INTRODUCTION

The COVID-19 pandemic had a seemingly instant impact on the economy: meetings shifted from boardrooms and convention centers to cyberspace; millions of workers across the nation left their offices to work from home; doctors, restauranteurs and other small business owners transitioned to digital business models.

Instead of an unexpected overnight shift, however, this transformation reflects the acceleration of long-term trends. For example, in the two decades before the pandemic, e-commerce websites took more and more market share from brick-and-mortar stores, forcing the bankruptcies of formerly nationwide chains such as Blockbuster.

As with the disappearance of Blockbuster, some aspects of the economy will not return to the pre-pandemic status quo. A variety of polls, for example, show that large numbers of workers do not want to go back to traditional office jobs and instead want the flexibility to work from home. Remote work alongside distance learning, restaurant delivery, telehealth and a variety of other services that skyrocketed during the pandemic will likely remain above the pre-pandemic baseline going forward.

This briefing focuses on five emerging technology industries in Orange County:

- Cybersecurity
- Artificial Intelligence (AI)
- Computer and Video Gaming
- Ophthalmics/Vision
- Drones
CYBERSECURITY

The pandemic-driven shift online has greatly increased vulnerability to cybersecurity attacks, so much so that the U.S. Chamber of Commerce released a Special Report on Cybersecure Remote Working During COVID-19 in October 2020. In the words of McKinsey & Company (McKinsey) writers Venky Anant, Jeffrey Caso, and Andreas Schwarz, “few corporate functions shifted priorities so much and so quickly when the COVID-19 crisis struck as corporate cybersecurity operations and the technology providers that support them.”

Unfortunately, due to a lack of government-defined industry or occupational codes for cybersecurity, measuring this industry or sector can prove challenging. Therefore, this report has identified one key occupation which best represents employment in this sector: Information Security Analysts.

At the state level, Cybersecurity employment increased by more than 43 percent from 2016 to 2021 and is expected to grow by an additional 20.7 percent from 2021 to 2026 reaching a total of 14,561 by 2026. Orange County’s Cybersecurity industry employed 1,028 workers in 2021, up from 934 in 2016. County-level Cybersecurity employment is expected to reach 1,191 by 2026, an increase of 162 jobs or 15.8 percent over the next five years.

ORANGE COUNTY CYBERSECURITY* EMPLOYMENT AND YOY GROWTH, 2016-2026

*Cybersecurity employment represented by Information Security Analysts employment.

Source: OCBC analysis; Emsi
Orange County had 751 Cybersecurity job postings in January 2021 compared to a pandemic low of 573 in May 2020 and a pre-pandemic high of 1,043 in July 2019. While the global economic downturn negatively affected industry employment demand, it did begin to recover in late 2020. Job posting data serves as a barometer of local labor market demand, and with total job postings over the past year surpassing total employment in the region, this is a strong indication that labor market demand in this sector is exploding.

Based on job posting aggregations, Orange County’s most in-demand Cybersecurity qualifications, hard (technical) skills and soft (non-technical) skills include:

- Cybersecurity (hard skill, 39.7 percent of job postings);
- Management (soft skill, 39.2 percent);
- Communications (soft skill, 35.1 percent);
- Certified Information Systems Security Professional (qualification, 26.2 percent);
- Operations (soft skill, 24.2 percent);
- Leadership (soft skill, 22.3 percent);
- Infrastructure (soft skill, 22.1 percent); and
- Auditing (hard skill, 20.4 percent).

There is no one commonly accepted Cybersecurity qualification, no equivalent of a law degree in the legal field or a PhD in academia; no one qualification appeared in more than 40 percent of the job postings. Instead, individual employers demand one of a number of qualifications. Cybersecurity, as might be imagined, is the most in-demand hard skill, while soft skills essential across the job market are also important parts of Cybersecurity employability.

Orange County had 2,373 unique Cybersecurity job postings over the past 12 months, with the highest concentration in Irvine, (864 job postings), Santa Ana (258 job postings) and Costa Mesa (256 job postings). The chart below highlights Orange County’s top Cybersecurity employers, which include a number of financial, defense, and telecommunication companies.
Fortunately, Orange County educational institutions are well positioned to create a pipeline of well-educated, qualified workers to fill these growing positions. The University of California, Irvine’s (UC Irvine) Cybersecurity Boot Camp at UC Irvine Continuing Education is a 24-week, part-time program with a multidisciplinary approach, including IT, networking and information security. California State University, Fullerton (CSUF) offers a Bachelor’s of Science in Computer Science with a Cybersecurity Concentration.

Multiple community colleges, including Cypress, Saddleback, Orange Coast, Coastline, Santa Ana, and Fullerton College, offer some form of cybersecurity certifications; Santiago Canyon and Irvine Valley have broader Computer Information Systems degrees and certifications. As demand for Cybersecurity employment continues to grow both in Orange County and throughout the nation, local educational institutions will need to expand program offerings while marketing these opportunities to both current and prospective students.
ARTIFICIAL INTELLIGENCE (AI)

While not thought of as a competitor to Silicon Valley, Orange County is quickly becoming a tech hub in its own right with the presence of Artificial Intelligence companies such as Syntiant in Irvine, developer of ultra-low-power deep learning processors to improve computing technology in the cloud and in physical devices such as smartphones, wearables, and drones. Anduril, also located in Irvine, specializes in using and developing AI technologies with applications in the military and defense sector. Other AI companies in the region include Costa Mesa startup Nirveda Cognition, which “uses cognitive Machine Learning and Natural Language Processing to automatically classify, extract, enrich and integrate relevant, timely, and accurate information” from documents, according to its website. Pegasus One, an established software development company located in Fullerton, also uses Machine Learning and Natural Language Processing in addition to Computer Vision – AI-powered spacial, facial, and character recognition tools – to provide clients with powerful data analysis allowing them to leverage customer data and gain dramatic insights into their markets as well as improve overall operational efficiency. Additional AI startups in Orange County include:

- Flikflix, based in Laguna Niguel, “the streaming recommendation app” with the tagline: “find the movies you’ll love, on the services you already use”;
- Newport Beach-based Cyrano.ai, which uses AI analysis to improve businesses’ interactions with their customers;
- Computer Strategies KB, based in Laguna Hills, which provides AI-related consulting services, working with companies to develop individual AI strategies;
- AMW Smart Shelf, based on Aliso Viejo, which uses AI to help retailers improve their brick-and-mortar consumer experience; and
- Irvine-based Terra Manta, which uses machine learning and data analytics to track and predict drivers of fluctuations in commodity prices.

Orange County universities have also fueled AI-related innovation. UC Irvine, for instance, is home to both the Center for Artificial Intelligence in Diagnostic Medicine (CAIDM) and the Center for Machine Learning and Intelligent Systems (part of the Bren School of Information and Computer Science). CAIDM’s mission is “to empower health care providers, researchers, and patients through the deployment of artificial intelligence (AI) healthcare applications,” while the Center for Machine Learning brings together researchers in a variety of fields. According to its website,

Examples of research activities in the Center range across areas as different as web search engines, statistical text mining, spam email filtering, information retrieval, automated reasoning, image and video data analysis, sensor networks, astronomy and planetary sciences, ocean and atmospheric sciences, systems biology, medical diagnosis, chemical informatics, and microarray genomics.

1 https://cml.ics.UC Irvine.edu/home/about-us/
At CSUF, Dr. Yu Bai’s research on using AI tools to improve STEM education has won a National Academies of Sciences, Engineering and Medicine award.

As with many new and emerging sectors, Artificial Intelligence does not yet have broadly defined industry or occupational codes, which makes industry analysis more complicated. Three industries commonly associated with Artificial Intelligence are Software Publishers, Custom Computer Programming Services, and Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology). In Orange County, both Software Publishers and Custom Computer Programming Services sectors grew by 31.7 percent and 18.4 percent, respectively, between 2016 and 2021. Conversely, Research and Development in the Physical, Engineering and Life Sciences industry saw employment levels decline by 24.8 percent from 2016 to 2021.

**EMPLOYMENT IN ARTIFICIAL INTELLIGENCE RELATED INDUSTRIES IN ORANGE COUNTY, 2016-2026**

![Graph of employment trends in AI-related industries in Orange County, 2016-2026](image)

*Source: OCBC analysis; Emsi*

An analysis of online job posting profiles using the words “Artificial Intelligence” reveals that in the past 12 months, there have been 1,842 unique job postings in the region with a median advertised salary of $133,000. Monthly average job postings with those keywords increased from 275 in September 2020 to 541 in July 2021, an increase of nearly 96 percent. The chart below highlights the top 10 most in-demand occupations that mention “Artificial Intelligence” in job posting profiles.
TOP 10 OCCUPATIONS WITH “ARTIFICIAL INTELLIGENCE” IN JOB POSTING PROFILES BY TOTAL JOB POSTINGS IN THE PAST YEAR

![Graph showing job postings by occupation.]

Source: OCBC analysis; Emsi

The top companies with job postings that contained “Artificial Intelligence” included Anduril, Inc. (151 job postings), Deloitte LLP (103 job postings), and Lever Inc (99 job postings).

TOP 10 COMPANIES BY “ARTIFICIAL INTELLIGENCE” KEYWORD IN JOB POSTINGS IN ORANGE COUNTY, JULY 2020 - JULY 2021

![Graph showing job postings by company.]

Source: OCBC analysis; Emsi
Despite AI’s relative newness, Orange County community colleges and universities have begun incorporating AI into curricula. Alongside CAIDM and the Center for Machine Learning and Intelligent Systems, UC Irvine also offers a Machine and Deep Learning program for in a multitude of disciplines, from Marketing to Data Engineers and Statisticians, with courses ranging from Introduction to Machine Learning and AI to Artificial Neural Networks and Big Data Analytics.

Santa Ana and Golden West community colleges offers students an Introduction to Artificial Intelligence, a 6-week course which summarizes AI and AI analytics across a number of industries and processes. Orange County high schools have also begun teaching AI; Anaheim Union High School District recently announced a new Artificial Intelligence Internship Program created in partnership with Loko AI.

As a man of color, Isaac Alferos is no stranger to rejection and racism. Through the Male Success Initiative at Cal State Fullerton — where men of color are empowered to achieve their potential — Isaac found the support to pursue his passion for social justice in higher education.

Now, as an appointee to the California Student Aid Commission, he advocates for affordable higher education for all Californians. Read more about Isaac’s story at campaign.fullerton.edu/resilience.
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COMPUTER AND VIDEO GAMING

Orange County is home to a number of computer and video game developers, most notably Irvine’s Blizzard Entertainment, developer of Starcraft, World of Warcraft and other internationally popular games. Other Irvine-based game developers include Obsidian Entertainment (Star Wars Knights of the Old Republic II: The Sith Lords, Fallout: New Vegas, Pillars of Eternity), Blind Squirrel Games (contributions to Mass Effect: Legendary Edition and XCOM: Enemy Unknown) and indie developer Bonfire Studios.

Other Orange County video game developers include Lake Forest-based Turtle Rock Studios, formerly Valve South (Left 4 Dead, contributions to Counter-Strike series), Foothill Ranch-based arcade game developer Specular Interactive and Tustin-based inXile Entertainment (The Bard’s Tale, Wasteland 2 and 3). Aliso Viejo-based startup Gaikai, which was acquired by Sony in 2012, produces technological foundations for streaming and cloud-based gaming.

Video and computer gaming is a major growth industry, one that received a significant boost during the pandemic. As economist Tyler Cowen noted in a recent Bloomberg article, global gaming revenue now totals approximately $179 billion, more than the global film industry and professional sports in North America combined. In his words, gaming’s “mix of digitization and immersion — combined with the closed, world-building, proprietary structure of the gaming enterprise — has created something new.” At a time when many other forms of entertainment – such as movies in theaters and concerts – have yet to return to the “old normal,” gaming has the potential to expand even further.

While Computer and Video Gaming does not have specific government-defined industry or occupation codes, analyzing the company profiles of employees at the companies highlighted above reveals insightful trends – most notably that these occupations provide above-average salaries. Additionally, the occupations highlighted in bold below indicate year-over-year increase in total jobs in the county while those in italics indicate a year-over-year increase in the supply of local graduates. Nearly every occupation saw the median hourly earnings increase over the past year, except for Software Developers and Software Quality Assurance Analysts and Testers.

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3 Ibid.
Employment of Software Developers and Software Quality Assurance Analysts – the industry’s most in-demand job – grew from 16,579 in 2016 to 20,732 by 2021, representing an increase of more than 25 percent. Orange County is expected to employ more than 22,400 Software Developers and Software Quality Assurance Analysts in 2026.

**Orange County Software Developer and Software Quality Assurance Analyst Employment and YoY Growth, 2016-2026**

Source: OCBC analysis; Emsi
The Computer and Video Gaming industry has and will continue to rapidly evolve alongside new and innovative technologies; the increased ‘gamification’ or application of game-design elements and principles in non-game contexts such as in systems, services, businesses, and even social impact efforts will also boost employment and increase demand for relevant skills. Fortunately, local educators have begun preparing students for employment in this growing field.

- The University of California, Irvine offers an Esports Management Certificate, with program advisors including Mark Candella, Director of Strategic Partnerships at Twitch; Doug Lombardi, Vice President of Marketing at Valve; Jay Puryear, Director of Brand Development at Treyarch; and Adam and Tyler Rosen, Esports Program Managers at Blizzard Entertainment. UC Irvine also publishes game-related education and research as well as funds research projects related to video games through the Undergraduate Research Opportunities Program.

- California State University, Fullerton offers students a course in Game-Based Learning Design.

- Chapman University provides a Minor in Game Development Programming with courses ranging from Visual Programming to The Unreal Game Engine and Production and Operations Management.


- Santa Ana College offers a Video Game Design and Development Training Program with disciplines including Game Mathematics and General Game Modeling and Texturing.

With the guidance of expert advisory boards and promotion by local gaming clubs, collaboration between academia and industry experts is already well-established in this sector; local stakeholders should continue to nurture these relationships in order to ensure these courses and programs continue to provide the most recent insights and trends.

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4 https://UC Irvine.edu/top-ranked/innovation/esports.php
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Orange County's rapidly aging population will continue to increase demand for Health Care-related industries such as Ophthalmology and Ophthalmic Goods Manufacturing. For the past several years, OCTANe OC has held an annual Ophthalmology Technology Summit. The 2020 summit featured notable speakers, including Johnson & Johnson CEO Alex Gorsky (on how AI, data analytics and machine learning could transform health care), Dr. Uday Devgan, MD (on innovative new lenses) and Dr. John A. Hovanesian, MD, FACS (on new trends in cataract surgery).

This focus on ophthalmic technology aligns with the county’s current and historical strengths in biotech and medical device manufacturing. Led by companies such as pulse oximeter manufacturer Masimo and cardiac medical device manufacturer Edwards Lifesciences, Orange County has the nation’s top Medical Device Location Quotient; its Location Quotient of 5.30 means that the industry is more than five times as concentrated in Orange County as at the national level. Allergan was the first major Orange County company in the field of eyecare. Santa Ana-based Johnson & Johnson Vision (formerly Abbott Medical Optics) is also a leader in both fields.

According to Emsi, Ophthalmic Goods Manufacturing employed 1,204 Orange County workers in Q3 2021 at an average annual salary of $98,990. Emsi notes that the average area of Orange County’s size would employ only 253 Ophthalmic Goods Manufacturing workers, which means that the industry, like Medical Device as a whole, is significantly more concentrated in Orange County. Emsi analysis also shows that Orange County Ophthalmic Goods manufacturing employs a racially diverse workforce and that it had a total gross regional product (GRP) of $257.3 million in 2020. In the same year, the industry accounted for approximately $5 million in tax revenue.

In 2020, Orange County’s most common Ophthalmic Goods Manufacturing occupations included:

- Production Occupations (48.3 percent of total industry employment);
- Office and Administrative Support Occupations (11.4 percent);
- Management Occupations (9.0 percent);
- Business and Financial Operations Occupations (7.2 percent);
- Architecture and Engineering Occupations (7.2 percent);
- Transportation and Material Moving Occupations (5.1 percent); and
- Other (11.8 percent).
Between March and May 2021, the industry’s most in-demand skills (as seen in job postings) included:

- Lean Manufacturing;
- Business to Business;
- Pharmaceuticals;
- Key Performance Indicators (KPIs);
- Continuous Improvement Process;
- Marketing Strategies;
- Manufacturing Processes; and
- Data Analysis.

In terms of recent job postings, the county’s top Ophthalmic Goods Manufacturing employers include Oakley, Bausch & Lomb Incorporated, Essilor of America and Tecport Optics.

In terms of education, the University of California, Irvine’s Gavin Herbert Institute and Department of Ophthalmology at the School of Medicine is an internationally recognized center, which provides high specialized training and access to fringe clinical trials. It offers third- and fourth-year medical students Ophthalmology electives as well as a residency program which is fully accredited by the Accreditation Council of Graduate Medical Education (ACGME). UC Irvine also provides certifications in Optical Engineering and Optical Instrument Design, allowing students to focus on either treating patients or creating products that can benefit patients.
DRONES

Market research analysts predict that the global drone industry will reach a value of $85 billion by 2020; Goldman Sachs expects, “$100 billion of growth in the commercial drone industry” over the next five years.

Despite regulatory difficulties related to the presence of John Wayne Airport, drones already have a strong presence in Orange County. Dronegenuity, for example, offers drone photography services throughout the county, as does OC Drone Photography and Irvine-based Digipulse. UC Irvine Media has a drone of its own, while a design team at the Samueli School of Engineering is working on designing a hydrogen fuel cell for drones.

California Automated tracks employment in Orange County’s drone industry and provides a comprehensive map of drone education programs and local drone companies. They aim to expand employment in the drone industry by helping people get educated about drones and thus find jobs in the drone industry. They list employment and drone usage in industries such as: Security, Manufacturing, Agriculture, Construction/Architecture, GIS, and Public Safety.

El Pollo Loco made headlines earlier this year when it announced plans to begin drone delivery, including from a few of its Orange County locations. El Pollo Loco predicts “Flytrex delivery will take 10-12 minutes, versus 36-40 minutes for ground delivery.” In Laguna Beach, drones are being used by the police department for surveillance, allowing officers to monitor from an aerial perspective. According to the department, drones are a much cheaper alternative to helicopters and provide quick responses in search and rescues.

Southern California Edison has used drones for “200,000 annual inspections of electrical infrastructure in high fire risk areas as part of its Wildfire Mitigation Plan.” Aerial inspections are now done 75% by drones and 25% by helicopters when just a year ago it was the exact opposite.

Similar to Cybersecurity and Artificial Intelligence, the Drone sector is relatively new and therefore does not have specific industry or occupational codes, which complicates any industry or occupational analysis. The industry currently most closely linked to Drones is Aircraft Manufacturing, which employed 273 in 2021 in Orange County and is expected to reach 289 by 2026. As the Drone industry continues to mature and attract more students, hobbyists and professionals, employment in this sector is likely to continue to grow, especially as innovators find new applications for drones and drone technologies.

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5 https://www.dronegenuity.com/aerial-photography/california/orange-county/
6 https://www.ocdronephotography.com/
7 https://digipulse.com/portfolio/drone/
8 https://home.due.UC Irvine.edu/news/flying-high-UC Irvine-UC Irvine-media-drone/
9 http://projects.eng.UC Irvine.edu/projects/2020-2021/long-range-drone
10 https://californiaautomated.com/engage-with-industry/
13 https://www.oc-breeze.com/2021/08/13/201417_drones-and-ai-future-is-now-for-sces-aerial-inspections/?noamp=mobile
Searching “Drones” as a keyword in Job Posting Analytics reveals a total of 253 unique job postings over the past year in Orange County with a median advertised salary of $89,500, an increase of 137.6 percent from a year ago when the median advertised salary was only $34,000. Demand for workers with experience with drones has been steadily increasing all year, starting at 43 unique postings in September 2020 to 72 unique postings in August 2021.

**JOB POSTINGS IN ORANGE COUNTY WITH KEYWORD “DRONES” IN POSTINGS, SEPTEMBER 2020 – AUGUST 2021**

Highlighting the importance of information technology employment, Software Developers and Software Quality Assurance Analysts and Testers was again the most in-demand occupation within this sector.
Drones will likely become a growth industry going forward due to their tremendous untapped commercial potential. Thus, Orange County educational institutions should develop drone related courses to prepare the workforce for the future of drones. California Automated tracks drone education programs, but only a few have been recorded in the Orange County area. Orange Coast College currently offers an Unmanned Aircraft Systems Certificate of Specialization, which prepares students to be capable of deploying and piloting unmanned aircraft, collecting and analyzing telemetry data, programming autonomous flights, and securely communicating with different aircrafts. Santa Ana College is also hosting events for students to explore drone related job opportunities in public services such as fire and public safety.\(^\text{14}\)

Another notable drone program in Orange County is Fullerton Colleges’ Drone Lab, which in 2020 was selected by the Federal Aviation Administrative (FAA) to conduct the Unmanned Aircraft Systems-Collegiate Training Program or the UAS-CTI. Started in 2018, Fullerton’s Drone Lab currently offers eight courses ranging from Basic Drone Piloting to Counter Drone Operations and Drone Journalism, an Associate of Science degree in Autonomous Systems Development and certifications for Autonomous Systems Development and Unmanned Aerial Systems Piloting. It is a certified Service Provider by the Association of Unmanned Vehicle Systems International and has received certification by ASTM International as a Certified Training Provider.

**CONCLUSION**

While many of Orange County’s historic strengths – its status as a global Hospitality and Tourism destination, its strong housing market fueled by a high quality of life – will continue into the post-pandemic era, the emerging technologies surveyed here will continue to transform the county’s workplaces, overall economy and daily life. Educators, administrators and other interested stakeholders must find ways to prepare today’s students for employment in these growing fields, jobs which will often require whole new skillsets. Fortunately, Orange County has the educational infrastructure to do so effectively, as well as the entrepreneurial ecosystem necessary to transform new technologies into economic growth and job creation.

\(^{14}\) https://atleducation.org/orange-county-drone-summit-continues-to-grow-in-second-year/
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