introduction of new 5G services while fully utilizing existing 4G networks. The second—standalone (SA)—mode uses a flexible, cloud-based 5G Packet Core to provide Software-Defined Networking (SDN) and Network Functions Virtualization (NFV) capabilities to unlock the full potential of 5G.

EXata 5G is focused on the use case of eMBB (Enhanced Mobile Broadband), expanding across PHY, MAC, and Network Core. Additionally, it offers heat mapping for coverage, interference, and optimization metrics. To that end, it implements MIMO customizable patterns, support for diverse QoS requirements, and OGC CDB standards. SCALABLE also plans to integrate EXata 5G with MBSE software to support cyber controls and policies testing, enabling users to investigate the impact of integrating historically isolated networks into a single, always-on network fabric on usability, cyber resilience, and business KPI. With all of these features, SCALABLE aims to support its users in planning 5G deployments, reconfigurations, or upgrades effectively and meeting their key performance goals.

Alongside the 5G version, SCALABLE also offers several other variants of their EXata products, such as EXata Cyber for evaluating cyber resilience and EXata CPS for simulating electrical grids, among others. All EXata products are typically packaged

with other SCALABLE products to provide complete functionality for the user's specific use scenario and are offered in bundles such as the Cyber Bundle, Network Analysis Bundles, and Wargaming/Operational Analysis Bundles.

Market Opportunities

Due to its diverse offering, SCALABLE Network Technologies is a participant in several markets, mainly targeting the one for digital twin technology. According to Markets and Markets, the global digital twin market is expected to grow from \$3.1 billion in 2020 to \$48.2 billion by 2026, exhibiting a CAGR of 58% during the forecast period. This growth rate has been propelled by the COVID-19 outbreak for the most part, with an increased demand for digital twin software in the healthcare and pharmaceutical industries.

With its specialized 5G network emulation software, SCALABLE also is poised to capitalize on the global 5G services market, which, according to the market research provider, is also expected to exhibit substantial growth during the same period. Valued at approximately \$53 billion in 2020, the market is expected to reach \$249.2 billion by 2026, growing at a CAGR of 24.9%, mainly due to the rapid innovation in virtualization in the networking domain, coupled with the growing number of applications that require a latent-free connection.

Achievements and Future Plans

With over two decades on the market, SCALABLE Network Technologies has concluded collaboration with experienced sim-tech partners worldwide to distribute its simulation software. These partners cooperate with local organizations to identify opportunities and develop specific solutions, often integrating elements of third-party technology.

SCALABLE has further attracted the industry's interest by receiving multiple awards. A notable example is the FY2012 "Cross Cutting" Award by the US Army Modeling & Simulation Office. Next on, the Military Training Technology Magazine has recognized SCALABLE with top 'Training and Simulation Companies' awards in different categories over the course of nine years. The awards' list also includes Dr. Rajive Bagrodia's

nomination for Best Tutorial at the Interservice/ Industry Training, Simulation and Education Conference (I/ITSEC) in 2012; the 2009 and 2010 Performance Excellence Award by Boeing, and the 2010 Presagis Award for creativity and innovation using Presagis's COTS software solutions.

However, its visibility on the market reached a peak in October 2021, when SCALABLE Network Technologies announced its acquisition by Keysight Technologies, a technology company that works with enterprises, governments, and service providers and helps them accelerate innovation in global connectivity and cybersecurity. Regarding the acquisition agreement, Dr. Rajive

Bagrodia, SCALABLE's CEO, gave the following statement:

“Joining forces with Keysight provides an excellent pathway to dramatically expand the use of our innovative network digital twin solutions across broad swaths of commercial and military markets. Working together with Keysight, we will accelerate the use of modeling and simulation capabilities to provide secure and reliable connectivity solutions to our customers worldwide.”



Featured Company:

Spirent Communications

Software

Hardware

Privacy & Security

Simulation

Wireless

Cyber Security

Year of Inception:
1936

Current Stage:
Established

Team:
1,973

Location:
Crawley, United Kingdom

Funding:
Publicly Listed

Website:
spirent.com

Spirent is a telecommunications company providing automated test and assurance solutions for networks, positioning, and cybersecurity. The company dates back to 1936 when Goodliffe Electric Supplies Ltd was formed in London, England. As the company expanded, it became the Bowthorpe Group, named after the founder, Jack Bowthorpe. After a shift in its strategic direction, focusing on investments in high-tech markets, Bowthorpe launched its new identity - Spirent, in 2000. As of 2021, the company's corporate headquarters are located in Crawley, UK, and its operational head office is located in San Jose, California. Spirent has additional offices in the Americas, EMEA, and the APAC region.

Executive Team



Eric Updyke

CEO

Eric Updyke is an accomplished executive with over 30 years of experience in the communications industry. Before joining Spirent in 2019, Updyke held executive management positions at Amdocs, serving as Division President for North America and Group President - Global Services. Before his time at Amdocs, Updyke held executive positions at Nokia Siemens Networks and AT&T. He holds an MBA in Finance and a BS in Electrical Engineering from Cornell University.



Paula Bell

CFO & COO

Paula Bell is a Fellow Certified Management Accountant and a Chartered Global Management Accountant with a 15-year-long background in large-scale global organizations in various sectors such as technology, engineering, and manufacturing. Bell's previous experience includes CFO position at John Menzies Plc and Picardo Plc. Additionally, Bell has served in senior leadership positions at AWG Plc and BAA Plc and is Non-Executive and Chairman of the Audit Committee for Keller Group Plc. She holds degrees in Environment & Sustainability from Cambridge University and Corporate Strategy & Leadership from Harvard Business School.

Business Model

Spirent's B2B model encompasses all the steps towards bringing a new offering to market. Addressing the customers' product and services lifecycle needs, the company covers the development, deployment, and operation of its customers' product and service offerings. Spirent also employs a customer-centric, Test-as-a-Service model, which means that its cybersecurity, network, and positioning experts analyze the unique customer needs to deliver a solution that meets the product goals. Spirent is divided into three operating segments: (2) Networks

& Security, (2) Lifecycle Service Assurance, and (3) Connected Devices.

The company targets multiple industries, including communications, government, defense, aerospace, financial services, healthcare, and retail. Adding on to its expertise and leadership in lab-based testing, Spirent is working towards expanding into its customers' operational networks and addressing their security needs. Furthermore, Spirent is also tapping into new areas such as connected and autonomous vehicles.

Value Proposition

Spirent delivers value across four dimensions: (1) accelerates time to market, (2) reduces cost and complexity, (3) optimizes user experiences, and (4) improves security defenses.

Across the first dimension, Spirent employs a testing approach that eliminates redundant testing, integrates with development systems, and automates execution. Across the second dimension, Spirent facilitates a frictionless operation of

multi-vendor networks, devices, and services through its independent test certification and validation solutions. The third value dimension encompasses Spirent's involvement in optimizing the user experience through rapidly identifying and resolving issues before users are impacted. Finally, Spirent pinpoints security weaknesses and enables customers to prepare for attacks proactively by recreating real-world cyberattacks.

Product Portfolio

Spirent offers products and services that accelerate technology development. Spirent's services portfolio includes managed solutions, product services, and consulting.

Through the managed solutions, Spirent performs strategic, operational functions for customers through services such as Lab-as-a-Service, Test-as-a-Service, Certification-as-a-Service, and Deployment-as-a-Service.

The company's product services include offerings such as implementation and integration, product training, resident engineers, and ongoing product support.

Spirent also offers consulting services in cases where customers have specific project strategies and

objectives. The consulting services portfolio includes planning and design, assessment and strategy services, network architecture and engineering, and test methodologies, among other services.

The product portfolio is divided into three categories: testing, assurance, and automation. The testing group of products includes: (1) mobile network testing, (2) cloud testing, (3) Ethernet & IP testing, (4) devices and services testing, (5) cybersecurity testing, and (6) positioning testing. The assurance group of products encompasses service assurance for 5G, SD-WAN, Ethernet, and cloud networks. Finally, the automation group of products includes lab and test automation and network automation products.

Technology Overview

Spirent's solution for 5G testing and assurance is 5G Digital Twin—automated software that replicates the network for which the 5G applications are intended via the process of emulation. The 5G Digital Twin's multiple emulation processes enable traffic and signal generation functions to work in harmony to mirror the real-world 5G network in every aspect. This allows the physical system's behavior to be tested, analyzed, and accurately predicted

for a nearly infinite number of “what if” scenarios.

By continuously emulating the living network, Spirent's 5G Digital Twin allows for continuous prototyping, modeling, and research, enabling, in turn, testing and assurance experts to develop new use cases on demand in a time- and cost-effective manner. The Digital Twin has several primary emulated components that facilitate examining nearly all aspects of the

physical operations system in the context of any possible situation.

Firstly, the 5G Radio Channel Emulation & Sounding component emulates new 5G RF channel ranges, densities, and novel RAN technologies, as well as the 4G RF for 5G NSA (non-standalone) scenarios. Secondly, the 5G gNodeB & 4G eNodeB Emulation component emulates 5G and 4G Base Stations and offers functionalities such as data transfers, positioning, mobility control, and functional splits. Thirdly, the Fronthaul Emulation component emulates next-generation Ethernet fronthaul devices and traffic such as eCRPI and NGFI. The fourth component is Core Network and Cloud Edge Emulation, while the fifth emulated component is Network Slices, which emulates multiple network slices with various configurations, performance requirements, and deployment topologies.

Furthermore, the sixth emulated component, Device and Traffic Emulation, enables the continuous validation of the network's performance, interfaces, and infrastructure by emulating millions of devices with various types of complex traffic mixes. The seventh component, the GNSS Simulator, provides a simulation of satellite constellation signals with complete control over environmental conditions, location, motion, timing, and errors. Moreover, the 5G Digital Twin solution enables recording and playback of real-world captured signals and traffic through the Real-World Emulation component. This component replicates real-world conditions in a

test-bed for increased repeatability, predictability, and realism. The Impairment Emulation component validates the network's performance and behavior through the emulation of network impairments. Finally, the Security Threat Emulation component makes the preemptive identification of vulnerabilities, which emulates complex multi-vendor attacks that test and audit the 5G environment.

As a solution equipped with all the aforementioned capabilities, the 5G Digital Twin has been applied in several use cases, including automotive drive testing, private 5G networks for smart factory configuring, and communications service provider (CSP) planning and management. For example, C-V2X virtual drive testing with the Digital Twin covers the multitude of C-V2X connectivity in terms of testing, refining, and optimizing within complex what-if scenarios and environmental conditions.

Additionally, the 5G Digital Twin enables factories with many complex sets of communication requirements and environmental challenges to model, plan, optimize, and assure 5G, and ubiquitous connectivity benefits the smart factory. Furthermore, the 5G Digital Twin of the physical network enables CSPs to continually test, configure, and validate the behavior of the living network as well as optimize the live network based on the evaluation of the optimal configuration and performance options through the Digital Twin.

Market Opportunities

According to Ericsson, 5G subscriptions are projected to reach 580 million by the end of 2021 and 3.5 billion by 2026-end. North America is expected to hold the largest share of 5G subscriptions reaching 84% by 2026-end. Additionally, Gartner has estimated that the global 5G network infrastructure revenue will reach \$23 billion by 2022, and 60% of CSPs will commercialize 5G service covering Tier-1 cities by the end of 2024. Spirent has identified acceleration as a major market opportunity, as complex and continuously evolving

5G networks, along with accelerated commercial deployments and new vendors, open up a wide range of new opportunities for testing, automation, security, and service assurance.

Concerning the global digital twin market, Grand View Research has projected that the market will grow at a CAGR of 42.7% from 2021 to 2028, reaching approximately \$86 billion by 2028-end. The main factor driving the market is the benefits businesses witness when deploying digital twins to guide their process efficiency, reduce costs, and augment profits.

Achievements and Future Plans

Since its pivot to high-tech markets and the incorporation of its new identity, Spirent has focused on high-growth, high-margin, and high-tech activities and has succeeded in becoming a prominent player in the telecommunications industry. The company increased revenues by 5.6% from 2018 to 2019 and 3.7% from 2019 to 2020, driven by the demand for its 5G assurance, 5G device test, and Fit4Launch solutions.

This strategy has brought Spirent numerous clients and accolades, closing over 600 deals across the global 5G ecosystem in 2020. The company also received the 2021 BIG Innovation Award for its contribution to the development of 5G via its digital twin technology.

Moreover, in March 2021, Spirent acquired octoScope, a provider of automated wireless test solutions for the telecommunications industry, further strengthening its portfolio of wireless testing solutions.

Spirent also focuses on R&D to maintain its future growth, spending \$103.1 million (20% of its revenue) on R&D activities in 2020. For 2021, Spirent has prioritized cloud, PNT assurance, 6G, operational assurance, Wi-Fi 6 and 6E, 800G, SD-WAN, and managed solutions as key areas for investment. Additionally, Spirent is expanding its reach into segments such as cloud service providers, enterprises, hyperscalers, and governments.

Valuer

Visit valuer.ai and learn how we can help you find innovative technology and enter untapped markets

