

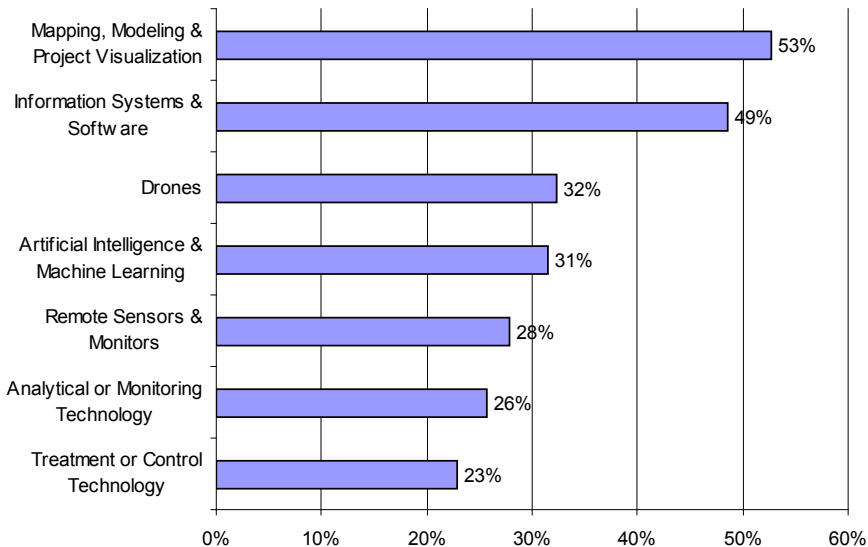
TECHNOLOGY AS THE DIFFERENTIATOR

Knowledge and perspective on technology has always been a differentiator in the environmental industry. Firms have developed \$100 million value propositions on a single technology. Others are technology agnostic: purporting to equally represent every technology available in the tool bag to make the most cost-efficient and enduring solution for their clients. So whether a service provider or a technology developer, or whether a consultant or a contractor, staying at the forefront of technology development and implementation is a key element in environmental industry competitiveness.

But not all technology is created equal. And not all technology works as intended or expected. And few and far between is the client or project that is willing to be experimented on. Equally elusive is the client willing to fund innovation on a project by project basis. The traditional regulatory paradigm behind prescriptive technologies or guaranteed results for treatment, pollution control, analytical methods or other processes across the environmental industry also serve to suppress or inhibit innovation. And while these barriers to technology innovation are important, they aren't the primary focus of this review. And while treatment and pollution control technologies are also important, they aren't the primary focus of this review either.

The technology revolution of the 21st century is about Information Technology (IT), and the revolution continues to be in full gear, if not accelerating, in 2023. From the mainframe to the personal computer to the smartphone and the interconnection of devices, and from data sharing to the internet and the cloud to computational models and artificial intelligence today, the pace of change has been persistent—and an underlying challenge of being in any business.

Areas Where Firms Have Significant Investments in Technology



Source: 2023 Survey of Disruptive Technologies in the Environmental Industry, EBI, Inc. Question was: What is the level of investment that your company is putting into the following technologies. Percentage are categories rated by respondents as 'very significant' or 'significant' investment in technology in 2023: just the top 7 of 18 displayed.

Inside EBJ: Technology & the Environmental Industry

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Deployment of Technologies in Environmental Projects: 2020-2023

	2023 Deployment	2020 Deployment	2023 vs. 2020
IT Systems & Software	52.5%	52.2%	0.3%
Mapping, Modeling & Visualization	47.4%	41.1%	6.3%
Analytical or Monitoring Technology	34.3%	44.0%	-9.7%
Treatment or Control Technology	22.5%	31.0%	-8.5%
Remote Sensors & Monitors	20.3%	22.5%	-2.1%
Satellite Technology	19.1%	19.4%	-0.3%
IoT or Connectivity	17.8%	14.4%	3.4%
Power Generation Equipment	15.3%	11.9%	3.4%
Energy Efficiency Systems/Equipment	14.6%	14.2%	0.4%
Drones	13.3%	9.6%	3.7%
Automated O&M Systems	12.0%	n/a	
Artificial Intelligence & Machine Learning	8.2%	8.8%	-0.6%
Power Storage Equipment	6.6%	7.5%	-0.9%
Automated Compliance/Permits	5.7%	n/a	
Robotics	3.8%	4.2%	-0.4%
Augmented & Virtual Reality	3.4%	5.6%	-2.2%
3D Printing	0.6%	3.5%	-2.8%
Block Chain	0.5%	3.0%	-2.5%

Source: 2023 and 2020 EBJ Survey of Disruptive Technologies in the Environmental Industry, EBI, Inc. Question was: Indicate the percentage of projects in which you are using the following technologies.

EBJ Respondents by Segment

Environmental C&E	20%
Remediation	16%
IT & Tech	11%
NRM/CRM	8%
AEC	6%
Investigation	5%
Remediation Tech/Eq	5%
Air Quality	3%
Compliance	3%
Statistics/Risk	3%
Sustainability	3%
Water/Wastewater	3%
Energy	2%
Infrastructure	2%
RNG	2%
Renewable Energy	2%
Solid waste	2%
Transportation	2%
Waste Management	2%
Water Instrumentation	2%
Water Testing	2%

Source: 2023 EBJ Survey of Disruptive Technologies in the Environmental Industry,

by the fact that we have more data due to better and more detailed data collection apparatus—putting pressure all the way along the continuum toward the ultimate goal of actually making a decision. And all this data and information taxes the human brain enough that we are becoming increasingly reliant on digital processes to make sense of the data and convert it into useful information and actionable intelligence. Hence today's obsession with artificial intelligence (AI) and debates about its ability to transform business and society in many ways.

But how are we using these tools to address today's challenges? And how is the environmental industry using technology to advance its ability to satisfy client needs and optimize its own business operations facing a changing future? Seeking answers to those questions, Environmental Business Journal conducted its second thorough survey of environmental service and technology providers in the summer of 2023, repeating a similar survey conducted early in 2020.

The results of EBJ's 2023 Survey of Disruptive Technologies in the environmental Industry are summarized here on these pages, and indicate some key trends that are affecting, and will increasingly affect the environmental industry throughout the rest of the 2020s and beyond. Along with this analysis we present some results of surveys conducted by peers in the industry that find an unsurprising recent surge in capital expenditures and operating

DATA-INFO-INTEL

So where are we in the development of Information Technology in the environmental industry? And how are we advancing on the continuum in our ability to collect and manage data, produce data into aggregated information, and assemble the appropriate information into actionable intelligence? Managing this data-information-intelligence continuum is not easy, but the difficulty is compounded

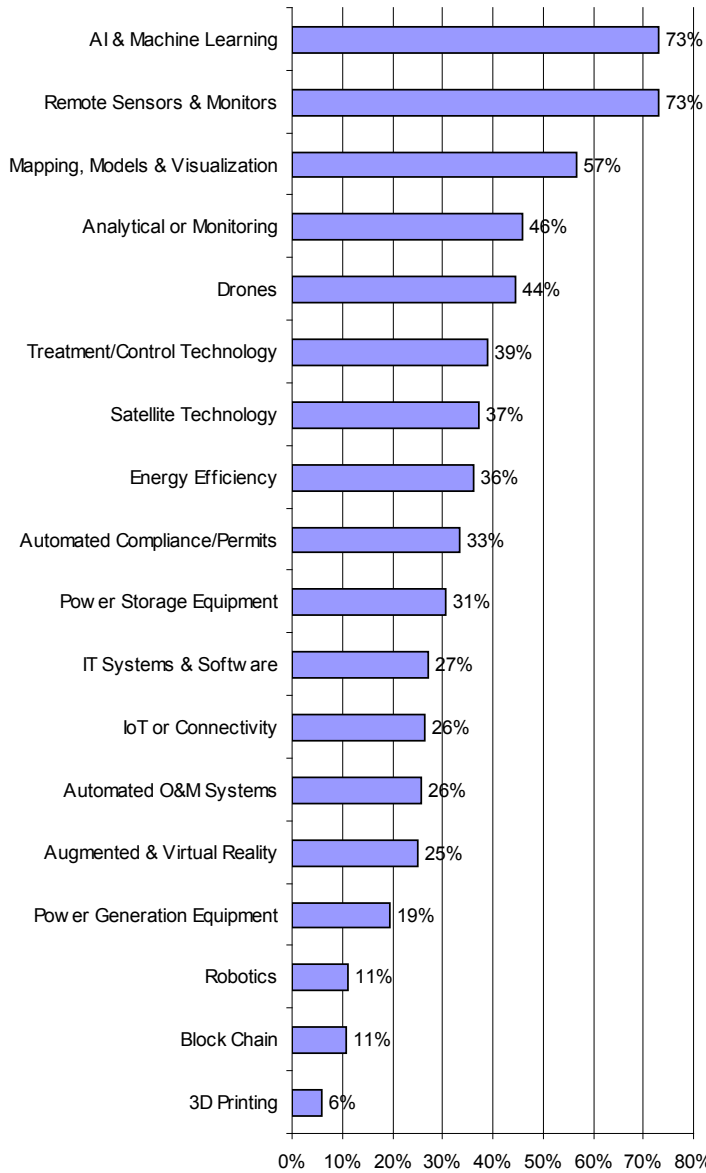
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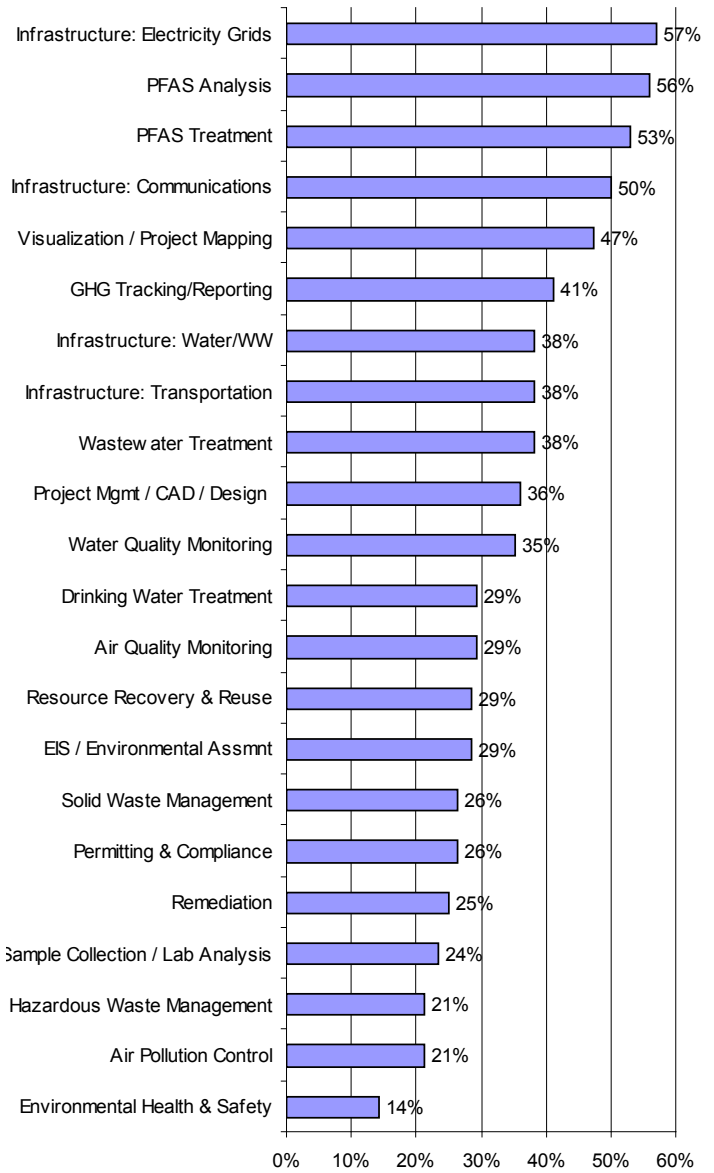
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Most Influential Technologies in the 2020s



Most Impacted Environmental Industry Segments



Source: 2023 Survey of Disruptive Technologies in the Environmental Industry, EBI, Inc. Question was: Rate how influential you believe the following technologies will be to the evolution of the environmental industry or your segment of the industry in the 2020s: Rated by respondents as 'most influential' or 'very influential' technologies in the 2020s; Question 2 was: How do you think that the following media or service segments will be impacted by technology in the 2020s: Rated by respondents as 'extreme' or 'very significant' impact of technology in the 2020s. (Tabular results of the same questions are presented on pages 4 and 6, respectively.)

expenditures on information technology across the Architect Engineering Consulting (AEC) industry — as well as an increasing expectation that it will be further monetized into revenue generation as part of their service offering.

Anecdotes selected from EBJ survey respondents also add color to key areas that will shape the future of technology in the environmental industry—including those barriers to technology; the sources of innovation and new technology; the ability of environmental service providers to have clients pay for or fund new technology on projects; how technology can increase cli-

ent fees or profitability; and long-term aspirations or hopes of what technology can deliver in the future.

INFORMATION IS THE CURRENCY OF THE REALM

What technologies are being applied to active projects indicates key trends on what is being demanded in projects, and perhaps on the nature of the projects themselves. The table on page 2 shows the deployment of technologies on projects in 2020 compared to 2023. At first blush the almost 10% reduction in deployment of analytical technology and treatment & control tech-

nology is alarming, but it's more likely a function of the change in demographics of EBJ's 2020 and 2023 self-selected survey groups that tilted more towards consulting firms over contracting firms in 2023. Either way the deployment of IT systems directly on projects remained consistent at 52%. Notable increases were in mapping and modeling technology, connectivity technology and IoT or the 'internet of things', as well as drones. Worth noting was a measurable increase in the deployment of power generation equipment on projects, presumably as green credentials and resilience raise in profile.

Most Influential Technologies in the 2020s

	Most Influential	Very Influential	Influential	Marginally Influential	Not Very Influential	Not Influential At All	2020 Ranking	2023 vs. 2020
Artificial Intelligence & Machine Learning	43%	30%	16%	5%	0%	5%	7	6
Remote Sensors & Monitors	22%	51%	24%	3%	0%	0%	2	0
Mapping, Modeling & Visualization	16%	41%	41%	3%	0%	0%	3	0
Drones	6%	39%	44%	8%	0%	3%	6	2
Analytical or Monitoring Technology	5%	41%	32%	14%	5%	3%	1	-4
Treatment or Control Technology	14%	25%	31%	14%	8%	8%	5	-1
IT Systems & Software	5%	22%	49%	14%	8%	3%	4	-3
Satellite Technology	9%	29%	29%	20%	9%	6%	9	1
Automated Compliance/Permit Systems	0%	33%	36%	19%	6%	6%	n/a	
IoT or Connectivity	6%	21%	41%	21%	6%	6%	8	-2
Energy Efficiency Systems or Equipment	8%	28%	22%	17%	11%	14%	10	-1
Augmented & Virtual Reality	3%	22%	31%	25%	14%	6%	12	0
Automated O&M Systems	0%	26%	29%	26%	14%	6%	n/a	
Power Storage Equipment	8%	22%	17%	28%	8%	17%	11	-3
Robotics	0%	11%	36%	22%	19%	11%	13	-2
Power Generation Equipment	0%	19%	19%	31%	8%	22%	14	-2
Block Chain	3%	8%	22%	22%	30%	16%	16	-1
3D Printing	0%	6%	21%	26%	38%	9%	15	-3

Source: 2023 Survey of Disruptive Technologies in the Environmental Industry, EBI, Inc. Rate how influential you believe the following technologies will be to the evolution of the environmental industry or your segment of the industry in the 2020s.

AI & ML TOP OF THE HEAP

Artificial intelligence and machine learning (AI/ML) were rated by survey respondents as the most influential technologies in the 2020s by a considerable margin. The effectiveness of AI, however, is dependent on the quality and continuity of data it has access to, so it is not surprising that remote sensors and monitoring devices, drones and other analytical or monitoring technologies are also rated as three of the top five most influential technologies by environmental firms. Also in the top five is mapping, modeling & visualization of data and information, setting it on the clear path towards the intelligence required for project decisions or execution—with or without the aid of AI/ML.

The table on page 4 illustrates the separation of these technologies compared to a host of others, and also the change in rankings from EBJ's 2020 survey. AI ascended the most in the rankings by six spots to number one, with drones and satellites also moving up the rankings in spite of the addition of two categories related to automation.

DATA IS KING

While the primary motivation of new technology in the industry is differentiation, or the quality of service and the enhanced productivity of employees, it is on the data side that companies are currently seeing the most significant impact. Data analysis was rated as the disruptive technology with the most significant positive impact to the business in the 2023 survey, with data collection technologies and data presentation technologies not far behind. (See table on page 5.) Not to be dismissed was the second ranked category of automation in systems and operations, rated by 44% of respondents as having a 'very significant impact' on their business today. Automation is almost universally seen as a tool to enhance productivity of staff, not to replace them, and although some may feel this may be just the 'party line', few executives admit to investing in automation merely to reduce headcount. Costs, time for training and new technology integration, as well as fear of technology obsolescence are concerns of environmental industry executives, but seemingly not enough to curtail much investment.

FEW SEGMENTS ESCAPE THE IMPACT OF TECHNOLOGY

Market and service segments are all impacted by technology, but some segments are expected to be more impacted than others. PFAS remediation at this point does not have a significant IT component, but both PFAS treatment and PFAS analysis rank as top segments that are expected to be impacted by technology development the rest of the 2020s.

With uncertainty around regulations, drinking water standards, wastewater discharge limitations, and state-by-state or federal regulations and enforcement, rapidly deployable treatment or containment technologies and systems to meet those standards will be required. Analytical technologies have already played a role in PFAS regulation, with EPA admitting as part of the issuance of its 4 ppt or part-per-trillion proposed standard in drinking water that 4 ppt was the most practically measurable concentration they could settle on based on currently available analytical technology, more than categorical data on threats to public health.

Impact of Disruptive Technologies on Various Business Areas

	Most Significant Positive Impact	Very Significant Positive Impact	Significant Positive Impact	Moderately Positive Impact	Not much Impact	Slightly Negative Impact	Significant Negative Impact
Data Analysis	14%	27%	35%	19%	5%	0%	0%
Automation of Systems or Operations	8%	36%	25%	22%	8%	0%	0%
Data Collection	5%	30%	35%	22%	8%	0%	0%
Data Presentation	5%	30%	32%	24%	8%	0%	0%
Differentiation & Quality of Service	8%	27%	24%	24%	16%	0%	0%
Enhanced Productivity of Teams	5%	16%	41%	27%	8%	3%	0%
Cost Efficiency: Reduced Labor	5%	8%	30%	14%	41%	3%	0%
Corporate Culture: Employee Retention	0%	11%	22%	19%	47%	0%	0%
GHGs or Carbon Footprint	3%	8%	11%	16%	62%	0%	0%
Technology Obsolescence	0%	3%	11%	14%	50%	19%	3%
Costs of New Technology & Evaluation	0%	3%	14%	22%	19%	39%	3%
Screen Time or Desk-bound Time	0%	0%	11%	14%	50%	19%	6%
Demands on Staff: Too Much Training	0%	3%	8%	6%	50%	33%	0%

Source: 2023 Survey of Disruptive Technologies in the Environmental Industry, EBI, Inc. Question was: What kind of impact are disruptive or innovation technologies having on the following areas of your business.

Investment Companies are Putting into Specific Technologies

	Very Significant Investment	Significant Investment	Moderate Investment	No Investment	2020 Ranking
Mapping, Modeling & Visualization	17%	36%	36%	11%	3
Information Systems & Software	11%	37%	31%	20%	1
Remote Sensors & Monitors	8%	19%	47%	25%	4
Artificial Intelligence & Machine Learning	11%	20%	34%	34%	8
Drones	3%	29%	35%	32%	6
Analytical or Monitoring Technology	3%	23%	43%	31%	2
Treatment or Control Technology	0%	23%	31%	46%	5
IoT	3%	11%	37%	49%	7
Energy Efficiency Systems	6%	11%	29%	54%	9
Satellite Technology	0%	6%	54%	40%	10
Automated O&M Systems	0%	11%	37%	51%	n/a
Augmented & Virtual Reality	3%	9%	31%	57%	11
Automated Compliance/Permits	0%	11%	29%	60%	n/a
Power Generation Equipment	9%	6%	14%	71%	12
Power Storage Equipment	6%	3%	17%	74%	13
Robotics	3%	3%	23%	71%	15
3D Printing	0%	3%	6%	91%	14
Block Chain	0%	0%	6%	94%	16

Source: 2023 Survey of Disruptive Technologies in the Environmental Industry, EBI, Inc. Question was: What is the level of investment that your company is putting into the following technologies.

Environmental Industry Segments Most Impacted by Technology in the 2020s

	Extreme Impact	Very Significant Impact	Significant Impact	Moderate Impact	Little Impact	No Impact	2020 Rank
Infrastructure: Electricity Grids	14%	43%	23%	9%	9%	3%	1
PFAS Treatment	21%	32%	24%	9%	12%	3%	n/a
PFAS Analysis	15%	41%	18%	9%	12%	6%	n/a
Visualization / Project Mapping	8%	39%	28%	11%	11%	3%	3
GHG Emissions Tracking & Reporting	12%	29%	29%	21%	6%	3%	n/a
Infrastructure: Communications	12%	38%	21%	12%	12%	6%	2
Wastewater Treatment	12%	26%	35%	15%	12%	0%	8
Infrastructure: Transportation	9%	29%	24%	32%	3%	3%	5
Project Management / CAD / Design	14%	22%	28%	19%	14%	3%	4
Infrastructure: Water/WW	9%	29%	21%	32%	6%	3%	11
Water Quality Monitoring	6%	29%	26%	29%	3%	6%	6
Air Quality Monitoring	6%	24%	35%	26%	6%	3%	12
Drinking Water Treatment	6%	24%	35%	24%	12%	0%	7
Remediation	3%	22%	39%	22%	14%	0%	9
Permitting & Compliance	0%	26%	24%	41%	6%	3%	19
Air Pollution Control	6%	15%	33%	30%	12%	3%	14
EIS / Environmental Assessments	0%	29%	23%	34%	11%	3%	15
Recycling, Resource Recovery & Reuse	6%	23%	20%	26%	20%	6%	13
Sample Collection / Laboratory Analysis	0%	24%	26%	32%	15%	3%	10
Hazardous Waste Management	0%	21%	33%	24%	15%	6%	17
Environmental Health & Safety	0%	14%	34%	43%	6%	3%	16
Solid Waste Management	0%	26%	15%	32%	24%	3%	18

Source: 2023 Survey of Disruptive Technologies in the Environmental Industry, EBI, Inc. Question was: How do you think that the following media or service segments will be impacted by technology in the 2020s.

Whether or not treatment technologies have a similarly influential path in setting final treatment requirements for water and wastewater, and ultimately for on-site remediation, plume containment and other remediation will be interesting to see. Even relative newcomers to the environmental industry can say 'BDAT'— the acronym for best demonstrated available technology, although 2023 Google searches list that behind 'Buenos Dias a Todos' and Battle Damage Assessment Teams.

Technologies related to climate change and the energy transition also are expected to be more significantly impacted by technology. Electricity grids, greenhouse gas reporting, and transportation and communications infrastructure were all ranked in the top eight of the 22 market or service categories rated by EBJ's survey respon-

dents (see table on page 6). And although populating the bottom of this list of 22 segments impacted by technology, still at least 40% of respondents rated Solid Waste Management, Environmental Health & Safety, Hazardous Waste Management, Resource Recovery and Air Pollution Control as segments where technology will still have a significant impact in the 2020s.

So there is no standing still even in the darkest corners and most conservative of environmental industry segments. As we are reminded by EBJ's tagline of 'Strategic Information for a Changing Industry' (adopted in 1988 no less), the only constant is change. But surely we could add that one of the constancies of is changing technology. Adapting to those changes in technology, or leading those changes in technology are increasingly at the competitive

forefront in the environmental and climate change industries.

AI & ChatGPT

In 2023, the potential of artificial intelligence across all industries is hard to underestimate. Some would say we are at a tipping point. Some would say we are in the midst of the 4th Industrial Revolution. Others would say we are at the start of the 5th Industrial Revolution (see p. 20).

Regardless of the label, we are at a critical point where technology is testing and crossing the boundaries of human intelligence. But whether this artificial intelligence can access and harness the right critical mass of data drawn from focused and accurate sources enough to develop and offer true perspective remains to be seen in the professional services world. And

with masses of data out there — much of which can't be characterized as completely reliable, and almost none of which will be pertinent to any task at hand — the limits to which AI can deliver in the short-term will constantly be tested, and will likely require human intervention.

Most experts believe these obstacles are not insurmountable. Defining or confining the parameters of data access, and refining the parameters of the prompt used, — backed up by fairly rigorous quality assurance based on human experience and some source validation — should produce volumes of usable content.

The extent that large language models and platforms like ChatGPT and other forms of 'generative AI' can produce usable reports, permit applications, planning documents, impact statements, and a host of other documents, — and eventually software code, engineering designs, diagrams, and other graphic and visualization documents pertinent to specific projects, and what level of human oversight is required to usher them to completion, will be a central competitive factor to the environmental industry for the remainder of the 2020s. ■

ChatGPT Output From EBJ Prompts: Take 2

User: What investments in technology should an environmental consulting company make to become more profitable?

ChatGPT: To become more profitable, an environmental consulting company should consider strategic investments in technology that enhance efficiency, accuracy, and client service. Here are some key technology investments to consider:

Data Management and Analysis Software: Invest in robust data management and analysis software to handle large datasets efficiently. Geographic Information Systems (GIS) and environmental modeling tools can aid in data processing, analysis, and visualization, allowing you to provide more accurate assessments and recommendations.

Remote Sensing and Satellite Technology: Utilize satellite imagery and remote sensing technology for environmental monitoring, which can reduce the need for costly on-site visits and enhance data collection capabilities.

Environmental Monitoring Sensors: Deploy environmental sensors for real-time data collection at client sites. These sensors can provide continuous data on parameters like air quality, water quality, and noise levels, allowing for proactive problem-solving and predictive maintenance.

Cloud-Based Project Management: Implement cloud-based project management and collaboration platforms to streamline workflows, improve communication with clients and team members, and enable remote work capabilities.

Machine Learning and AI: Invest in machine learning and artificial intelligence to analyze complex environmental data, identify patterns, and make predictive models. This can help in risk assessment, pollution detection, and resource optimization.

Environmental Compliance Software: Consider investing in software that helps clients manage environmental compliance and reporting requirements more efficiently. This can be a value-added service that generates recurring revenue.

Mobile Apps: Develop mobile apps for field data collection and reporting. This can improve fieldwork efficiency, reduce errors, and provide clients with real-time updates.

Renewable Energy Solutions: Explore opportunities in renewable energy, such as solar panels and wind turbines, to reduce your own energy costs and potentially generate additional income.

Cybersecurity Measures: Ensure robust cybersecurity measures are in place to protect sensitive environmental data, client information, and proprietary software.

Training and Skill Development: Invest in ongoing training for your staff to stay updated with the latest environmental technologies and regulatory changes. Skilled professionals can provide better services and attract more clients.

Marketing and Online Presence: Invest in digital marketing and website optimization to reach a broader client base.

ChatGPT Environmental Industry Q&A With EBJ

EBJ decided to put ChatGPT to the test in our own real-time example. In August 2023 we at EBJ used the following prompts and got the unedited ChatGPT replies.

User: Write a short summary of how information technology is revolutionizing the Environmental Consulting and Engineering business

ChatGPT: Information technology is transforming the Environmental Consulting and Engineering business by streamlining processes, enhancing data analysis, and improving communication. Through the use of digital tools, such as Geographic Information Systems (GIS) and environmental modeling software, professionals in this field can collect, analyze, and visualize vast amounts of data more efficiently. This enables them to make data-driven decisions for environmental assessments, remediation projects, and sustainability initiatives. Additionally, cloud-based collaboration platforms and remote monitoring solutions allow teams to work more flexibly and share information in real-time, ultimately increasing productivity and reducing environmental impact by minimizing travel. In summary, IT is revolutionizing this industry by increasing accuracy, efficiency, and sustainability in environmental consulting and engineering practices.

Note: ChatGPT did not reference itself or AI as a factor impacting the environmental consulting industry. However, once it get hold of the text in this review that may change. Stay tuned. We did give it another chance as the other two examples show.

A strong online presence can help attract new business opportunities.

Sustainability Initiatives: Consider adopting sustainable practices within your own operations, such as reducing energy consumption and waste, which can lead to cost savings over time and enhance your company's reputation.

It's essential to conduct a thorough cost-benefit analysis for each technology investment to ensure it aligns with your company's goals and budget. Additionally, staying informed about emerging environmental technologies and trends will help you make informed decisions about future investments that can drive profitability in the long run. □

ChatGPT Output From EBJ Prompts: Take 3

User: How can satellite data revolutionize greenhouse gas emissions tracking and reporting

ChatGPT: Satellite data plays a pivotal role in revolutionizing greenhouse gas (GHG) emissions tracking and reporting in several ways:

Global Coverage: Satellites provide comprehensive global coverage, allowing for monitoring of GHG emissions across vast and remote areas that may be challenging to access on the ground.

Real-Time Monitoring: Satellites offer real-time or frequent data updates, enabling continuous tracking of GHG sources, such as industrial facilities, deforestation, and natural gas flaring.

Precise Measurement: Advanced satellite instruments can measure GHG concentrations, such as carbon dioxide (CO₂) and methane (CH₄), with high accuracy, providing quantitative data for emissions assessment.

Emission Source Identification: Satellite imagery can identify emission sources, making it easier to pinpoint areas where reductions are needed and hold responsible parties accountable.

Verification and Validation: Satellite data can be used to verify reported emissions data, enhancing transparency and trust in emission reports submitted by governments and industries.

Emission Hotspot Detection: Satellites can identify emission hotspots and anomalies, helping authorities prioritize mitigation efforts and respond to unexpected events, such as leaks or wildfires.

Forest Monitoring: Satellites can track deforestation and forest degradation, which are major contributors to GHG emissions, aiding in conservation efforts and REDD+ (Reducing Emissions from Deforestation and Forest Degradation) initiatives.

Compliance Monitoring: Satellite data can assist in monitoring compliance with international agreements, like the Paris Agreement, by providing independent assessments of countries' emissions reduction efforts.

Historical Data Analysis: Long-term satellite datasets allow for the analysis of emission trends over time, facilitating informed policy decisions and assessing the effectiveness of emission reduction measures.

Accessibility: Satellite data is publicly available, making it accessible to researchers, policymakers, and the public, promoting transparency and informed decision-making.

In summary, satellite data is a powerful tool that enhances the accuracy, transparency, and effectiveness of tracking and reporting greenhouse gas emissions, contributing significantly to global efforts to combat climate change.

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Environmental Industry Outlook*

OBSERVATIONS ON NATURAL LANGUAGE PROCESSING & AI

Artificial intelligence is rated as the area of most increased interest across the environmental industry in information technology in the last few years. EBJ survey respondents were asked: Is ChatGPT just the latest technology flavor of the month? Or is it and other Large Language Models or Natural Language Processing platforms generating real usable outputs in terms of text, image, design drawings or other outputs suitable for work products, reports, permit applications or other applications?

Note: Acknowledging that artificial Intelligence is more than LLM and NLP, so respondents were asked to provide some examples of where AI is contributing real short-term value, and to what types of project work?

Paul Black, Founder, Neptune and Company Inc.

From our perspective ChatGPT and similar are more Natural Language Processing platforms than they are AI. These NLPs are searching across the net (so, massive data) to find answers to questions posed - if there is an AI part it is there ability to translate the responses into English - but that is NLP essentially.

What we do is build decision analysis systems that allow for Bayesian updating. Our software is based on the idea of understanding value systems first, leading to defining objectives or attributes, followed by identifying options that might achieve those objectives, followed by realizing what "science" or probability models are needed to evaluate the options (how well they satisfy the objectives).

By itself that is perhaps not AI, but once the science or probability models include some form of Bayesian updating or learning, then they are.

So, from our perspective, some of our applications are AI-based because they allow for that type of Bayesian updating. Learning has to be done somehow - Bayes theorem provides a formula for learning (not perfect perhaps, but that requires another discussion) - various algorithms seem to learn by brute force instead, including one aspect of ChatGPT (brute force searching of all databases it can access) - and there are some other learning formulas, but I don't know that anyone has gone beyond Bayes in these tools so far.

We've applied this approach to decision making to coral reef management, climate change resiliency, radioactive waste disposal/management, enrollment at a University that was struggling for funding, groundwater contamination, and others.

Jan Haemers, Managing Director, Haemers Technology

AI and Natural Language processing do already bring substantial added value when it comes to communications in several languages as well as for research purposes, where it has proven to be quite effective in focusing, summarizing and helping to get to the core of what we need much faster and better. It is not yet a game-changer as we cannot select the sources it takes for its learning, in particular internal data, which will be the next step in having AI a productivity tool for avoiding making the same mistakes several times.

For example, remediation projects all over the world are generating field data, with, individually, great lessons to be learned from each project. However, the communication about the lessons learned is very inefficient today with conventional tools. AI will be a key tool, in my opinion, to make sure that when we start a project, all lessons learned from similar projects, are summarized and integrated before start-up. It will also be very helpful in troubleshooting by having integrated all actual remedies applied in the past and proposing similar ones to the case at hand.

So AI and NLP is not so much a tool to replace our engineers, but definitely a tool to boost their productivity.

Michael Battle, Executive Vice President and Chief Operating Officer, EA Engineering, Science, and Technology, Inc., PBC

Our sense is that while the technology is rapidly evolving, ultimately AI/ML will prove to be valuable platforms to create tools for generation of a wide variety of project-focused and back-office productivity enhancements. Like many in our industry, earlier this year we embarked on our journey towards AI/ML strategy development, focusing on internal guidance as well as pilot projects intended to better inform our broader strategy. We expect that process to keep us busy for the balance of the year.

Jerry Strub, Founder & CEO, Strategic Growth Consulting, Inc.

ChatGPT can be used for marketing and content generation now by AEC firms. The use of other AI processes is still early in its development but over time will gain a foothold. My experience including the dot.com days is that the environmental industry is slow to adapt and most of our clients are OK with that. The next issue will be the legal ramifications of incorrect data causing damages. The legal issue applies to all industries.

David Hostetter, Business Manager, SCS Engineers RMC

ChatGPT and other large language models (LLMs) are the current headline-grabbing AI technologies, but until recently, I think most people were considering the implications and use cases for AI systems focused on data processing and analytics. I think we will see industry changes from LLMs through eventual increased efficiencies. That said, I think that the largest industry-changing AI technologies will come through AI technologies that help us improve our understanding of the data we're collecting and make better decisions with that data.

Christopher Dore, Heritage Business International

ChatGPT and other similar types of generative AI software (and there are a handful of other commercial products available) are a flavor of the month. The one place they have been useful to me is with summarizing thick reports and documents. There is a lot of value there in time savings. In these cases, they are primarily using the content of the document, and not “generating” content. I initially tried using ChatGPT to find some published literature on an obscure topic. I had difficulty finding publications using traditional methods, so I thought I’d try Chat GPT. It was awesome, so I thought. The software quickly came up with four journal articles. The journals were real, the authors were real, and the titles sounded real. However, the articles didn’t exist. The software had generated them. Thus, for fact-based scientific work, ChatGPT is actually dangerous.

Plus, AI isn’t anything new in the environmental field. Over 30 years ago, I was using AI classifiers for the analysis of multispectral satellite data. In supervised

classification, you take a sample of pixels for known features-of-interest and then the algorithms figure out how to classify the rest of the pixels. Sometimes these algorithms come from “mainstream” statistics, other times they are AI-based neural network classifiers. So, the environmental industry has been using AI for a long time, and it will continue to use non-generative AI into the future. However, generative AI like ChatGPT won’t be so hot after people realize its limitations.

Michael Schwerin, CEO, HELIX Environmental Planning, Inc.

We’re not using AI for our technical work products because it would be too easy for AI to write a complete falsehood (“hallucination”) that seems reasonable and gets missed during QC review. I also don’t want our employees uploading draft work products, or anything else that is not yet public, to an AI platform because then we lose control over the content. We have used ChatGPT in a limited context to help with soft products. For example, it’s good at writing a first draft of a cover let-

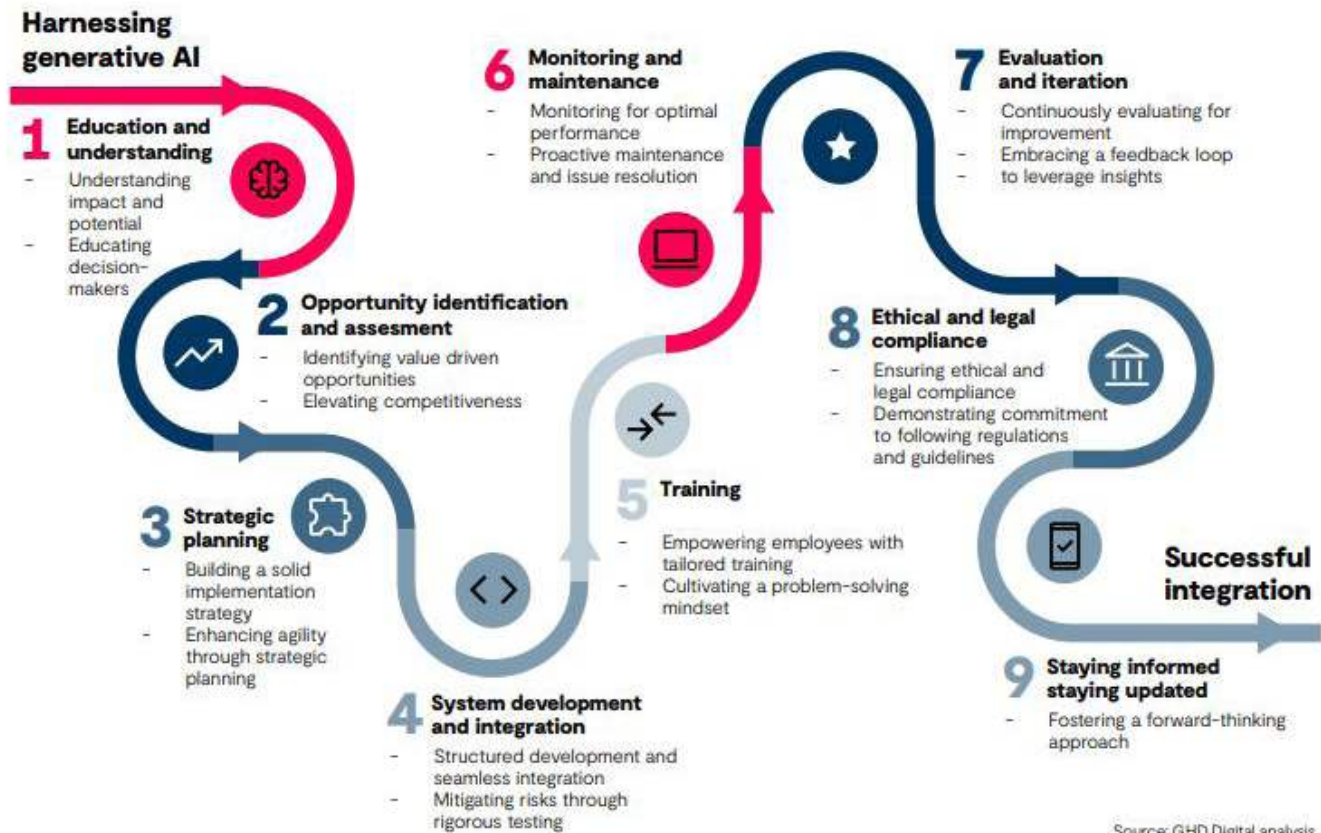
ter. We’re not using any of the AI imaging software for work products at this point.

I used 11Labs voice generation software, but only to demonstrate to our employees that they now need to add voice mails to the list of things that could be faked. My employees get a lot of fake emails and texts purportedly from me asking for them to buy gift cards (e.g., as a reward for a hard-working team). Although it hasn’t happened yet, I expect them to soon get voice mails from “me” asking for the same thing.

Marcus Quigley, Partner, Technology Practice, Environmental Financial Consulting Group

There is real progress in using LLMs for workflow automation ongoing in the industry. We expect this to not just be just the shiny object of the year, but a key technology step change in the efficiency of these businesses. Longer term, we anticipate (as do others) that >90% of current design, specification, and report writing work will be automated or semiautomated in the next decade (by 2033). □

GHD Digital's Roadmap to Effectively Leverage Generative AI



EBJ Survey: Sources of Innovation & New Technology

Responses to open-ended question in EBJ's 2023 Technology survey. Question was: Where do you believe much of the innovation and disruptive technologies in the industry will be coming from in the next decade? (From inside the environmental industry through collaboration, from government, from universities, from tech, etc. Note: Responses separated by ; indicate a separate respondent)

Automating the collection of data, which will then require "big data" pattern recognition and analytics to figure out what's important. Improved AI will help to train and assess big data sets.

All the above; AI/ML; BIM for Infrastructure, robotics

Both from within the industry and from the tech sector; Broad mix of start up companies, academic contributions, government R&D; Commercial sector with some university collaborations; Consulting Industry and Universities

For right now industry and tech is participating because of federal funding support; From tech and within the industry; From technology firms

From the government sponsored research and universities; From both Tech and Government; Funded by Government

I think the continued evolution of AI and its ability to manage the increasing amounts of data -- companies finding applications of AI in the environmental space will have a long sales cycle but will ultimately be successful

Industry and universities

Inside industry / schools / tech. startups; Inside industry and inventors; Inside our industry and tech companies

Largely from government as those are the most impacted: the federal government-DoD with PFAS and states that are responding. State and federal government agencies are pushing out the most R&D funding to support innovation

Our industry will continue to adopt, adapt, and innovate technologies for our customers however much of the innovation tends to originate from a combination of universities and federal government. The DOD has played a significant role and will likely continue to do so.

Private sector; From tech and from within the environmental industry

Innovation will come from technology and government mandates primarily

Technology firms think differently about the services we provide, and they will launch some disruptive services in the coming years. The financial model in this industry may not be as attractive to them, so how long they stay will be a question.

The innovation often comes from tech or academia and is transformed to apply to the environment industry--e.g., AI, IoT, alternate energy

Universities & start-ups; Universities and Tech will drive change with some facilitation by the government. Unlike previous environmental eras, more early adoption by industry may occur; Universities have been on top of the rapidly advancing technologies.

Source: EBJ survey *Disruptive Technologies in the Environmental Industry 2023*

EBJ Survey: Role of Technology in Client Fees & Profitability

Responses to open-ended question in EBJ's 2023 Technology survey. Question was: How much has, or can technology change the way in which you are charging your clients, and what is technology's potential to enhance profitability? (Comment on the proportion of time & materials vs. fixed fee.)

As our process becomes installed in a few locations it should become the first choice, but getting the first unit in the bio-gas applications is difficult. We have our technology in refineries but a shift in industry use is met with caution.

The big issue is there is no real intel; Changing from billable hours to technology fees is tough.

Clients have been reluctant to pay for technology as 'equipment' charges. (Remember 20 years ago when we billed computer time...it seems laughable now) There is a real cost to implementing technology innovations, such as new platforms, computer storage/memory of large datasets. These charges all get rolled into "fee" and cannot be easily recouped at all on T&M jobs.

Early adoption of technology can create a competitive edge, but that edge quickly fades as others adopt as well.

Excellent question! I would argue that there is little true disruptive innovation in our industry. Innovation is usually evolutionary, and we are heavy borrowers of other industries. We rarely develop on our own: we apply. Most importantly, we only focus on technology when we talk about innovation. The biggest potential disruptive innovation in the environmental consulting industry is on *business processes* and innovation on our basic business model. This never gets attention. It is though, where we have the biggest issues (primarily labor issues), and where we can do something about them.

Has potential - subscription services and data compilation/reuse. Generally T&M projects with retainers and automatic fee updates.

EBJ Survey: Barriers to development and implementation of Innovation & New Technology

Responses to open-ended question in EBJ's 2023 Technology survey. Question was: What barriers is the environmental industry facing that limit the development and implementation of disrupting technologies?

Applying traditional approaches; Lack of innovation; As has always been the case, a lack of funding to make the leap from lab to field.

Barriers- the need is immediate but technology development is on longer cycle. Approvals of new technologies by States and approving authorities takes longer than schedule permits. Funding from government entities that cannot react quickly.

CAPEX; Conservative industry & slow to adapt, worry about replacing billable hours; Cost and scalability; Cost factors for piloting new technologies; Cost: Most polluters want to reduce their environmental liability and dislike paying for new or innovative solutions, even if they may be more sustainable or cost less in the long run. So capital cost is the obstacle; Costs, learning/training, implementation

Customers are going to be slow to change -- our environmental customers typically have small budgets and small mandates -- we have to go beyond that to solve the environmental -- operations interface to really get technology traction, but this is a difficult thing for our customers to navigate on their own; Development costs and resistance from regulating authorities to new technology.

Firms won't want to share "their" data, which will be necessary for AI systems to learn our industry; Funding - need a government that prioritizes research and provides tax breaks or other financial incentives for it.

Funding to support research and development, and investments in new technologies. Also, getting public agencies to embrace new technologies in scopes of work; Getting the first client; I suggest lack of multidisciplinary capacity with practitioners.; If new technologies end up being less cost, clients will use it, if it is more expensive, that will be more difficult to promote

In my niche, cultural and environmental compliance, there is little money and time (in a must be highly billable world) to research, develop, and test-apply new technologies; Lack of desire for more or better environmental controls; Large risk averse businesses, funding (public/private), customer buy in

Politics and lack of timely guidance from government agencies; Regulation; industry stagnation and commodification; Regulatory acceptance for compliance purposes of new technology is often a limitation in the environmental industry. The approval of new methods, approaches and tools by EPA is slow; Resistance to change, up-front cost to purchase and implement, dated agency standards and guidelines

Risk aversion, regulatory lag, proof of cost savings; Skillset and payment methods; The key problems (with exception of PFAS) have been around a long time so difficult to overcome inertia, particularly for problems that involve consent of multiple stakeholders (e.g., regulators).

We need to think more like Technology firms and less like AEC. We need to develop products with value-based pricing -- fixed fee or unit costs -- in order to compete in the long run. Waiting to invest in Technology until we have a client that will pay for us to build something as part of their T&M project kills innovation. We also need to be less risk-averse when it comes to adoption of technologies -- this also means that we must be more tolerant of failure. These are cultural issues, not technology issues.

Source: EBJ survey *Disruptive Technologies in the Environmental Industry 2023*

Hasn't yet. If expensive AI systems dramatically reduce the time necessary for certain tasks, billing by the hour for staff time may no longer be a good model.

Higher margins when technology can enhance remediation results; I see there being an increasing potential over time to add client-facing data science & analytics services as a subscription basis, which could also be used to drive T&M professional services, but this is a work in progress.

If anything, the technologies that we have adopted over the last few years for assessment and due diligence are keeping prices low; In certain administrative areas, technology has the capability to enhance the bottom line, especially when it comes to report generation and accounting

Lower man-hours; Mostly allows us to provide more useful results for our clients; No major changes yet; None at all

Possibility for SaaS model, reduce cost due to efficiency gain can allow for more value add to the client for the same money, automation/AI can reduce overhead

Proprietary technologies allow us to charge higher prices for the services associated with the technologies. We don't sell our systems. Best margin for us is when we can bill the proprietary tech under a fixed fee arrangement.

Technology diffusion into our business has been steady for past 30 years even though much of the work is T&M.

The key will be moving from T&M models to more fixed fee and unit cost pricing. Investing in technology to reduce the "T" part of the equation is a losing proposition. We can invest more in automation AND be more profitable when we adopt value-based pricing models.

Too early to tell; We have had limited success in directly charging clients other than equipment or software rental; Work efficiency reduces labor costs for data analyses allowing staff to focus on results and implications. No real change in profitability, except possibly better work, more clients/projects/growth so more profit. ■

EBJ Survey: Can Clients Fund New Technology

Responses to open-ended question in EBJ's 2023 Technology survey. Question was: To what extent can you get project or client work to finance investments in new technologies?

A very small (but finite) portion of investment in innovation comes in the form of funding a standalone project. Often investment is a match, with consultants sharing some of the innovation cost through uncompensated time.

Always need to be creative, and drive partnerships with industries.

Depends on the sector. Government clients investing, O&G very narrowly and Industrial sector not investing- waiting on others to advance the technologies.

For Dept. of Defense, fairly easy to test new approaches through their SERDP/ ESTCP programs. Some but not all industrial firms have R&D programs as well.

Hardly ever. Fast and cheap, with emphasis on cheap

To a high extent if we can demonstrate value, but that is not easy

I cannot do that with my client base.

If the economics work, clients will fund new technology.

It is challenging - we must run bench style studies to prove efficacy

Limited; Limited; Only limited opportunities; Very limited

Limited with our client base. Too much price pressure. Seems to be significant amount in Government contracts - DOD, DOE, Military - especially around PFAS.

Moderate; Moderately; Moderate success in piloting projects, but hard to get to full-scale revenue-generating solutions

Never, although innovators are willing to try new technologies, just not pay for them; None; Not much; Not really, but many are open to innovation.

Our investments are based on a strong client demand and return on investment.

Pretty easily if the ROI can be demonstrated.

Rarely, but it has happened. When it has, it is typically with a repeat client who may benefit in the future from the development and nurturing of a new technology. They are typically happy to pay if the cost/benefit argument can be made.

Some; Somewhat

There are always a few you can find, but if we wait for client work to fund these investments, we'll be behind.

This is always difficult. The client's money wants to be safe.

To some extent, I would estimate about 30%, and the rest is overhead cost

This is a tough sell unless proven

We have been able to secure funding from a handful of clients to improve technologies that help their projects meet regulatory requirements.

Source: EBJ survey *Disruptive Technologies in the Environmental Industry 2023*

EBJ Survey: Aspirations in Innovation & Technology

Responses to open-ended question in EBJ's 2023 Technology survey. Question was: What invention do you have on your mind, or what disruptive innovation do you wish most would come into your practice?

AI has so much potential to make our lives easier when it comes to equipment trouble shooting. We could easily have a trouble shooting program using AI that could be a boon for our customers.

At the end of the day, consulting is a people business that requires trust between individuals. The pandemic hampered that as we stopped meeting as often to share meals with one another. This simple act is proven to improve trust between people. I would love to invent a time-traveling system so that we can prove to one another that we can trust each other more.

Combination of direct sensing into injection tooling for better targeting of heterogeneous sites. Just not enough room in the tooling ID to fit in all tubing, electronics, injection hosing.

Extraction of additional data from reports and improved hiring and retention tools

Better ways to separate, destroy PFAS from environmental media; Field sensors for PFAS; Full-scale PFAS destruction; Off-the-shelf PFAS remediation technologies; PFAS treatment, 1-4 Dioxane treatment technologies

I would like to send a drone to conduct a vegetation map, and maybe even an archaeology survey, of a site. At the same time, an autonomous vehicle would drive to the site and release a robot that would collect soil (and water, if applicable) samples to check for environmental DNA to see if there are threatened and endangered species in the area. The robot would also take site photos and record ambient noise levels. All this information would be fed into an AI system that could make a solid first draft of the technical reports needed to support an environmental impact analysis.

In my world, there are lots of jobs but few careers. Temporary field workers are taken advantage of and not invested in. Why? Because the profit margins are greatest with these employees and because firms must have a high billable percentage to ensure profitability and value growth. A simple thing, keeping a project-hire employed between projects, is rarely possible. Yet, that career investment in junior employees is exactly what we need to keep them in an industry they are passionate about. Too many junior employees are lost to other industries because we can't pay them competitively, no benefits, there is little job security, and they are on the road away from home working hard under challenging conditions. That's okay for a few years after college, but few of these people survive in the industry or go back to school for an advanced degree that will help them get on the career track. There are some compelling numbers and presented papers on this.

Large scale AI adoption; ML/AI, decision analysis, statistics, but we are working on all of those; Rapid characterization of diffuse groundwater contaminant plumes; Skynet

Private generative AI models will allow for extreme efficiency in some things, especially once the data is cleaned and tagged correctly. Ubiquitous LEO satellite sensor networks will allow for many new things to be monitored that weren't before, allowing for extremely multi-dimensions digital twins.

We are increasingly deploying digital twin technology for our clients and using remote sensing for improving infrastructure design, construction and maintenance. Digital twins have the potential to revolutionize the management of agencies and businesses, enabling real-time monitoring, analysis, and optimization of buildings, infrastructure, energy systems, security, and operations. Technology can support information management integration, predictive maintenance, reducing downtime and improving resource utilization. In cities, digital twins can simulate urban planning scenarios, aiding in sustainable development and disaster preparedness. Businesses can optimize energy consumption and enhance security measures through continuous monitoring and data-driven insights. The ability to test scenarios in a risk-free virtual environment can lead to more informed decision-making, increased efficiency, and overall resilience in managing complex systems. We are excited to see our work in this area growing and our investments in technology to deliver these solutions for our clients being implemented.

We are working on way to improve PFOA & PFAS Mass removal (in-situ) from soil & groundwater; We have employed proprietary technology in the hydro power and terrestrial wind markets for decades. We have recently developed remote sensing and smart curtailment technologies we use to support both offshore and onshore wind efforts; Use of "Bio-SWAATS" in the processing of stripped ammonia and H₂S in biogas from anaerobic digesters and landfills. The ammonia is currently vented or captured with sulfuric acid making a very low analysis fertilizer. ■

EBJ Survey: Segment Trends in Technology

Edited responses to an open-ended question in EBJ's 2023 survey. Question was: Comment on how innovative, disruptive or cutting edge technologies are being used for project categories, the impacts that they are having, and how you think that they will evolve. Note: Responses separated by ; indicate a separate respondent

Remediation

Activated Carbon Sequestration and treatment versus traditional ISCO and Bio; Advancing remedial technologies are showing promise with recalcitrant issues and persistent contaminants.

Current research will lead to new discoveries for PFAS and other recalcitrant compounds; Enhancing physical, biological and/or chemical remediation; General remediation continues to incrementally advance; Greater reliance on remote automated measurement and O&M in treatment systems; Lower cost, faster, in situ/on-site; Modeling using ML/AI, decision analysis; More opportunities for in-situ treatment; PFAS for landfill leachate.

Some improved remediation technologies, but no silver bullets; Technology selection and implementation should be streamlined a great deal.

Water / Wastewater

Better in-stream active monitoring; Heat recovery; Modeling using ML/AI, decision analysis; New technologies may be needed to address PFAS problem; PFAS for landfill leachate and groundwater; Remote sensing is key here and in stormwater

Stripping of contaminants from water is a feedstock for us; Water/wastewater incrementally advances, but also adopts technologies from other industries (automation, sensors, etc.)

Solid Waste & Recycling MSW

Gasification; Digesting of solid waste creates NH₃ and H₂S feeding our plant; PFAS treatment; Solid waste is a tradition-bound and cost sensitive industry.

PFAS Treatment

Trade-offs between Pump and Treat and In Situ Carbon Sequestration; Treatment technology advancement will be a focus for the next 5-10 years; New Technologies leading to new treatment approaches; Significantly improve present options for in-situ remediation; Explosive innovation and growth.

Sensors will enable flow-through over batch remediation; lower cost, faster, in situ/on-site; Hopefully be able to fully remediate PFAS when necessary; Destruction technology; New commercially proven technologies will emerge for PFAS separation, destruction; Innovative PFAS destruction technology continues to evolve -especially for the high concentration PFAS waste across all media. I anticipate this will change the way project wastes are managed and more centralized treatment/destruction hubs will be operating to handle high volumes of waste across sectors.

PFAS Analysis

Ability to meet absurdly low regulatory standards; Dawn of passive samplers; Dawn of screening methods will make an enormous difference in how sites can be characterized and monitored; Evaluating large data sets, determining trends, sources will become very important and used more as understanding improves.

Expanding analyte lists; In situ/on-site treatments; Lowering detection limits will be key, as well as real time analytic capability; Modeling using ML/AI, decision analysis, computational toxicology; Rapid and evolving advancements; Significant technology improvements in form of passive samplers, test kits

EIA / EIS / Assessments

AI may soon be summarizing technical data and writing reports; Drones/Remote Sensing; I see little impact. Still need boots on the ground and human judgement; Modeling using ML/AI, decision analysis; Virtual tools reach a broader audience than the paper of yesteryear; significantly greater engagement from Millennials and GenZ will all be virtual/digital

Air Quality & APC

Remote sensing devices should improve; Visualization / Mapping; Automation, monitoring and computational technology; Better data management and usage with more powerful computers and software; Continues to grow and evolve rapidly.

Enhancements in CAD technology are improving in this area; May be possible to send a drone to a site, upload its results to an AI system, and have that AI system create an accurate vegetation map; Modeling using ML/AI, decision analysis, statistics; The ability to manage larger datasets enables more 'realistic' visualization and mapping of complex problems; Used to Display the results of our Remote Monitoring Systems

Permitting & Automated Compliance

New software and data methods for automating the documentation and reporting of permit compliance... this will only increase

Health & Safety

Continues to hold more importance than many think; Remote sensing is driving change; Continuous monitors more widespread; Improved monitoring equipment to safeguard employees

Sampling / Measurements / Lab Analysis

Better sampling/analytical methods for PFAS will emerge; Data analysis will improve; Increasingly low standards and detection limits; Risk management, statistics, ISO; Technology increasingly provides for more real time analysis of liquids and gasses.

Remote Monitoring

Continued penetration of sensor and IOT into the environmental / remediation industry; In-line monitoring allows us to

operate remotely; IoT; Saving time & project cost; Strong needs drives more advancements; This is a key technology across all segments; We have patented and proprietary systems we use today.

Project Management & Software Applications

In the process of upgrading to new Commercial Project Management software. We develop our own internal code for use with our Remote Monitoring Systems.

GHG Emissions Tracking

Analysis: more detail and accuracy with every project; Emissions data being piped into GHG platforms to seamlessly and transparently track emissions, especially with public satellites now identifying methane emissions down to the source, will become the norm; Important to ESG programs; Remote technology will improve this, also better monitoring for the sea and other water bodies and streams; Software development and integration with technologies will be driving improvement in this area ; The ability to track and report on GHG with more widely-available tools, paired with advanced automation and AI, is critical for organizations, governments, and citizens to understand where we are today and how to mitigate risk; GHG tracking will drive our technology in a lot of applications.

GHG Emissions Reduction or Capture

Monitoring is the first step; This will be state by state, WA state has a new cap & trade, not sure if other states will ever do that; Will be driven by ESG programs

Climate Adaptation & Resilience

Driven by the need for business continuity and risk management, not any regulatory requirement; Modeling using ML/AI, decision analysis, statistics; Predicting the likelihood of future climate stressors on infrastructure will improve as better models, better existing conditions are understood through satellites and better weather predicting tools are developed.

The ability to aggregate data and harness IOT is key here; The technology can be cost effective and has a good rate of return for the client.

The integration of remote sensing technologies like LiDAR and satellites with AI and machine learning will revolutionize environmental assessments, compliance management, and infrastructure design. These technologies allow for detailed and real-time data collection, enabling more accurate monitoring of ecosystems and changes over time. AI and machine learning can process vast amounts of data, identifying patterns and anomalies that humans might miss, facilitating quicker and more informed decision-making in environmental management. Moreover, these insights will inform more sustainable and resilient infrastructure design by considering environmental factors from the outset. This convergence of technologies holds the potential to greatly enhance our ability to protect the environment while developing critical infrastructure. □

DIGITAL INVESTMENT RISES IN AEC FIRMS

AEC Advisors survey shows big increase in drone investment and client offerings, but an overall maturity in digital marketing programs.

According to **AEC Advisors'** State of the AEC Industry: Analysis and Insights, released in October 2022, commitments to digitalization remain strong across the industry, although the 2022 survey by AEC Advisors summarized here indicates that the overall level of investment was fairly similar from 2021 to 2022. Drones were both the most popular and fastest growing investment area with 67% firms actively expanding their internal drone proficiency. Research & development funding is also actively engaged in by about 2/3 of firms.

AEC Advisors survey data indicates that internal development of proprietary analytics and dedicated marketing for digital services declined somewhat in 2022. Commitments to building internal digital platforms has also waned a bit, although acquisitions of digital businesses have increased, perhaps indicating the presence of more firms of scale and competence worth acquiring, as well as the overall growing interest, and possibly some firms are pivoting from internal commitments to external innovation opportunities.

More than one in 10 of surveyed firms indicate that they do have minority equity investments in digital startups, and although this is one of the lowest areas of investment of the survey categories, historically investments in external innovation ventures or startups have been a rare thing indeed in the environmental consulting & engineering and the AEC business.

As far as what is being offered the customer, 58% of firms offered drone services in 2022. A host of services listed on the chart are deployed by anywhere from 26% to 47% of companies. Notably still just 37% of firms are using fixed price contracting to leverage digital advantages for greater profitability.

Cyber security, historically a high internal priority is only offered as an external consulting service by 10% of AEC survey respondents, I figure down from 14% from their earlier survey.

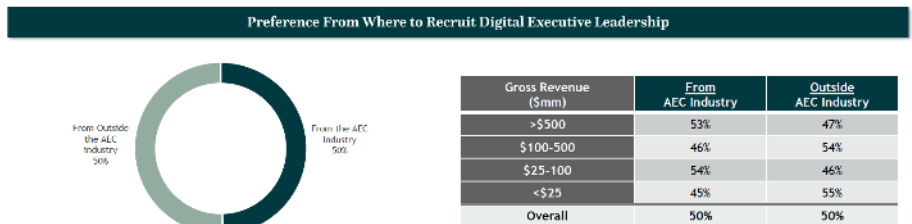
Hiring technical expertise and leadership is a balance between drawing and building from within, and drawing on IT proficient and focused digital management in external hires. Survey data indicates that executives plan to source their digital leadership personnel relatively evenly split between inside and outside the industry.

Fixed pricing is expected to increase with more productive technology. However, according to a 2021 AEC Advisors survey, little change in the percentage of revenue generated from fixed price work over the decade between 2011 and 2021, although the impact of digitalization was not likely apparent in 2021.

AEC Advisors says that some large firms were taking on more fixed price construction risk a few years ago, but most of them no longer do, and while smaller firms tend to generate greater profit margins from fixed price work, the largest firms do not.

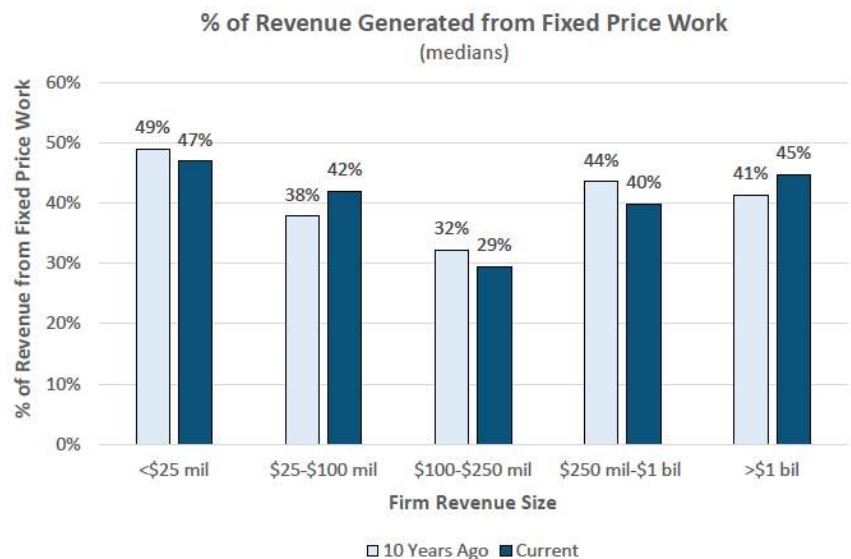
Fixed price can mean different things. It could be a fixed unit price for a small task (e.g., phase 1 environmental assessment), or it could be part of a major design-build project where there may be construction risk and substantial upfront marketing and design costs are incurred but not necessarily fully recouped if the design-build team loses. AEC surmised that a lot of the larger firms are more active in riskier fixed price design-build work, which may explain why on average the work is comparatively less profitable for them. The 2022 survey shows 37% of firms use fixed pricing to leverage digital skills, but that's a newer use of fixed pricing. □

Recruiting Digital Executive Leadership



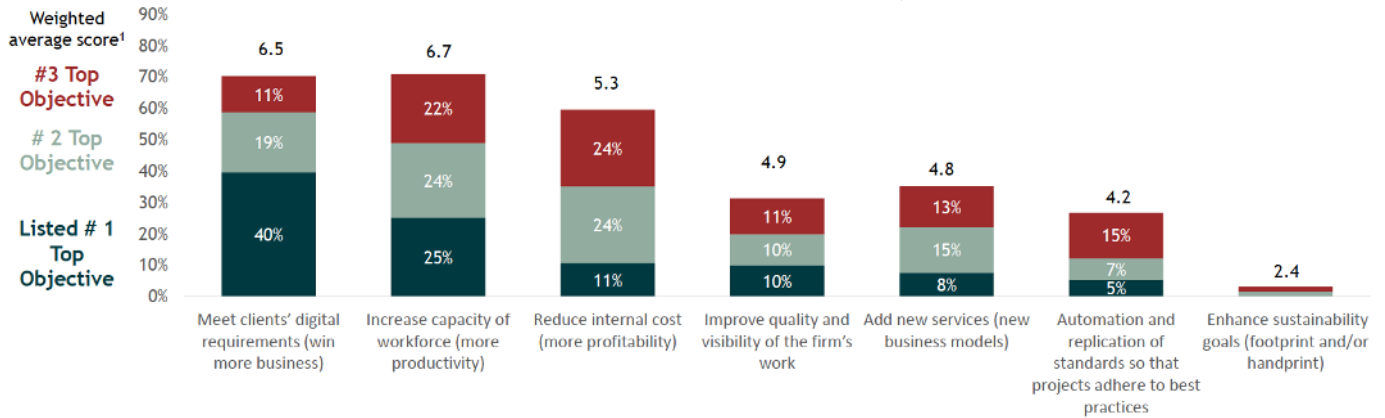
Even split in participants preference to recruit digital executive leadership from the AEC industry vs. outside the AEC industry

- Interestingly, there is little difference among various sized firms
- For what other AEC executive roles would 50% come from outside of the industry?
- Are there enough AEC digital experts in this industry to recruit internally?



Source: AEC Advisors, State of the AEC Industry: Analysis and Insights, October 2022 & April 2021

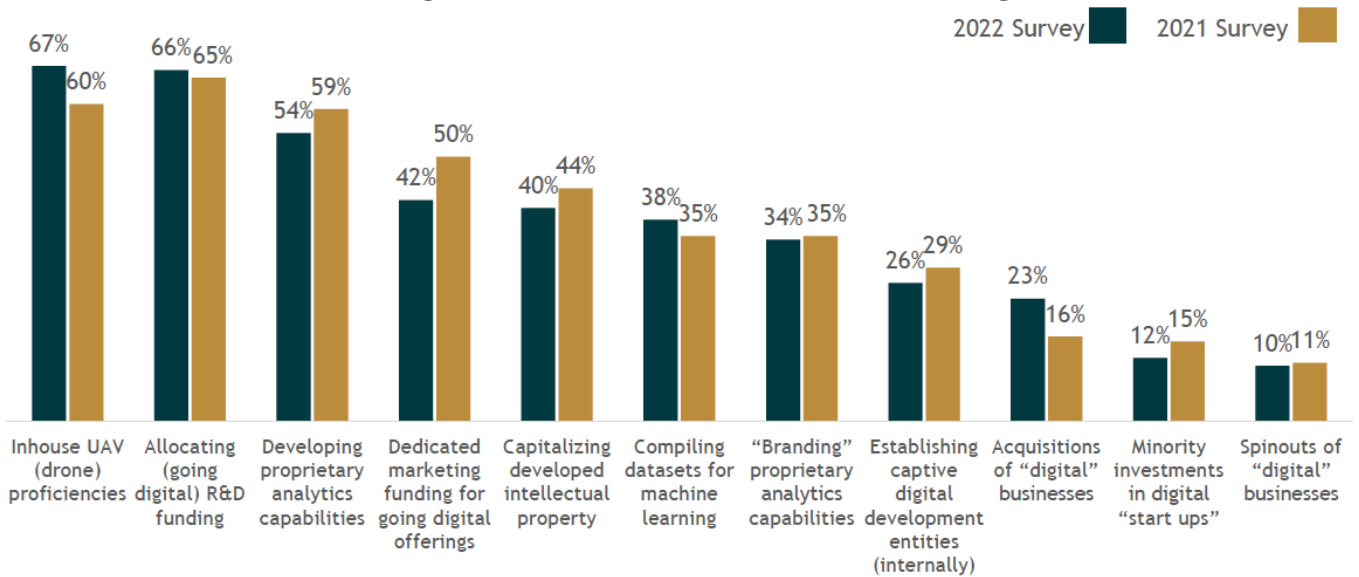
Objectives of Going Digital: What Firms are Trying to Achieve



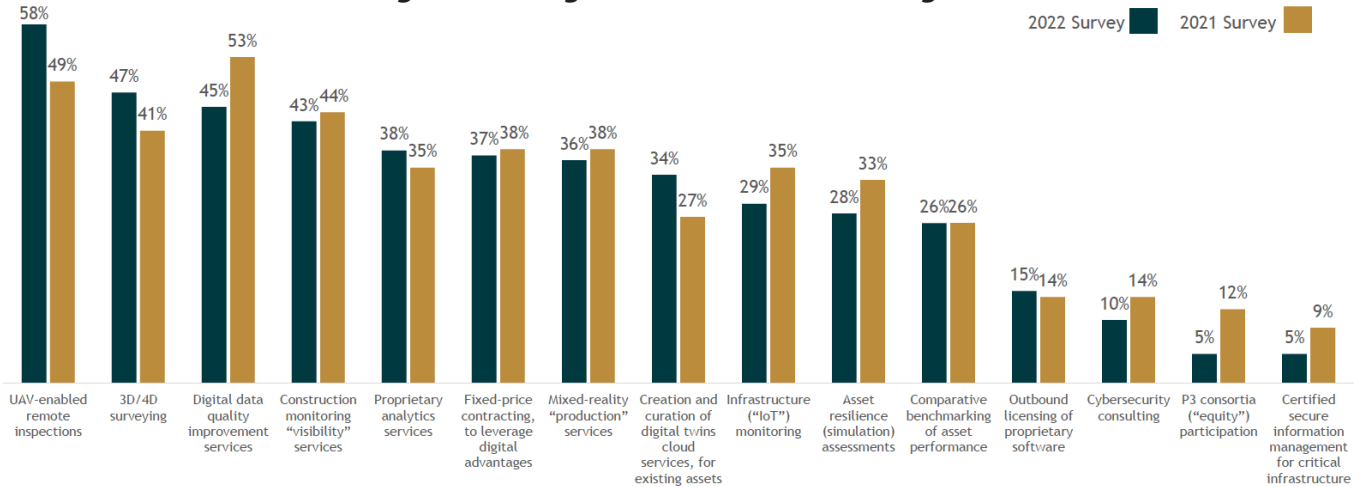
Clients' digital requirements and increasing workforce capacity remain the top digital objectives for AEC firms

Source: AEC Advisors, State of the AEC Industry: Analysis and Insights, October 2022. Weighted rating based on ranking of eight categories

2022 Digital Investments: What Firms are Investing In



2022 Digital Offerings: What Firms are Offering to Clients



Source: AEC Advisors, State of the AEC Industry: Analysis and Insights, October 2022.

Notes: Objectives and areas of digital investments have not changed dramatically from 2021 to 2022, says AEC Advisors. The majority of investments are for organic purposes and not acquisitions of digital businesses or investments in digital startups.

EFCG TRACKS CIOs & RISING IT SPENDING

In April 2023, **Environmental Financial Consulting Group (EFCG)** held a technology leadership conference, gathering Chief Information Officers, Chief Technology Officers, Chief Data Officers, Chief Digital Officers and other titles to discuss IT infrastructure, innovation and digitalization. These executive positions are increasingly prominent in many organizations, with heightened engagement across the C-suite.

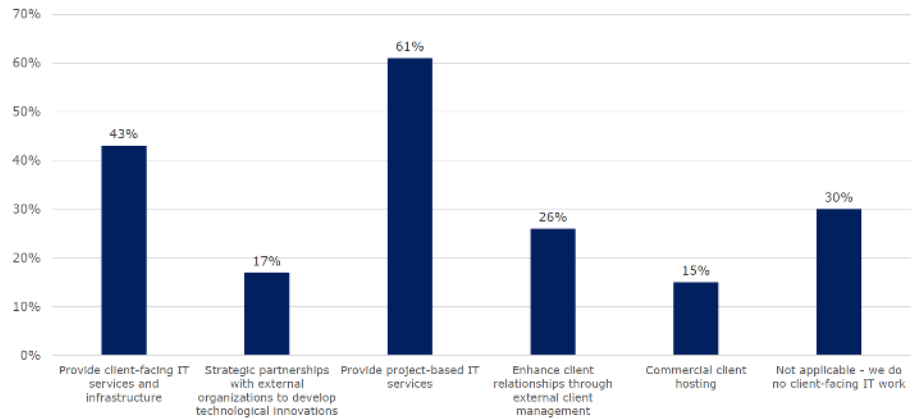
Summarized here are the results of the 2023 EFCG Technology Leadership Conference Survey shared by EFCG Partner and leader of its Technology Practice, Marcus Quigley. Responding to the survey was group of 46 firms with a median firm employee count of 977 people. Median IT staff count by department were: 17 in dedicated IT infrastructure; 4 people in a dedicated digital group; and 3 people in a dedicated innovation group.

Median IT labor costs were ~2% of total labor costs, and median IT spend in 2022 was about \$5.7 million. Per employee spend is shown on the chart with the 2016 capex and opex total of \$5,400 growing to \$7,800 in 2022.

In addition to the results shown on the facing pages are additional findings:

- Technology is being acquired as well as developed: 87% of responding firms acquired a business in the past 5 years primarily to add a specific technology or innovation capabilities.
- Most spending is on internal personnel: 67% of firms spend 75-100% of their total IT expenditure on in-house staff vs. vendors; 13% spend 50-75% internally; and 15% spend 25-50%.
- More companies track IT spending as a function of revenue than overall costs.
- Although AI and cybersecurity were among the biggest 'disrupters' in technology over the next 5 years, 'talent sourcing' was the new number one disrupter in the 2023 survey.

External Business Purposes of IT Function % of Firms



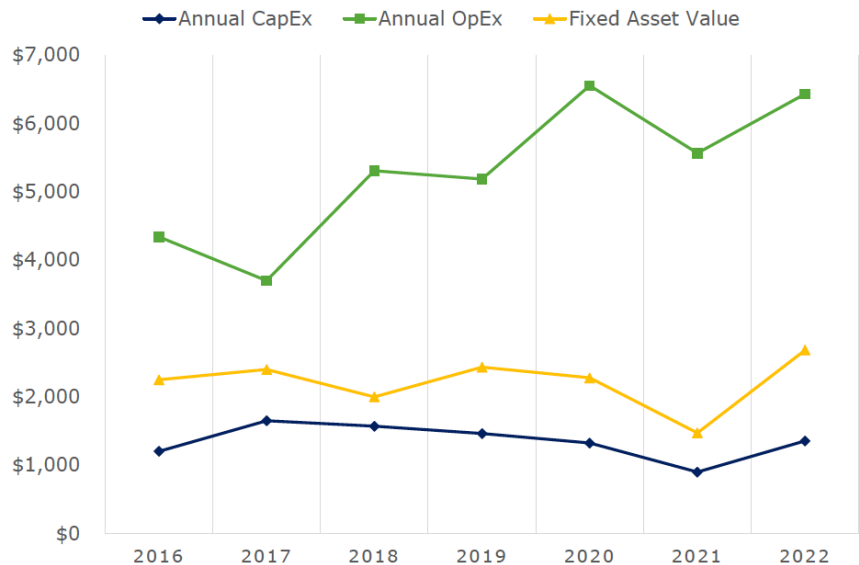
What Are Firms Spending per Employee?



	Annual CapEx	Annual OpEx	Fixed Asset Value
3rd Quartile	\$1,800	\$8,208	\$4,510
Median	\$1,355	\$6,430	\$2,684
1st Quartile	\$974	\$4,684	\$1,400
Last Year's Median	\$900	\$5,565	\$1,473

Last year's median has almost become this year's 1st Quartile value -

Historical Medians



Total IT Cost Distribution



What percentage of your IT cost is:

	Chargeable to Projects (not overhead)	Included in Corporate IT Budget	Outsourced
Maximum	93%	100%	25%
3rd Quartile	5%	100%	10%
Median	3%	98%	2%
1st Quartile	0%	90%	0%
Minimum	0%	0%	0%

Source: 2023 EFCG Technology Leadership Conference Survey Results Presentation

Top 5 Areas of Focus, Over the Next 5 Years



Overall Rank	Focus Area	Score	# of Rankings	2022 Rank
1	Cyber Security	89	36	1
2	Digital Transformation	85	29	2
3	Risk Assessment & Management	62	16	8
4	Information Management	59	16	10
5	Organization Growth	55	26	3
6	Project Management	55	17	7
7	Cognitive Computing	51	13	14
8	BIM & 3D Modelling	44	14	5
9	Research & Development	42	11	11
	Big Data	42	11	12

11. Customer Focused (Score: 34; # of Rankings: 14) 12. Business Development (31;14)
 13. Systems Integration (26;9); 14. Acquisition of Technology Company (10;3); 15. Vendor Management (5;1)
 16. Recruitment (0;0); 16. Sustainability (0;0); 16. Compliance (0;0)

Disrupters of the AEC Space in the Next 5 Years

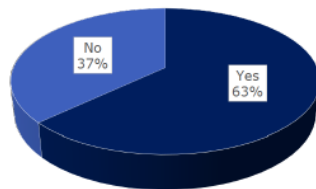


Overall Rank	Focus Area	Score	# of Rankings	2022 Rank
1	Talent Sourcing	96	27	3
2	Cyber Security	89	38	1
3	AI	87	43	4
4	Disruptive Competitors	62	20	2
5	M&A	58	15	6
6	Budget	53	13	11
7	Digital	49	16	5
8	Industry Competitors – AEC Firms	45	14	10
9	Need for Speed	43	14	9
10	Regulatory Issues	35	11	7

11. Outsourcing (Score: 24; # of Rankings: 6) 12. Big Data (20;5)
 13. Vendor Upgrades (20;6); 14. Gig Economy (9;2)

Technology As A Revenue Generator

Does your firm generate revenue through technology as a service or product?



How much in 2022? How much in 5 years?

	2022 Revenues	+5 Years Revenues	% Growth
Median	\$1.0 Million	\$3.3 Million	325%
Average	\$3.1 Million	\$8.4 Million	270%

Does your firm have a formal IT strategic plan, and if so, is it derived from your organization's overall strategic plan?

Response	2017	2018	2019	2020	2021	2022
Yes, derived from the organization's strategic plan	63%	56%	64%	58%	68%	54%
Yes, but not derived from the organization's strategic plan	17%	23%	19%	32%	12%	17%
No, we don't have a formal strategic plan	19%	21%	17%	11%	20%	28%

AEC IT and AI Spending Up; Hacking Way Down

Zweig Group's Information Technology Survey Report 2023 gathered data on IT spending, staff, department composition, implications of Artificial Intelligence, project websites, systems & platforms, and IT challenges. Representing a comparison between 2019 and 2023, ZG's IT report identified shifts that have redefined the AEC industry's technology landscape, including:

- **Cloud Technologies** - The shared online storage usage in the cloud has increased substantially, from 3 terabytes to 17 terabytes, indicating a solid commitment to modernization.
- **Improved Cybersecurity** - Instances of hacking plummeted from nearly 25% in 2019 to 9% in 2023.
- **Increased AI Adoption** - ZG introduced a new section focusing on AI data with growing adoption and integration of artificial intelligence.
- **Higher IT Spending** - IT spending per full-time employee has increased by over \$1,000 per full-time employee since 2019.
- **Remote Network Access** - The percentage of remote network access has risen from 56% to 88% after the pandemic.

IT budget per FTE

Lower Quartile	\$2,660
Median	\$4,580
Mean	\$4,780
Upper Quartile	\$6,380

IT budget as % of NSR

Lower Quartile	1.9%
Median	2.5%
Mean	2.8%
Upper Quartile	3.9%

Source: Zweig Group, Information Technology Survey Report 2023

INDUSTRIAL REVOLUTIONS IN HUMAN HISTORY

The first industrial revolution used water and steam power to mechanize production. The second industrial revolution used electricity to create mass production. The third industrial revolution used computers to automate production. The on-going fourth industrial revolution uses information technologies to collect the physical world and the digital world. The fifth industrial revolution is expected to bring the human back to the center of operation through a human-cyber-physical system for value creation. Two observations are worth noting. The first one is that the transition time from one industrial revolution to the next becomes considerably shorter, manifesting the rapid development of technologies in the modern era. The second one is that from the second to the fourth industrial revolution, there was a big leap in conceptually new technologies, nevertheless, the next industrial revolution is still based on its predecessor. Projecting from these historical observations suggests a human-cyber-physical system (HCPS) will be the most likely topic of the fifth industrial revolution in the coming one to two decades.

For industry the HCPS is a composite intelligent manufacturing system comprising humans, cyber systems, and physical systems with the aim of achieving specific manufacturing goals at an optimized level. In terms of technology, HCPSs can both reveal technological principles and form the technological architecture for intelligent manufacturing. The essence of intelligent manufacturing, and theoretically all project management, is to design, construct, and apply HCPSs in various cases and at different levels. With advances in information technology, intelligent manufacturing has passed through the stages of digital manufacturing and digital-networked manufacturing, and is evolving toward new-generation intelligent manufacturing. NGIM is characterized by the in-depth integration of new-generation artificial intelligence (AI) technology (i.e.,

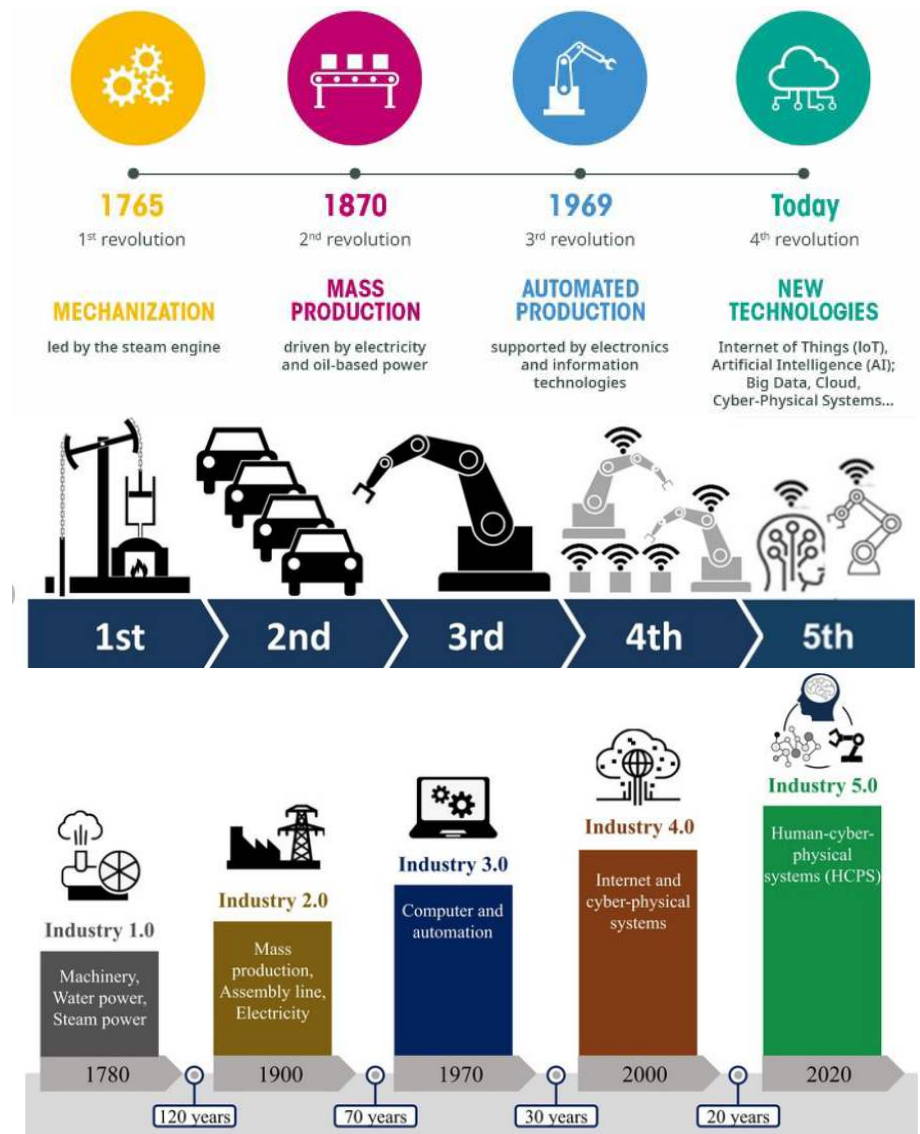
enabling technology) with advanced manufacturing technology (i.e., root technology); it is the core driving force of the new industrial revolution.

HCPS examples being implemented at some scale include self-driving cars that could lead to fully functional autonomous vehicle networks and home healthcare that could lead to a series of health & wellness, prevention, health maintenance and healthcare delivery systems. Research on wireless body area networks (WBANs),

that connect independent sensors on clothing, the body, or under the skin are already being used for many applications, including remote health monitoring. A number of environmental C&E firms would assert that the equivalent is being used almost routinely in projects involving monitoring and remote operations & maintenance, belying the reputation of the environmental industry being behind in technology, but still rarely integrated into a fully functional multi-media, ecosystem monitoring system. □

The Fourth Industrial Revolution: With the Fifth and Sixth Ahead

The term Fourth Industrial Revolution or Industry 4.0 was popularised in 2016 by Klaus Schwab, the **World Economic Forum** founder and executive chairman, who says technology changes show a significant shift in industrial capitalism. A part of this phase of industrial change is the joining of technologies like artificial intelligence, gene editing, to advanced robotics that blur the lines between the physical, digital, and biological worlds.



ENVIRONMENTAL TECHNOLOGY, ARTIFICIAL INTELLIGENCE, ChatGPT AND THE HYPE CYCLE

In EBJ's 'Emerging Technology in the Environmental Industry' edition published early in 2020 (Volume 33, Nos. 1/2), EBJ introduced the concept of the 'Hype Cycle' that **Gartner Inc.** coined and has charted, primarily for the IT industry, for 20 years. EBJ applied it to environmental technologies of various types. While not usually subject to the roller coaster ride as depicted on the charts at the right illustrating the theoretical arc of technology hype, environmental treatment technology does exhibit some similar characteristics. However, the preponderance of IT, AI, ML, UAVs, LLPs across the environmental industry demands a focus on information, data management and digitalization. On the facing page the charts explain the hype cycle premise and Gartner's 2022 version of where things stood in 'emerging technology'. What follows below is a most useful summary of the rapid emergence of ChatGPT and how it relates to the hype cycle.

HOW ChatGPT BROKE THE AI HYPE CYCLE

*Adapted by EBJ from an article by Anirudh VK in **Analytics India Magazine** published in February 2023. The mission of AIM is to make technology a greater force for good by bringing about better-informed, more conscious technology decisions through authoritative, influential, and trustworthy journalism.*

According to the Gartner hype cycle, the least amount of time a product takes to hit the 'plateau' of expectations is two years. Not with ChatGPT, though. The hot chatbot shattered all records of a product lifecycle, going through all stages of the cycle within 3 months.

Launched in November 2022, ChatGPT has already been through the innovation trigger, inflated expectations, disillusionment, enlightenment, and is now reaching a mature period of measured expectations, leading to industry adoption. A contributing factor to this might be the bot's meteoric growth, which scaled to 10 million users within 40 days. For contrast, Instagram took almost a year to reach the same milestone.

The hype cycle is a concept created by research firm Gartner to depict the relationship between time, the maturity of technologies, and expectations associated with it. The cycle generally progresses through five phases before reaching maturity. AIM delved deeper into these phases and how ChatGPT raced through each of them.

Technology Trigger

As the name implies, this phase is birthed out of years of research and technology. The technology trigger phase is characterized by the publishing of proof-of-concepts, research papers, and the beginning of mainstream media coverage. In the case of ChatGPT, OpenAI's research into LLMs like GPT-2, GPT-3, and GPT-3.5 were the triggers that led to the creation of ChatGPT, laying the groundwork for the chatbot.

OpenAI had been working on these algorithms and others for years before the launch of ChatGPT. While the company chose to not release its models to open access, and instead went the application programming interface (API) way, its steady pace of innovation cemented its place in the minds of AI enthusiasts. This could have been a 'sleeper' trigger, where expectations for OpenAI's products slowly increased over the years, compounded by the mystery surrounding their closed nature. Once this trigger was pulled, ChatGPT rode the wave of hype all the way to the peak.

Peak of Inflated Expectations

This phase represents the peak of the hype cycle. In this stage, media coverage and user expectations reach an all-time high, representing the peak of hype surrounding the product. ChatGPT reached 1 million users within just 5 days of launch, with media attention further amplifying the expectations associated with the service. AIM places this around December 11-17, 2022, as evidenced by a spike in a Google Trends graph. As more people began to search for ChatGPT, the conversation also trended around bold predictions regarding ChatGPT's capabilities for disruption. Articles with headlines such as 'ChatGPT Could Transform Academia' or 'ChatGPT May Doom High School English Classes', painted an embellished picture of what the bot was capable of doing — a reliable portent of inflated expectations which would come crashing down.

Trough of Disillusionment

The trough of disillusionment is a phase wherein experimentation of the technology begins to shed light on its shortcomings. As more people began to use ChatGPT, the cracks began to show, as the bot's token responses began to fray the nerves of users. Further, reports emerged of the rampant disinformation spread by ChatGPT, especially in political contexts.

This experimentation also exposed the various exploits present in the bot. Users found what they termed 'jailbreaks', which were ways to get the large language model (LLM) to sidestep its programming and provide responses that violate OpenAI's content policy. This, along with other basic mistakes by the chatbot — like a failure to multiply $-1 \times -1 = 1$ or the inability to write a sentence ending in a specific letter — led to detractors of the bot growing in number. However, the true capabilities of the bot were not forgotten, resulting in a slow spike in adoption by users who found value in the service.

Slope of Enlightenment

This phase is categorized by the world achieving a larger understanding of what the product is capable of as a whole. The second- and third-order effects become

clear, and more parties aim to contribute to the ecosystem and solve some of its more obvious issues.

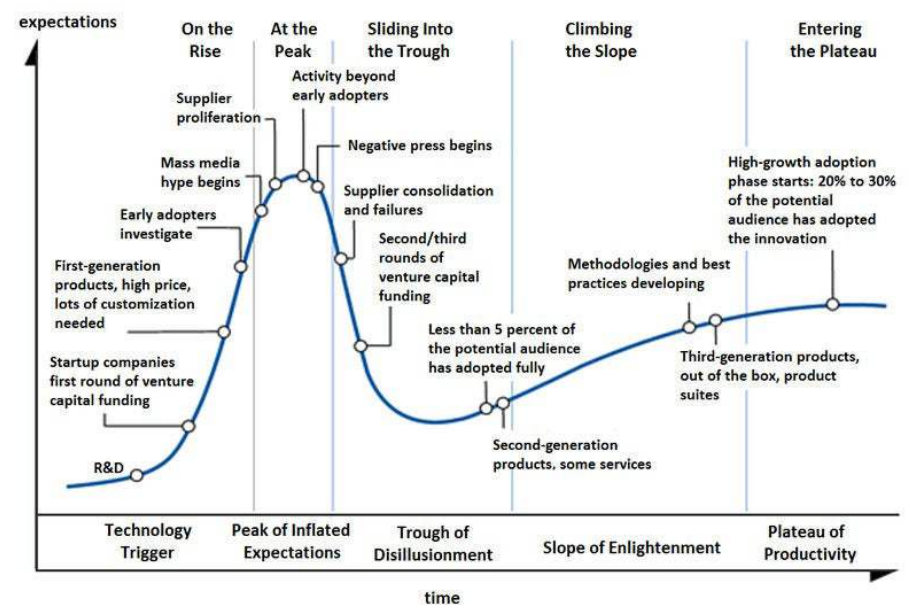
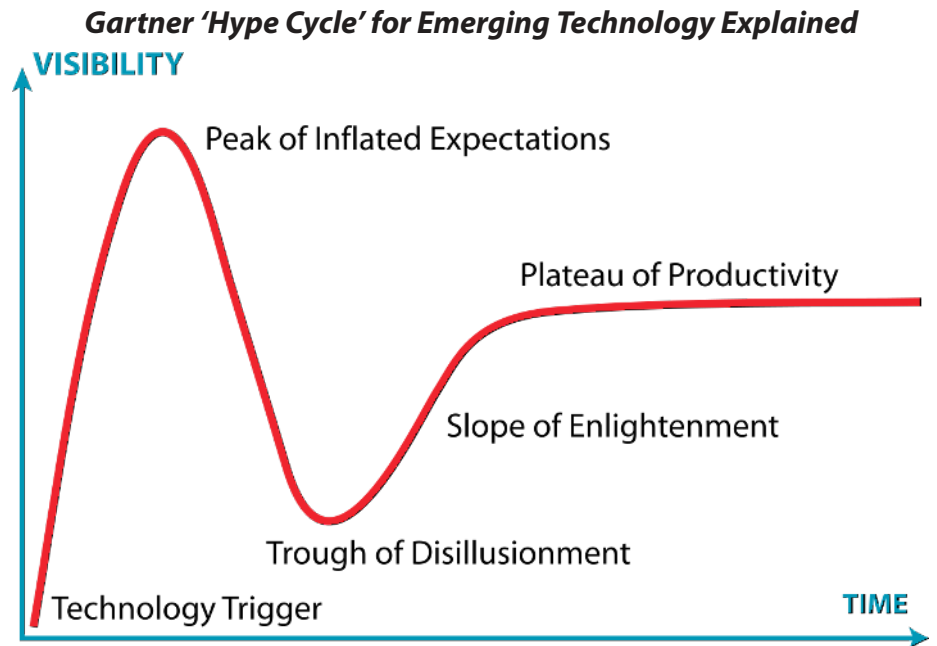
After the initial wave of disappointment that ChatGPT was not omnipotent wore off, an ecosystem began to spring up around the bot. Many community members added extensions to ChatGPT, making it more capable and powerful, such as this extension to make it a Grammarly substitute, or one which added the chatbot's capabilities to Google. This phase also saw the rise of tutorials that provided insights into how to get the most out of ChatGPT, further increasing its usability and utility.

Plateau of Productivity

This phase is the ideal position for all products on the hype cycle, as it represents market maturity and widespread adoption. Many technologies don't reach this point, as evidenced by the metric of 'obsolete before plateau' that is sometimes included in Gartner's visualizations. However, it seems that ChatGPT has traversed the hype cycle and is currently on its journey to the plateau.

Not only did ChatGPT complete all stages of the hype cycle in record time, spurred by a strong network effect and fascination towards AI, it also paved the way for industry adoption — the true sign of a mature product. Google and Microsoft have both decided to integrate ChatGPT-like chatbots into their search functionalities, and the industry as a whole has moved past the shortcomings of LLMs and is looking to adapt to the coming wave of AI-generated content.

In this respect, ChatGPT has not only bypassed the traditional timeline associated with the hype cycle, it has also gone beyond it and become a generational leap in technology. It holds the potential to change the way people interact with the web, even when adopted slowly and with a measured approach. Moreover, the media attention to ChatGPT's meteoric growth might also bring the focus on the problems plaguing LLMs as a whole, leading to the creation of more powerful AIs with strong moral and ethical guidelines. ■



Gartner 'Hype Cycle' for Emerging Technology: 2022 Version



Source: Gartner Inc. Many versions and variations have been produced on the Hype Cycle premise for investors and industry evolution. Gartner releases an annual update for 'Emerging Technologies'

The Future of Coding with AI

The role of AI in coding and software development is rapidly expanding. AI-powered code generators are providing powerful, intelligent, and intuitive tools to both seasoned developers and newcomers alike. They not only speed up the process of writing code but also make it more accessible to a broader audience, expanding the capabilities of individuals and organizations. From creating fully functioning eCommerce websites to converting audio commands into code, AI-powered tools have opened up new opportunities and possibilities.

Unite.AI ranked the 10 Best AI Code Generators in September 2023, including GitHub Copilot, developed by GitHub in collaboration with OpenAI, Cody by Sourcegraph, Tabnine, Replit GhostWriter and MutableAI.

Features include:

- Predictive code generation: Beyond simple auto-completion, they suggest entire lines or blocks of code.
- Multilingual capability: Trained on a myriad of public code repositories, they understand and assist with a vast range of programming languages.
- Continuous learning: They learn from each coding style and habits, delivering personalized suggestions that improve.
- Automatic bug detection and fixing: Identifies potential bugs in code and even suggests appropriate fixes.
- Real-time code completion: Auto-fills code as you type, accelerating the coding process and reducing the chances of syntactical errors.
- Sketch to code: Some can convert UI sketches into working HTML and CSS code, significantly speeding up the prototyping and iteration process.
- Interprets hand-drawn sketches: Some code generators have the ability to interpret hand-drawn sketches allowing for a seamless transition from initial design ideas to functional code.

AI for the Earth: Environmental and Climate Applications

1. Autonomous and connected electric vehicles: AI-guided autonomous vehicles (AVs) will enable a transition to mobility on-demand. Substantial greenhouse gas reductions for urban transport can be unlocked through route and traffic optimization, eco-driving algorithms, programmed “platooning” of cars to traffic, and autonomous ride-sharing services. Electric AV fleets will be critical to deliver real gains.

2. Distributed energy grids: AI can enhance the predictability of demand and supply for renewables across a distributed grid, improve energy storage, efficiency and load management, assist in the integration and reliability of renewables and enable dynamic pricing and trading, creating market incentives.

3. Smart agriculture and food systems: AI-augmented agriculture involves automated data collection, decision-making and corrective actions via robotics to allow early detection of crop diseases and nutrition, and to optimize agricultural inputs and returns, lowering the use of water, fertilizers and pesticides, and increase resilience to climate extremes.

4. Next generation weather and climate prediction: A new field of “Climate Informatics” uses AI to transform weather forecasting and improve our understanding of the effects of climate change. Deep-learning networks now allow computers to run much faster enough to incorporate more complexity of the ‘real-world’ system into the calculations. In just over a decade, computational power and advances in AI will enable home computers to have as much power as today’s supercomputers, lowering the cost of research, boosting scientific productivity and accelerating discoveries. AI techniques may also help correct biases in models, extract the most relevant data to avoid data degradation, predict extreme events and be used for impacts modelling.

5. Smart disaster response: AI can analyze simulations and real-time data (including social media) of weather events and disasters in a region to seek out vulnerabilities and enhance disaster preparation, provide early warning, and prioritize response through coordination of emergency information capabilities. Deep reinforcement learning may one day be integrated into disaster simulations to determine optimal response strategies, similar to the way AI is currently being used to identify the best move in games like AlphaGo.

6. AI-designed intelligent, connected and livable cities: AI could be used to simulate and automate the generation of zoning laws, building ordinances and floodplains, combined with augmented and virtual reality (AR and VR). Real-time city-wide data on energy, water consumption and availability, traffic flows, people flows, and weather could create an “urban dashboard” to optimize urban sustainability.

7. A transparent digital Earth: A real-time, open API, AI-infused, digital geospatial dashboard for the planet would enable the monitoring, modelling and management of environmental systems at a scale and speed never before possible – from tackling illegal deforestation, water extraction, fishing and poaching, to air pollution, natural disaster response and smart agriculture.

8. Reinforcement learning for Earth sciences breakthroughs: This nascent AI technique – which requires no input data, substantially less computing power, and in which the evolutionary-like AI learns from itself – could soon evolve to enable its application to real-world problems in the natural sciences. Collaboration with Earth scientists to identify the systems – from climate science, materials science, biology, and other areas – which can be codified to apply reinforcement learning for scientific progress and discovery is vital. For example, DeepMind founder Demis Hassabis, has suggested that in materials science, a descendant of AlphaGo Zero could be used to search for a room temperature superconductor – a hypothetical substance that allows for incredibly efficient energy systems.

Source: *Harnessing Artificial Intelligence for the Earth*; World Economic Forum in collaboration with PwC and Stanford Woods Institute for the Environment

GHD DIGITAL HELPS ENVIRONMENTAL INDUSTRY COME UP SPEED TO ON REWARDS OF INVESTING IN DIGITAL TRANSFORMATION

GHD Digital (Waterloo, Ontario), a subsidiary of \$1.6-billion Australia-based, 11,000-person professional services firm **GHD**, was launched in 2018, as a business dedicated to innovation and digital transformation. GHD Digital helps clients to define their digital transformation strategies – from automating operations to monitoring critical assets and generating virtual replicas through digital twins. In 2023, GHD Digital has a staff of more than 600 people, including data scientists, design thinkers, immersive digital consultants, engineers, project managers and innovators, and a global footprint across 86 offices and nine countries.

Dr. Nipa Basu, Global Director, Digital Intelligence of GHD Digital, is a global digital transformation leader helping clients transform their businesses through data analytics and artificial intelligence solutions. She has led the Digital Intelligence team globally for GHD Digital for last three years. Her team's expertise and contribution cover data and digital strategy, data collection, data management, drawing insights from data especially spatial data, predictive-prescriptive analytics, machine learning, and artificial intelligence.

EBJ: Has the environmental industry been slow to adopt digital technologies and, if so, is that changing?

Basu: The environmental consulting sector has been slow to adopt digital technologies and utilize the full value of data compared to other industries. This is partly a result of the architecture, engineering, and construction (AEC) industry executing work on a project-by-project basis where data has traditionally been collected, managed, and interpreted in isolation.

This has largely resulted in disparate data sets across the industry with data not being readily accessible or easily operationalized and has prevented the full value of data being utilized for decision making. For many, much of the data is tied up in documents or spreadsheets and is siloed across the organisation. Additionally, data is in different formats without applied standards.

Another challenge with the project-by-project mindset of the industry, is “How do we fund investment in technology?” At a project level, it is more difficult to justify investment in digital technology. However, when the costs and benefits of centralizing data management and implementing new technology are considered across a portfolio of projects, clients or markets, the return-on-investment equation is clear.

Investment in technology brings significant returns through efficiency gains and improved outcomes.

Clients are at different levels of digital maturity. Some are still comfortable with traditional spreadsheet approaches to managing data. However, we are seeing many more clients begin to advance their digital maturity and start adopting digital data collection and centralized data management, environmental management software systems, and geographic information systems. There are also some organizations at the front edge of the digital maturity curve adopting advanced visualization (e.g., virtual, augmented and mixed reality), advanced analytics and use of artificial intelligence.

Most client organizations are going through digital transformation programs for their operations. This digital transformation has typically been slow to trickle down to their environmental compliance, environmental liability and waste management programs. However, the increased focus on sustainability and ESG has accelerated the digital transformation of environmental programs. Also, the value of integrating operational data with environmental and sustainability data is beginning to be realized and implemented. Significant efficiencies and improvements in

environmental compliance, carbon emissions, and sustainability performance is achieved when the datasets are integrated and used for decision making and optimizing operations.

EBJ: Please describe GHD Digital and its various practices.

Basu: GHD launched its digital business in 2018 with a mission to create a start-up within an established company to navigate the complexities of digital disruption. With a small team of less than 20 individuals, GHD Digital integrated engineering, technology, and creative capabilities to solve the global challenges across water, energy and infrastructure. Today, GHD Digital is a globally recognized digital agency with over 600 employees across nine countries and 86 offices. We serve Fortune 500 companies, major utilities, large government agencies and leading organizations across the world.

Our practices bring innovation and digital solutions to the forefront of GHD's offerings, maximizing opportunities for growth and success by thinking differently and embracing innovation, tools, and technologies.

DIGITAL INTELLIGENCE

The Digital Intelligence practice provides our customers with end-to-end solutions on all things data and consists of key capabilities:

1. Data strategy
2. Digital data collection, including form-based data collection, remote sensing, drones, and geomatics.
3. Data management, including a web-based interface called ADAPT allowing users to download, explore, graph, and visualize environmental data.
4. Location intelligence, including GIS-based solutions, spatial analytics, and multi-criteria analysis.
5. Advanced analytics, data science and artificial intelligence.

DIGITAL EXPERIENCE

The Digital Experience practice consists of eight key capabilities:

1. Advanced security and communication systems.
2. Advanced industrial and process automation.
3. Connected infrastructure and smart places.
4. Digital engineering and information management.
5. Digital risk and cyber security.
6. Digital Twins.
7. Intelligent Automation and robotic process automation.
8. Immersive visualization solutions.

The value of integrating operational data with environmental and sustainability data is beginning to be realized and implemented.

INNOVATION CONSULTING

Our award-winning innovation consulting practice partners with clients to imagine, transform and help them innovate for the future.

Our team of innovation specialists and intrapreneurs work at the intersection of people, business, technology, and creativity to devise strategies and innovative solutions that deliver exceptional results and create new business value.

PRODUCTS AND PLATFORMS

Our team of specialists work with clients to co-create, design, and deliver software solutions and platforms.

In addition to developing new software solutions for clients, GHD has four software products that it sells to clients as well as using to deliver services to clients.

Two of the software products are used extensively across the environment market:

1. GHD Navigator is a Waste Tracking and Management Software solution enabling clients to streamline waste management practices and track progress in meeting sustainability, circular economy, recycling, and reuse goals.

2. GHD Engage is a single, easy-to-use platform that uses interactive maps, digital content, dashboards, and visual tools to allow internal, agency and community stakeholders to engage on a project from their computer, tablet, or mobile phone.

EBJ: GHD Digital is launching the AI Centre of Excellence to accelerate innovation. How will the Centre support GHD's environmental practice?

Basu: Our AI CoE is actively involved in bringing bespoke and repeatable solutions to our environmental clients, as well as delivering efficiencies to the way our environmental teams deliver projects. Some examples include:

- Mining data and information from photographs, borehole logs and documents to build large databases.
- Processing and summarizing thousands of public comments on infrastructure projects.
- Mining data from publicly available websites and documents to build large, contaminated site databases and then applying GHD Digital's patent-pending S3 predictive analytics framework that can be used to accurately predict time and cost to closure for contaminated sites, identifying the key factors driving costs to closure, enabling improved regulatory advocacy, predicting risks for third party claims, better forecasting reserves across a portfolio, and optimizing spending to reduce overall liabilities.

- Development of a bot that quickly reads and processes hundreds of documents and enables users to ask the bot any question. The bot quickly answers the questions based on the information contained in the documents. This has been successfully used, for example, when GHD

Digital has taken over a new contaminated site which requires the project team to read and understand a large amount of historic information quickly.

- Improving the accuracy of waste planning based on demographic changes, changing patterns of recycling and reuse, changes in regulations, and other factors. This enables improved accuracy for cities to plan for future landfill, transfer stations and other waste infrastructure.

- Development of permitting management database, dashboard and analytics system that allows the client to search for and have all information related to environmental compliance at its fingertips across facilities and assets.

- Automating greenhouse gas reporting process including emission calculations and generation and submission of reports to regulatory agencies.

- Automating routine environmental compliance and monitoring reporting.

- Enabling quick evaluation of different decarbonization scenarios for industrial organizations through changes in their operations.

- Spatially based real-time notifications and alerts to warn clients of hazards to operations and workers from climate change hazards like wildfires and floods.

EBJ: How is GHD collaborating with startups and other technology companies to accelerate innovation and adoption of new technology by the environmental industry?

Basu: GHD is actively partnering with small start-up and larger technology companies to complement our digital and traditional consulting services. Additionally, GHD is investing in some start-up companies through our ventures team.

Examples of technology companies that GHD is partnering with include:

- **ESRI** for the delivery of GIS-based solutions.
- **Microsoft** for hosting cloud-based solutions.

- **Bentley** for the delivery of digital engineering and geology services.
- **ENFOS** - enterprise software for environmental liability portfolio management.
- ESG enterprise software solutions like Figbytes and Ensogo.
- Climate risk management, mitigation and reporting software like Jupiter Intelligence and XDI.

EBJ: How are different environmental industry business segments being disrupted by new technologies?

Basu: GHD is leading the digital disruption of environmental services to bring improved efficiency and outcomes. This includes the application of:

- Use of real-time sensors to continuously collect and monitor environmental data.
- Centralized data management, cloud-based data storage, and web-based interfaces for access to explore, download, visualize and conduct analytics.
- Spatial based visualization and analytics
- Immersive visualization using virtual reality, augmented reality and mixed reality along with more traditional 3D and 4D models.
- Application of advanced analytics using AI, machine learning, natural language processing to mine data and information, provide predictive and prescriptive analytics.
- Application of intelligent and robotic process automation to automate routine tasks such as data entry, data validation, etc.
- Automating report generation so reports can be generated by a click of a button in the matter of seconds once report templates are set up.
- Development of software solutions.
- Integration of datasets to enable improved decision making, such as the integration of environmental compliance and operations data, or environmental data and financial data, or environmental data and

At a project level, it is more difficult to justify investment in digital technology. However, when the costs and benefits of centralizing data management and implementing new technology are considered across a portfolio of projects, clients or markets, the return-on-investment equation is clear.

publicly available data like environmental justice, demographic and census data.

Below are specific examples of how GHD is bringing digital technology to disrupt each service area.

AIR & NOISE

Development of permitting management database, dashboard and AI-based analytics system that allows the client to search for and have all information related to environmental compliance at its fingertips across all facilities and assets.

Development and application of a system that uses natural language processing (NLP) and AI to deconstruct over 10,000 permits into permit requirements in less than two weeks, which would have taken about 6 months to do manually.

CONTAMINATION ASSESSMENT & REMEDIATION

To support clients in their contamination, assessment, and remediation services, we provide analytical, field and spatial digital data capture in a central repository to deliver standardized outputs, regulatory deliverables, and data analytics. Our tailored solutions and software platforms are designed to help clients to successfully collect, validate, organize, manage, visualize and use critical data and information to enable smarter decision making. We work across the data lifecycle, from strategy and governance to automated reporting and AI-based portfolio management solutions.

ENGAGEMENT, COMMUNICATION & COMMUNITIES

GHD Engage is a central gateway that uses interactive maps, digital content, dashboards, and visual tools to allow internal teams, agencies and associated stake-

holders to engage on a project from any device. It provides an engaging and accessible executive summary of complex project information like reports, plans, environmental impact statement documentation, project maps, design visualisations and construction information. Additionally, the platform can be used by internal stakeholders to access a broader suite of technical delivery tools and project information to support their stakeholder management and project activities.

HSE SYSTEMS & INDUSTRIAL HYGIENE ENVIRONMENTAL HEALTH AND SAFETY

With increasing pressure to become part of the circular economy and eliminate waste and greenhouse gas emissions, we can help clients simplify the path to compliance. GHD Navigator is an integrated software solution that manages, automates, and streamlines key aspects of your Environmental, Health, Safety and Sustainability (EHS&S) activities.

IMPACT ASSESSMENT AND PERMITTING

GHD uses drones and remote sensing to collect environmental impact data at a fraction of the cost and time it takes for professionals to collect the data in the field.

GHD has developed and used a virtual EIS/EIA system to enable more efficient and effective management, visualization and reporting of environmental impact data and information.

WASTE MANAGEMENT

GHD Navigator's Waste Manager allows clients to manage sustainability goals such as zero landfill or help increase recycling percentages.

EBJ: What decarbonization solutions does GHD provide, and how are you using technology to help clients to reach their goals?

Basu: GHD Digital has developed a number of tools that support both the delivery of our decarbonization services and enable clients to use the tools themselves. Examples include:

- A carbon calculator and decarbonization analytics tool that enables clients to quickly evaluate and visualize in dashboards the different decarbonization scenarios against baseline and assess the marginal abatement cost curve for the different scenarios.
- Bespoke data ingestion, management and analytics solutions developed for clients to enable them to measure and track carbon emissions in real time. Emissions data can also be integrated with operations data to enable clients to understand how changing operations impacts their carbon emissions.
- Product lifecycle assessment (LCA) tools that enable GHD to help clients understand their carbon footprint across the full lifecycle of their product.
- An automated GHG reporting tool that enables clients to automate the collection, management, calculation and reporting of GHG emissions.
- ZEVO – GHD’s zero emissions vehicle optimization tool to help clients develop transition plans and optimize the management of vehicle fleets towards achieving zero emissions.

A recent GHD report entitled “Shocked” found that 80% of high-growth companies identified digitalization as an effective strategy to support the decarbonization of energy supplies.

Forward-thinking companies are focusing their investment on making energy smarter through advanced tools and transition technology. □

GHD Report Aims to De-Risk the Energy Transition

*In the introduction to **Shocked**, a 2023 GHD report on the energy sector, Ashley Wright, Chief Executive Officer of GHD summarizes the shocked 'trilemma'.*

Three distinct, but interconnected, shocks — security, society and climate — now confront the energy sector. It is in the context of this ‘trilemma’ that GHD undertook SHOCKED: one of the largest global research studies ever conducted among energy sector leaders. We wanted to provide our partners with insight into the current energy crisis and most importantly, an informed perspective on opportunities to de-risk the energy transition in this period of uncertainty. It is the energy businesses at the centre of this shock; businesses that are being impacted from all angles — strategic, operational, financial and reputational.

SHOCKED reveals that 94% of respondents believe the current energy crisis is the greatest to have impacted their market in decades. It also shows that the crisis has dented capital flows into projects, with CFOs who took part in the study estimating that investment levels during the crisis (2020 to 2022) were \$203 billion lower than they otherwise would have been. Importantly, in this critical decade for energy transition, almost half of leaders (47%) say the crisis has decelerated their net-zero plans by an average of six years.

What is clear is that this energy crisis is unique and will transform the sector forever. Unlike previous crises — such as the oil shocks of the 1970s and 1990s — the current shock is global, multifaceted and multidimensional. Crucially, underlying the current focus on energy security is a drive to decarbonise that is set to reshape the sector beyond recognition.

The SHOCKED trilemma

The security shock:

Extreme market volatility and geopolitical tensions have put energy security high on the global agenda.

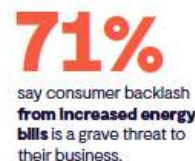


On average, energy companies could continue to supply energy in line with normal demand for just



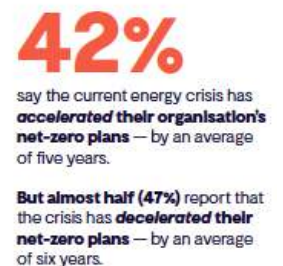
The society shock:

Societal pressure on the energy sector to provide reliable, affordable, low-carbon energy has never been greater.



The climate shock:

The climate crisis continues to force an acceleration of energy transition, but progress towards net zero is being impacted by the complex dynamics at play.



ICF APPLIES DIGITAL TECHNOLOGY TO ENVIRONMENTAL USES AND CLIMATE RISK

ICF (Reston, Va.) is a global consulting and technology services provider with approximately 9,000 employees and \$1.78 billion in annual revenue. ICF combines domain expertise with leading-edge technologies and advanced analytics to design and implement transformative projects across diverse industries including climate, environment, and infrastructure, disaster management, public health, IT, and utility consulting. In 2022, ICF acquired three technology-based companies to deepen its support of federal agencies grappling with significant and unprecedented obstacles and seeking technology to help them approach these challenges. ICF also grew its environmental capabilities by acquiring an environmental consulting firm, Blanton & Associates (Austin, Texas), to strengthen both its support for larger infrastructure projects and its ability to help states leverage federal investment dollars from the Infrastructure Investment and Jobs Act.

Jess Borrevik, Chief Technology Officer – Energy, Environment, and Infrastructure, has over 20 years of experience in helping companies embrace digital adoption and leverage enterprise technology. He supports ICF’s U.S. federal agency, state and local government, and commercial utility clients to create meaningful change through vision, partnerships, fresh thinking, and innovative technology.

EBJ: What steps has ICF taken to advance the use of digital technology both within the company and on behalf of clients?

Borrevik: ICF is hyper-focused on using and advancing technology in smart and innovative ways. Over the last several years, we have been aggressive in how we build our technology and digital modernization capabilities both for our clients and for our people.

We recently stood up a new group focused on increasing our technology and user experience capabilities and continuing the strong growth momentum of our U.S. federal agency digital modernization business. In addition, ICF launched a company-wide Chief Technology Officer (CTO) organization to further drive technology growth and innovation across all our markets. This new direction drives innovation, empowers us to use technology to bring our deep domain expertise to bear, and helps us deliver more impact for our clients.

We’re building multidisciplinary, cross-functional teams that bridge the gap between our domain experts and our technologists not only to accelerate our client delivery but also increase the impact their programs have. This is critical to the success of our technology-forward approach.

Technology and data are inseparable, which is why we are also very focused on identifying smart, modern approaches to data management, insights, and analytics. Our consultants leverage the latest science, data, and analytics—combined with our technology platforms—to help our clients across sectors.

The sheer volume of climate, energy, and environmental data can be overwhelming. Our clients are increasingly turning to our technology platforms to help them access and visualize all that data in one place and use it to explore risks, options, and pathways—and take action with confidence.

A decade ago, much of this work across the industry was done in Excel spreadsheets. Today, we can leverage our proprietary technology platforms or harness the strengths of our many technology partners to analyze bigger data sets, better and faster than ever before.

EBJ: What parts of ICF’s environmental practice are likely to experience the greatest transformation over the next couple of years?

Borrevik: There is a lot to be excited about. Beyond a burst in emerging technology around artificial intelligence (AI), legacy technologies with strong applica-

tion to environmental use cases are becoming easier to use and more cost effective. Some key areas of focus include:

CLIMATE RISK ANALYTICS

We’re using our ClimateSight™ platform to understand current and future climate risks, like extreme heat and precipitation, as well as the impacts of this extreme weather on people and all sectors of the economy. The platform can process 25 terabytes of data with more than 10,000 lines of code and 70-plus climate variables. That’s only possible with technology.

DECARBONIZATION PLANNING

With public institutions and private sector companies setting ambitious climate goals to reduce greenhouse gas emissions, they need technology to help them develop and implement their plans. Our CO2Sight™ platform, for example, helps our clients create practical, achievable decarbonization plans.

REPORTING

AI language models will automate portions of reporting for both compliance and project management. This transitions labor to higher value work, improves information consistency, and enhances scalability.

DRONES, LIDAR, AND IMAGERY CAPTURE

Costs and complexity are steadily decreasing, while capabilities are rapidly improving. Drones can now fly for longer durations, capture more data, and legally operate in expanded areas. The management and analysis of LiDAR and imagery data is less complex with the emergence of purpose-built SaaS solutions that offer integrations with drone and other data capture platforms.

GEOSPATIAL APPLICATIONS AND ANALYSIS

Legacy GIS cloud platforms are maturing and focusing on ease of use and collaboration. This enables non-developers to author user friendly mobile and web applications. On analysis, cloud native data and analytical technologies continue

to add geospatial capabilities. This creates expanded opportunities to leverage cutting edge technology and data science experts for scenarios that involve spatial relationships.

eDNA

Our ability to collect and analyze DNA that organisms shed as they pass through water is transforming our species detection and monitoring efforts. Not only does eDNA allow us to scale our operations, but it improves our accuracy and gives us a non-invasive way to detect and count otherwise hard-to-count species. We look to eDNA to quickly and significantly improve our ability to monitor and study biodiversity in a given area.

EBJ: Which digital platforms have you adopted to improve collaboration among employees and with clients?

Borrevik: ICF's core operational collaboration remains rooted in the Microsoft ecosystem; however, we also leverage a suite of visual collaboration tools like Mural and Miro for dynamic exploratory workshop scenarios.

To enhance collaboration, we leverage technologies that improve workflow, reporting, forms, as well as web and mobile applications. For example, we use platforms like Salesforce, Appian, and ServiceNow. These vendors have domain offerings that further accelerate deployment; however, we also have technical experts that can quickly configure collaboration solutions.

We've also had great success leveraging ICF Waypoint technology, a highly customizable platform accelerator we've developed in-house that can be tailored to scenarios with more unique and complex requirements.

EBJ: Are public agencies adopting these types of platforms, and are they generating more public engagement?

Borrevik: Public agencies and their partners are demonstrating successful use of these technologies. It's working because the technology now, more easily, provides a user experience the public is used to on their mobile devices and expect whenever they engage with technology. An example can be seen in our work with the New

York State Department of Transportation (NYSDOT).

After launching the 511NY Rideshare program in 2010—designed to provide personalized commuting assistance and reduce single-occupancy vehicle commuting for New York City residents—ICF worked with NYSDOT to expand the program statewide.

Through various technology solutions and platforms, including **Salesforce** and **Amazon Web Services** or AWS, we moved the legacy 511nyrideshare.org web application and all its data to the cloud—in just two weeks—and built innovative outreach campaigns to help commuters visualize the environmental benefits, cost-effectiveness, and greater availability of rideshare and mobility services across New York State.

We reached millions of commuters with information about the 511NY Rideshare program and contributed to a dramatic decrease in overall traffic congestion and carbon dioxide emissions on New York's roads by streamlining software, overhauling customer relations management systems, and employing data-driven targeted communications campaigns.

EBJ: How does the data ecosystem need to mature and expand to support the next generation of compliance and problem solving?

Borrevik: Fundamentally, the core objectives haven't changed over the years: leverage data and technology to enable easy and secure access to trusted, clear, and actionable information. AI has the potential to greatly accelerate and expand how we use data to achieve our core objectives. Important areas of emphasis for environmental work include:

DATA COLLABORATION BETWEEN ORGANIZATIONS

Maximize collaboration, analysis, and insight by making data (approved and secured to share) simple to access and understand for external entities. Additionally, seek ways to streamline your internal analyst's ability to consume external data.

DATA INTEGRATION

Maximize pattern and relationship detection by strategically positioning data to unlock the analytical potential of AI technologies like Machine Learning and Natural Language Processing. At ICF, we are breaking down data silos between our various practices areas, including climate, energy, disaster management, health, environmental and more, to meet the market demand for multi-dimensional analysis.

EBJ: How is imagery and LiDAR adding value to our industry? Which new technologies are coming out, and how will they evolve over the next few years?

Borrevik: Imagery and Light Detection and Ranging (LiDAR) have been foundational to environmental work for decades. Key use cases include monitoring, biodiversity assessment, mapping, change detection, planning, and environmental impact assessments. Quickly evolving technologies include:

- Multi-sensor fusion (aggregating data from multiple sensor types for more holistic analysis), which offers a more comprehensive and accurate analysis.
- Expanding LiDAR capture with both drones and mobile devices, which can be much more cost effective and repeatable for detecting changes in data sets.
- AI based enhanced image processing, which can detect infrastructure impacts, illegal logging, changes in water levels, etc.
- A growing market of cloud (SaaS) solutions for managing these technologies and data, which can significantly simplify and accelerate the path to value.

In the coming years, we can expect the relative return on these investments to increase due to increased capability and accessibility of both the sensors and supporting technologies including AI based analysis. ICF is actively using or experimenting with many of these technologies in partnership with clients.

EBJ: How is the industry leveraging emerging capabilities in artificial intelligence to lower costs and increase insight?

Borrevik: We all need to be mindful and strategic regarding the growing impact of AI in environmental work. AI is a field of computer science that includes many technologies and techniques that deliver outcomes typically reliant on human intelligence. AI has been used in environmental work for many years in areas like correlation and prediction analysis; however, other AI technologies are notably surging.

NATURAL LANGUAGE PROCESSING

Collaboration, documentation, and analysis in environmental work is being impacted by the growing adoption and energy around technologies like ChatGPT and BERT. The result is greater automation in generating, summarizing, and analyzing information.

COMPUTER VISION, AND AUDIO PROCESSING

Improved technology that's easier to leverage is further automating and enhancing detection and monitoring. The result is more informed decisions and strategies to safeguard ecosystems.

Organizations should be scanning their operational capabilities to identify and explore areas where AI technologies could add value. They can also empower small, dedicated teams to conduct experiments that reveal new insights that inspire better ways of working. As you get started with Natural Language Processing specifically be sure to think holistically about governance to ensure intellectual property and other considerations are identified and managed.

EBJ: In what other ways is ICF combining multiple technologies to offer new possibilities for clients?

Borrevik: Technology is transforming the world and the communities we live in. ICF is committed to understanding market challenges and client needs, and then determining together how technology can improve or enhance our delivery. ICF leverages multiple technologies to capture, process, and leverage aerial, mobile, and terrestrial imagery. This smart and inno-

vative integration of several technologies shields clients from complexity and provides a direct path to insight.

ICF Waypoint™ pulls together multiple modern technologies to ingest, analyze, and visualize data from a variety of sources such as project databases and other live services (e.g., ESRI, Census, parcels, etc.). Having this foundation in place makes automating common analytical needs a reality, including the generation of reports for environmental constraints and historical preservation reviews. It also can shield clients from issues like license management while providing a modern user experience tailored to their specific project or program needs.

ICF has also leveraged two of our platforms to help one of the largest utilities in the U.S. address climate change. CO2Sight™ provided an integrated platform environment to quickly explore and dive deep to quantify greenhouse gas reductions, costs, and benefits for decarbonization measures. ClimateSight™ generated customized climate risk analyses using big datasets and cutting-edge science. Together, these two platforms are helping the utility reduce their greenhouse gas emissions and adapt to extreme weather.

Most recently, with our EnergyInsite™ solution we've combined advanced map-based data visualization and analytics technologies to provide holistic insight to renewable energy infrastructure investments. Though the map perspective continues to grow in value, having the technology detect spatial relationships between infrastructure, land and environmental data creates scaled perspective, awareness, and opportunities for our clients.

EBJ: How is ICF's IT budget changing and being allocated?

Borrevik: Technology transformation requires careful financial planning that goes beyond a potential increase in spending. To be strategic around emerging capabilities, companies may see a shift in allocation to innovation and technology adoption. Following an iterative approach to innovation is the growing need for budgeting agility. □

AI + PEOPLE ANALYTICS

David Birken, Senior VP & Public Sector Transformation and Professional Services at ICF, is a management consultant expert who helps clients develop systems, programs, and operations to achieve mission outcomes for complex and critical public sector services.

With the explosive growth of new Natural Language Processing Artificial Intelligence (NLP AI) and deep learning tools, such as ChatGPT, optimizing personnel time will be brought to the forefront faster than organizations realize. Experts believe that these tools have the potential to automate time intensive, but non-glamorous parts of professionals' jobs. Consider the "pre-work" or analysis that goes into getting ready to do higher level tasks. With the implementation of AI tools, work could be automated and ready for the next step within seconds. In organizations that have put deliberate planning into NLP AI technologies, there will be an opportunity to effectively harness these new tools for increased productivity and worker engagement. However, unlike other tech disruptions, a lack of planning will not mean just missing out on benefits but could actually cause significant organizational and workforce harm.

Potential & Pitfalls of NLP AI

Historically, there are two key findings when a new disruptive technology is integrated into our everyday working experiences. First, the technology's impact is uneven across the workforce. Rarely is it contained to a single person or role and, to complicate the situation, the impact accelerates over time as it cascades through the organization. Second, when capacity or time is created for people, it is not guaranteed that the increase will result in better outcomes for the individual or the organization. Rather, proper planning is needed to amplify the productivity benefits and new ways of working, while mitigating negative impacts to people's work routines. The good news is that if we engage deliberately and plan for this new capacity, the potential benefit to both an organization and its people can be extraordinary.

Planning for AI Capacity

To effectively manage and leverage the benefits of AI in the professional workforce, organizations must consider:

Assessing the immediate and long-term cascading effects on work functions.

To plan for the integration of NLP AI, organizations should consider mapping their workforce-based core work functions and clusters of related work functions. This mapping exercise provides a sound understanding of how work is performed—and makes it easier to see how outcomes are achieved. Next, by leveraging People Analytic models, an organization can project an evolving probabilistic pathway of how NLP AI integration will impact its workforce down to the discrete work function and team tasks. This allows for a deliberate approach to AI automation of certain work functions—and the associated immediate and cascade impacts of that automation—at a pace the organization can adapt to. In addition to mapping new ways of working, this will also provide a quantification of time created for people via the automation of previously performed functions.

Enabling higher-level work. While implementing NLP AI may seem like the focus, the challenge facing organizations is helping their people to understand:

a. That a true desire for them is to focus on high-level activities and not simply ensuring compliance not busy work (i.e., enabling this reorientation).

b. What this new capacity should be used for on an individual and organizational basis (i.e., planning for capacity).

The dilemma is that people will fill the new capacity, whether it is beneficial for the organization's outcomes. Without deliberate planning and explicit direction as a part of a change management effort, organizations risk employees being adrift in their jobs or worse, resisting the changes. Both risk undermining any potential benefits of integrating AI. However, by repatterning individual behavior, as well as the organizational systems that support it, organizations can ensure that the integration of AI becomes a force multiplier and that the promised benefits do materialize. ■

ARCADIS INCORPORATES DIGITAL LEADERSHIP STRATEGY AND MULTIPLE TOOLS INTO ITS ENVIRONMENTAL PRACTICE

Arcadis (Amsterdam, The Netherlands) is a global design and consultancy organization for natural and built assets. Applying deep market sector insights and collective design, consultancy, engineering, project and management services, Arcadis partners with clients to deliver sustainable outcomes throughout the lifecycle of their natural and built assets. Arcadis has 36,000 people active in over 70 countries and generated €4 billion in revenues in 2022. In 2022 Arcadis acquired IBI Group, DPS Group, and Giftge Consult.

Kathleen Abbott, Global Executive Director of Clients and Business Development, leads the business development and sales function for Arcadis' Places Global Business Area. She provides strategic oversight and direction on commercial excellence, solutions, pursuits and bids, sector priorities and client programs. Building on her passion and expertise in supporting the sustainability aspirations of multinational clients as President of Arcadis' Environment business in North America, this global role extends to both new geographies, sectors and asset types, championing the decarbonization agenda across the built asset lifecycle. In addition, she partners with key and emerging clients to bring the best of Arcadis to solve their biggest and most complex problems, connecting them with the right people, capabilities, solutions, technologies and strategies to establish meaningful and measurable change.

EBJ: How has technology changed the way Arcadis operates on a day-to-day basis? Describe the key factors that have made this possible and also the challenges posed by digital technology.

Abbott: Over the last few years, technology has significantly transformed the way Arcadis operates on a day-to-day basis in several ways:

DIGITAL COLLABORATION

Arcadis now uses advanced digital collaboration tools (such as the Microsoft Office 365 as well as Autodesk, Bentley, and ArcGIS design suites) to enhance communication and collaboration among its teams. This allows employees to work together seamlessly, regardless of their physical location, fostering greater efficiency and productivity.

DATA ANALYSIS

With the advent of big data and advanced analytics, Arcadis can now analyze vast amounts of data to gain insights and make informed decisions. This enables the company to provide more accurate and data-driven solutions to clients, improving project outcomes and reducing risks.

REMOTE WORK

Technology has enabled Arcadis to embrace remote work and flexible working arrangements. Employees can now work from anywhere, accessing project information, collaborating with colleagues, and providing timely updates using digital platforms. This flexibility enhances work-life balance and attracts talent from a wider geographical pool.

BUILDING INFORMATION MODELING (BIM)

Arcadis has integrated the use of BIM, a digital representation of physical and functional characteristics of a facility, into its workflow. BIM allows for improved visualization, design coordination, and clash detection, resulting in more efficient planning, construction, and maintenance processes.

AUTOMATION AND ARTIFICIAL INTELLIGENCE (AI)

We have put concerted efforts towards standardizing our processes and services to enable automation, which streamline routine tasks and improve operational efficiency within Arcadis. By leveraging these

technological advancements, Arcadis has become more agile, efficient, and capable of delivering innovative solutions to its clients.

Key factors that have made this happen include the digital transformation that Arcadis began to take on over five years ago, empowering our organization both from IT and employee competency to understand and embrace the direction of travel and the benefits realized through technology, for ourselves and our clients.

Challenges are both technical and human. Data security and privacy as well as integration and compatibility of software has challenged our IT organization. Meanwhile, skill development and training (which is a never ending process) as well as the resistance to change of our employees creates friction in how we can progress as an organization.

EBJ: Tell us about Arcadis' Digital Leadership initiative and how it has been incorporated into the company's environmental practice.

Abbott: Arcadis' Digital Leadership is a strategic initiative that focuses on leveraging technology and digital solutions to drive innovation, efficiency, and sustainability both in the company's operations as well as for our clients. This approach has also been incorporated into Arcadis' environmental practice, aiming to address complex environmental challenges and deliver sustainable solutions. Following are some examples of how Digital Leadership has been integrated into the company's environmental practice:

DIGITAL ENVIRONMENTAL SOLUTIONS

Arcadis has developed digital tools and solutions to enhance environmental assessments, monitoring, and management. For example, Arcadis utilizes remote sensing technologies, such as aerial and satellite imagery, to gather data on environmental conditions and changes. This data is then processed using advanced analytics and machine learning algorithms to provide insights into ecosystem health, land use, and environmental risks.

DATA-DRIVEN DECISION-MAKING

Arcadis harnesses the power of data analytics and modeling to support evidence-based decision-making in environmental projects. By collecting and analyzing large volumes of data, the company can identify trends, patterns, and potential risks, enabling proactive environmental management. For instance, Arcadis uses data-driven models to assess the impact of infrastructure projects on ecosystems, predict the effectiveness of restoration measures, and optimize resource allocation.

DIGITAL TWIN TECHNOLOGY

Arcadis employs digital twin technology to create virtual replicas of physical assets and environmental systems. This allows for real-time monitoring, simulation, and optimization of environmental performance.

By integrating sensor data, GIS mapping, and predictive analytics, Arcadis can create digital twins of natural resources like rivers, coasts, or forests. These digital twins enable better understanding, management, and planning of environmental assets, leading to more sustainable outcomes.

COLLABORATIVE PLATFORMS

Arcadis utilizes collaborative digital platforms to engage stakeholders, enhance transparency, and foster sustainable practices. For example, the company may develop online portals or mobile applications to involve local communities in environmental projects. These platforms facilitate information sharing, collect feedback, and provide educational resources, fostering a sense of ownership and promoting sustainable behavior.

Overall, Arcadis' Digital Leadership approach in the environmental practice combines data-driven decision-making, advanced analytics, digital twin technol-

ogy, collaborative platforms, and smart city solutions. By leveraging these digital solutions, the company aims to deliver innovative and sustainable environmental projects, promote efficient resource management, and create resilient ecosystems.

EBJ: How is Arcadis collaborating with startups and other technology companies to accelerate the rate at which technology and innovation is adopted by the environmental industry?

Abbott: We believe that external collaboration with startups but also other players like governments and academia is critical for Arcadis' growth and innovation. Our Global Ecosystems team plays a key role in helping us accelerate innovation and getting to market quicker through developing partners with startups and other organizations that complement our core capabilities.

We started this journey through our collaboration with Techstars, a well-established organization in this space. From this experience we are now able to show results like our global partnership with **Niricson**, to scale digital asset management technologies. Arcadis embraced the learnings from this program and evolved them into our Global Ecosystems framework, which helps us accelerate growth and innovation through partnering.

Another Techstars collaboration included working with **Cobalt Water Global**, an artificial intelligence (AI) and modelling specialist, to reduce nitrous oxide (N₂O). Our partnership allowed us to develop and scale an innovative tool that will help the wastewater sector reduce the amount of harmful ozone-depleting N₂O it releases into the environment.

EBJ: Tell us about Arcadis' Industry 4.0 solutions.

Abbott: Arcadis uses an Industry 4.0 digital approach to explore the art of the possible of innovative technologies to un-

Arcadis' Digital Leadership approach in the environmental practice combines data-driven decision-making, advanced analytics, digital twin technology, collaborative platforms, and smart city solutions.

lock strategic and financial benefits for our clients. We plan and simulate operational scenarios digitally in order to reduce planning time. Additionally, we introduce cloud-based digital platforms and the Industrial Internet of Things to connect every product, process and person through transparent, always-available, and integrated data. The use of data science improves quality control, boosts efficiency, and enables predictive management.

Wallbox, a global electric vehicle charging and energy management provider, partnered with Arcadis to build its first U.S.-based charger manufacturing facility in Arlington, Texas to help close this gap. To meet the needs of the growing EV market in the United States, it was critical to complete the design and construction of the facility and begin manufacturing as quickly as possible, with two additional goals in mind: to improve quality of life for the people who work at the plant, and to create the most sustainable facility possible. Throughout construction, the team utilized Open Space to allow team members from other locations to view and navigate the construction site like they would using Google Street View, which allowed for quick decision making and eliminated the need for excess travel to and from the site. As a result, phase one of the project was completed ahead of schedule, allowing Wallbox to begin manufacturing EV charger units sooner than expected.

EBJ: How are new technologies disrupting the following segments?

RESILIENCE

Technologies are also supporting climate adaptation and resilience efforts. For example, advanced modeling and simulation tools help identify vulnerable areas and develop strategies to address climate risks, such as flood mapping or urban heat island mitigation. Innovations in water management, resilient infrastructure, and disaster response systems enhance communities' ability to cope with climate-related challenges.

CLIMATE CHANGE

One example of technology that has disrupted climate change is the develop-

ment and advancement of renewable energy technologies have been instrumental in combating climate change. Technologies like solar panels, wind turbines, and advanced energy storage systems have become more efficient and affordable, leading to increased adoption and deployment. These technologies reduce reliance on fossil fuels, decrease greenhouse gas emissions, and contribute to the transition towards a low-carbon energy sector.

ENVIRONMENTAL RESTORATION

Advanced data analytics and machine learning algorithms are transforming environmental restoration. These technologies can process large datasets, identify patterns, and predict ecosystem responses. They help optimize restoration strategies, prioritize interventions, and forecast outcomes. Machine learning algorithms can analyze historical restoration data to develop models that improve the success rate of restoration projects.

SUSTAINABILITY

New technologies are driving improvements in energy efficiency across various sectors. Smart grids, energy management systems, and smart appliances enable better monitoring and optimization of energy consumption. Building automation systems, efficient lighting, and insulation technologies further contribute to energy savings and reduced emissions. These technologies help mitigate climate change by minimizing resource waste and reducing greenhouse gas emissions associated with energy use.

ENVIRONMENTAL HEALTH AND SAFETY

Drones equipped with cameras and sensors are used for aerial inspections, surveying, and monitoring in hazardous environments. They can assess the condition of infrastructure, detect potential risks, and identify maintenance needs without exposing workers to danger. Robotics and autonomous systems are being deployed in various industries to perform hazardous tasks, reducing human exposure to risks and enhancing overall safety.

WATER

IoT sensors, data analytics, and automation technologies are transforming water management practices. Smart water networks can monitor water distribution systems, detect leaks, and optimize water usage. These technologies provide real-time data on water flow, pressure, and quality, enabling proactive maintenance, conservation efforts, and efficient water allocation.

EBJ: Which technologies have the potential to revolutionize our industry over the next five years?

Abbott: The first one that comes to mind is Artificial Intelligence. With Generative AI becoming mainstream, other AI techniques will also see rapid growth across our industry. We expect a wide range of applications, as we are now just scratching the surface. Expect optimization of building and urban layouts, structural design or construction project schedules, but also enhanced regulatory compliance, material selection and project documentation. We will also see use cases that go beyond traditional data sources (text and numbers) and into multimodal spaces like audio or video. Think about noise pollution analysis or accessibility design simulations, as well as the new possibilities for generative design.

With the proliferation of IoT devices, Digital Twins are gaining more traction in our industry. This technology offers value from the planning phase all the way through to the operations stages. As it collates data from the real world, allowing for real time monitoring, it also becomes a powerful instrument for simulations, able to predict potential issues and failures in physical assets.

Geospatial technologies also have the potential to create a revolution in terms of enabling new solutions to solve existing problems. Mapping allows for a more comprehensive view of risks to society, where for instance climate related risks can be overlaid on top of economic data. The next generation of geospatial platforms will be interconnected and able to bring together disparate data sources.

We cannot forget about the wide realm of Climate Tech applications. We are observing an explosion in the number of startups in this space. Despite the need to harness climate solutions inherent to nature like reducing reforestation and protecting our oceans, our two largest carbon sinks, we will also need climate technologies to get us over the line.

Technologies in this space include low-cost renewable energy storage solutions, satellite imagery to track carbon emissions, energy usage optimization, hydrogen-powered aircrafts, carbon credits platforms and more.

EBJ: What processes does Arcadis use to test, launch and scale innovation quickly throughout the organization?

Abbott: At Arcadis, we follow a clear framework for innovation that allows employees to innovate closer to the core through optimizing our existing value propositions, as well as giving them the space to explore further out opportunities and new business models.

Several years ago, we professionalized the idea management process and we have evolved this to the point where our global innovation platform has become a place for global collaboration. By giving everyone an opportunity to elaborate on or provide feedback on ideas, we enrich the experience and ensure we are focusing on globally relevant problems and globally scalable solutions.

Our dedicated Innovation Management team spends time assessing opportunities, connecting individuals to strategy and expertise and coaching them throughout the process. We embrace agility and a culture of experimentation in order to quickly adapt to change and make faster decisions about progressing or stopping opportunities.

Our Global Innovation Studio is formed by a group of professional innovators that partner with Subject Matter Experts across our business to address the most complex challenges.

EBJ: Are new regulations affecting how Arcadis uses technology, and have they expanded your services?

Abbott: New regulations can have a significant impact on the ways companies use technology, including: data privacy and protection as well as the environmental impact associated with the use of technology. With the increasing focus on data protection and privacy, companies need to ensure compliance with regulations such as the European Union's General Data Protection Regulation (GDPR) or California Consumer Privacy Act (CCPA). These regulations often require companies to implement robust data security measures, obtain user consent, and provide transparency in data handling. This impacts how companies use technology to collect, store, and process data, necessitating the implementation of privacy-enhancing technologies and data governance frameworks.

Environmental regulations, such as those related to emissions, waste management, or conservation, can influence the use of technology in environmental practices. Companies may need to adopt innovative technologies to monitor and reduce environmental impacts, improve energy efficiency, or develop sustainable solutions. This creates opportunities for companies to expand their services by offering expertise in environmental technology solutions.

Arcadis has both changed our internal structures as well as expanded services in response to these regulations. We have:

- Offered consulting services to help clients understand and navigate environmental/sustainability regulatory requirements and implement technology solutions accordingly. Our Sustainable Advisory team works closely with our Sustainable Operations team to help clients comply with corporate and federal goals.
- Developed applications/platforms that automate compliance processes, data management, and reporting.
- Conducted audits and assessments to ensure clients' technology systems meet regulatory standards and advised on how to comply with updated cyber security requirements, for example.

EBJ: What impact are global uncertainties having on your environmental practice and on Arcadis as a whole?

Abbott: Global uncertainties can have significant impacts on a company's practice and overall operations. Global uncertainties, such as geopolitical tensions, trade disputes, or economic downturns, can impact the economic conditions in which a company operates. Fluctuations in currency exchange rates, inflation, or changes in government policies can affect project budgets, funding availability, and market demand. This can lead to shifts in project priorities, delays, or cancellations. Additionally, these uncertain economic conditions may lead to reduced investment in certain sectors or a shift in client demands.

Natural disasters, political instability, or trade disruptions can also affect supply chains. This can lead to delays in material procurement, increased costs, or challenges in project execution. Both Arcadis and our clients need to assess and manage supply chain risks, identify alternative suppliers, or implement contingency plans to ensure project continuity.

Specifically in the environmental space, uncertainties regarding regulatory changes and compliance requirements can impact the practice of both Arcadis as well as our clients. New regulations or changes in existing regulations may require adjustments to project approaches, designs, or environmental impact assessments. Keeping up with evolving regulations becomes crucial to ensure compliance and avoid potential legal or reputational risks.

Finally, global uncertainties impact the availability and mobility of talent. Changes in immigration policies, labor market conditions, or health crises can affect the recruitment and retention of skilled professionals. This is not only a challenge that impacts Arcadis but we feel it every day with our clients. We do our best to support our clients in adapting their talent strategies, investing in training and upskilling programs, or exploring remote work options to mitigate talent-related risks. ■

TRC REAPS DIGITAL EFFICIENCIES FROM STREAMLINED AUDITS TO IMPROVED REMEDIAL STRATEGIES AND GRID SOLUTIONS

TRC (Windsor, Conn.) is a global professional services firm providing strategy, consulting, engineering and applied technologies. With revenues in excess of \$1 billion and over 7,000 employees across more than 100 strategic locations, TRC operates in five countries and all continents except Africa. TRC has executed more than 25 acquisitions since 2010, ranks No.16 in ENR's Design firms and works with every top U.S. investor-owned utility. Over the last two years, TRC has executed a number of strategic acquisitions, including one in India, which has not only expanded TRC's global footprint but also its capabilities in product development supporting the markets it serves. TRC was recently ranked by ENR (2023) as the No. 5 Power Firm, the No. 5 Environmental Management Firm (Top 200), and the No. 9 Pure Design Firm (Top 500). In 2020, TRC launched TRC Digital, combining engineering and consulting services with new technologies such as AI, blockchain, automation, cloud and cyber innovations and bringing forward three new digital platforms.

Chief Information & Digital Officer, Rajeev Gollarahalli is responsible for TRC's company-wide IT advancement and digital innovation and has been with TRC for a little over three years. An experienced and proven leader of transformation, Rajeev brings over 25 years of technology experience, including large scale international digital transformation and IT operations. Prior to joining TRC, Rajeev was the VP IT Strategic at Sanmina, a large global hi-tech manufacturing organization and prior to that was SVP Digital Transformation at Coats, a global fiber manufacturer.

Mark Robbins, President of TRC's Environmental Sector, joined the company in 1999 and has served in a variety of leadership roles. He has more than 30 years of experience in the engineering and environmental consulting business and extensive experience in developing and running multi-disciplinary engineering and environmental projects. Mr. Robbins has also championed the growth of TRC's enterprise-wide renewables energy offerings, TRC's RE-POWER® offering, as well as the accelerated growth of the firm's ESG practice.

EBJ: Which technologies has TRC incorporated over the last two years that have had a big impact on the firm's operations and efficiencies?

TRC: We are continuously upgrading the technologies we deploy to support our vision of transforming ourselves to being a digitally savvy professional services organization. Having a client-first culture almost requires us to operate on the cutting edge of technology keeping in mind the needs of our clients while becoming more efficient in how we deliver our services. While there are a number of technologies that we have incorporated in the last year some of the more predominant ones are listed below.

GIS SOLUTIONS (SPECIFICALLY ESRI)

Close collaboration and communication with our partners and customers is one of the key factors for our success. ESRI allows us to deliver an integrated and common platform to share and collaborate Geo Spatial data. We have been successful in reimagining how we deliver services to our customers. As our ESG services grow, ESRI will be a key foundational technology within our tech portfolio. An example of the application of this technology is in determining carbon footprints and developing algorithms that advise our customers on the best path forward in locating renewable energy sites as they transition from fossil fuel-based plants.

AI/ML

As the amount of data we collect rapidly grows, the ability to make timely and accurate data-driven decisions has greatly improved using AI/ML. With the advent of generative AI, this ability has now become even more valuable as it allows us to make context-sensitive decisions. This technology while creating "competitive advantages" for us has also opened the doors to challenges around privacy, integrity, security, and loss of IP. TRC is making significant investments to ensure we provide safe and secure access to the technology. When we refer to safe and secure, it not only applies to TRC but also to all our partners in the supply chain and most importantly to our customers as well.

DIGITAL TWINS

Digital twin technology has enabled TRC to deliver market leading services within our Environmental sector. Specifically, we are deploying this technology within ESG, waste management, natural disaster preparedness and response, and air quality monitoring to name a few. Examples where digital twin technology is helping is predicting hotspots and pollution dispersion in our Air Quality Monitoring practice.

RPA

Robotic process automation (RPA) has been in use at TRC for over three years and has allowed us to streamline and automate several processes both within our back office as well as service delivery. TRC uses the Automation Anywhere platform to deploy the robots. Some areas where RPA has been deployed include automated data delivery to clients, permitting, and quality assurance.

Digital innovation has been a cornerstone of TRC and we leverage a range of technologies, including those listed above, in our digital platforms. Highlighted below are three recent examples within our rapidly growing ESG practice that assist our clients in understanding and monitoring ESG priorities and performance.

1. AnalyzEJ leverages TRC's extensive library of GIS and digital resources to sup-

port our clients with rapid environmental justice screen briefs to support siting analyses, critical issues reports addressing stakeholder concerns, and full portfolio reviews including GIS impact mapping.

2. Beyond The Scope™ (BTS) provides an integrated, customizable climate strategy framework that incorporates an easy-to-follow, step-by-step approach encompassing the development of an accurate carbon footprint inclusive of Scope 1 to 3 emissions in a comprehensive fashion to the establishment of decarbonization pathways along with target setting, linking back to financial impact. By combining client data, climate data, financial data, and TRC's in depth knowledge of decarbonization in an integrated, interactive platform, TRC provides clients with a full picture of their ESG position.

3. Power Generation Transition Platform combines TRC's robust technical expertise and datasets from across several of our key markets to inform and guide clients' efforts to develop clean energy resources and understand the system impacts of retiring generators.

EBJ: Describe how particular technological changes have created advantages for TRC's environmental practice.

TRC: Our commitment to digital innovation has influenced, and in some cases completely transformed, the way we execute projects which has led to improved quality, responsiveness, cost-effectiveness, and client satisfaction.

TRC's Mobile Audit Tool has significantly reduced our EHS auditor time in the field due to streamlined collaboration amongst auditors and targeted and visually enhanced closeout meetings. Remote sensing, LiDAR, drones, and satellite imagery have enabled improved site characterization and monitoring. Advanced analytics and modeling improves prediction and optimization of remedial strategies through machine learning algorithms, numerical modeling, real-time data management and geospatial visualization tools.

TRC's use of mobile data collection tools has nearly eliminated the use of pen and paper during field activities. These

tools often include data validation requirements at the point of data collection thus reducing potential errors and ensuring critical data is not inadvertently missed. Cloud-based data management and automated workflows accelerates our ability to make informed decisions and communicate findings in near real-time through client accessible dashboards and other visualization platforms.

EBJ: How has TRC Digital evolved, and what new components will be incorporated into this practice in the near future?

TRC: Our Intelligent Grid Solutions Sector was created in 2019 to be an expert services practice to facilitate and guide the energy transition. The organization has evolved both organically and inorganically over the interim to deepen expertise from the point of generation to consumption, hiring and acquiring experts in energy control systems, smart metering, distributed energy resource control, geospatial information systems, and intelligent asset management.

Intelligent Grid Solutions has also developed discrete capabilities in developing products to fill white spaces in the current supplier fabric and a world class cloud-enabled managed services team that provides our clients with resiliency in manpower and technology. In 2022, Intelligent Grid Solutions acquired a firm largely based in India to bolster its capabilities and access to key talent and markets in Asia and will likely continue this global trajectory in the near future.

EBJ: How does Connected EnviroView support TRC's environmental practice?

TRC: Connected EnviroView is TRC's digital platform for providing integrated solutions across our service offerings and the markets we serve. This platform, which includes numerous underlying technologies, focuses on digital data collection, cloud-based data processing and management, tech-enabled reporting, and data visualization. The Connected EnviroView platform has grown substantially since its inception nearly five years ago as it provides greater accuracy, reduces labor hours, accelerates schedules, and conveys project

results in a straightforward and easily digestible manner. The platform provides an exceptional foundation with proven success and rapidly expanding capabilities which enables TRC to rapidly tailor each solution to the specific needs and opportunities of each situation.

EBJ: What procedures does TRC use to test, launch and scale innovation throughout the organization?

TRC: We host an annual Digital Innovation Challenge that challenges our employees to work together and share their bold, innovative, and groundbreaking ideas that address our clients' most complex challenges. Top ideas are short-listed, and teams have two weeks to meet with key stakeholders across TRC and prepare their business case. The top five business cases are selected to present in a shark-tank style format to the TRC's Executive Leadership Team who vote on the three winning teams.

Not only do the winners earn prizes and major accolades, but they go on to serve as Digital Innovation Fellows. During their fellowship, they are given a budget, training, resources, and support from areas across the business to build prototypes for their ideas and gain market feedback. The Fellowship Capstone is a presentation to a small group of Executive Leaders who decide on additional funding to support future development.

In addition to the Challenge, TRC has an idea portal for employees to submit their innovation ideas year-round, which is managed by our Digital Automation Center of Excellence. Ideas are prioritized based on strategic alignment, return on investment, change management, risk and technical feasibility. Larger projects requiring significant investment are also evaluated by our Digital Steering Committee, chaired by the CEO and CIDO.

EBJ: How have TRC's IT budgets grown over the past couple of years, and how do you see those budgets being allocated?

TRC: In general, IT investment is seeing a steady increase. As digital matures, several aspects of the IT budgets are im-

pacted. Some of the aspects that are impacted more are the shift from CapEX to OpEX with the shift from on prem infrastructure to more Cloud and SaaS. Training is another aspect within the budget that is impacted. TRC has been investing heavily in upskilling its employees to support the more advanced technologies as Cloud, AI/ML, Data Science etc. Investments in cyber technologies is also steadily increasing as we address the cyber security challenges that arise from the use of digital technologies and generative AI.

We do expect the share of IT budgets allocated to advanced technologies such as generative AI and ML to increase. However, we also expect that the ROI from these investments will help offset absolute increase in the budgets as we begin to realize efficiencies that these technologies are expected to deliver.

EBJ: Which technologies have the potential to revolutionize the environmental industry over the next five years?

TRC: Clearly, digital technologies in general will disrupt the industry moving forward. Digital will redefine how we deliver services while also giving rise to new services that have not even been thought of as of now. Some of the specific technologies that will likely disrupt the industry are IoT, generative AI & ML, digital twins and AR/VR. The industry is moving fast towards real time data-based decision making using streaming data. The ability to ingest the data and quickly aggregate and analyze large volumes of data will play a pivotal role in how decisions are made and services are delivered.

As an example, with climate change and the more frequent natural disasters the ability to monitor air and water quality and make real-time decisions is becoming critical. This capability will require the foundational technologies of IoT to ingest data, digital twins to simulate and learn, AI/ML to automate decision making and will revolutionize how our customers are served. With work transitioning more to remote working environments AR/VR will help understand ground conditions and allow remote workers to either act locally or assist local crews more effectively. ■

'The Potential for Generative AI is Immense'

Additional EBJ survey responses from Rajeev Gollarahalli, Chief Information & Digital Officer, TRC Companies

To what extent can you get project or client work to finance investments in new technologies?

There will be plenty of opportunities to get clients to fund technology investments. The key will be to be able to demonstrate quantifiable ROI on the investments.

How much has, or can technology change the way in which you are charging your clients, and what is technology's potential to enhance profitability?

Technology will play a big role if not the biggest role in improving profitability. As labor dependencies reduce the fixed fee / unit priced projects will become more prevalent as adoption increases. I expect the fixed fee projects to make up 30% or more of the projects in the next 18 months.

Where do you believe much of the innovation and disruptive technologies in the industry will be coming from in the next decade?

The industry itself will be adopters of new technologies. I don't see new technologies emerging from within the industry but plenty of creative applications and adoption will be the norm.

What barriers is the environmental industry facing that limit the development and implementation of disrupting technologies?

I believe the most significant barriers will be data quality and consistency. I also think a significant barrier is the adoption of the Digital culture at pace.

How are innovative, disruptive or cutting edge technologies are being used in project categories?

Remediation: GIS along with predictive analytics will be key technologies; Sampling / Measurements / Lab Analysis: IoT and remote sensor along with high volume data ingestion, visualization and predictive analytics technologies will play roles; Design & CAD: Outcome based design philosophies will change how we approach engineering design projects; AI: Generative AI and predictive analytics will be applicable in almost all advanced services. The potential for Generative AI is immense. TRC is working on several Generative AI based initiatives and expect it to play a major role in our growth and profitability.

TRC Companies Acquires GNA, Expanding Climate Solutions with the Addition of Sustainable Transportation Solutions

In June 2023, TRC acquired **Gladstein, Neandross & Associates (GNA)**, the leading North American consulting firm specializing in low- and zero-emission transportation technologies, infrastructure, and ultra-low carbon fuels for commercial transportation. During the past 30 years, GNA has managed the design and development of more clean fleet deployment projects than any other firm in North America, fueled by the firm's industry-leading grant-writing and management team. Using its proprietary Funding 360 product, GNA has helped its clients track, apply for, and secure more than \$1 billion in incentives for clean commercial vehicles and infrastructure. The acquisition expands TRC's Climate Solutions offering and accelerates the zero-emission vehicle transition. Together, they bring new capabilities and broader support to clients and utility partners as they address the challenges of fleet electrification.

SCS REFLECTS ON IMPACT OF TECHNOLOGY INNOVATION IN LANDFILL ENVIRONMENTS

Environmental engineers, consultants, and scientists at **SCS Engineers** (Long Beach, Calif.) work on solutions for pollution, energy consumption and emissions reductions, land remediation, water/wastewater treatment, and waste management. Core capabilities are solid and hazardous waste management, renewable energy, remediation, carbon capture, measurement and verification. Enhancing the firm's environmental engineering and consulting work are specialized in-house groups producing technologies and programs that lower industrial operating costs and reduce greenhouse gases for private and public clients establishing goals to reduce their environmental impact. These technologies and programs serve the agricultural, industrial, and manufacturing sectors. SCS Engineers reported a record year of gross and net revenues in 2022, its 16th consecutive fiscal year with record net revenues. Gross revenue for 2022 increased to \$423 million, supported by 1,100 employee-owners.

Ken Brynda, SCS Field Services OM&M Quality Advisor, is an active member of SWANA's Landfill Gas and Biogas Technical Division, Field Practices Committee serving clients for over 30 years. Ken's expertise includes the design, construction, operation and maintenance, evaluation, troubleshooting, and assessment of landfill gas collection and control systems and LFG-to-energy production facilities.. Ken is a SWANA-certified as a Landfill Technical Associate in the Manager of Landfill Operations (MOLO) program, and has also taught the SWANA introductory Landfill Gas System Operation and Maintenance training course.

David Hostetter, SCS Engineers Business Manager, manages remote monitoring and controls (RMC) work across the United States and internationally. His experience includes RMC systems engineering, construction, and operation; landfill gas and leachate engineering; and mechanical engineering. He is a graduate of Messiah College's mechanical engineering program. He is a registered Professional Engineer in Pennsylvania and Virginia, a Certified Energy Manager, and a LEED Accredited Professional. His projects have received an Environmental Business Journal Technology Merit Award and an Inductive Automation Firebrand Award.

Note: Responses relate to landfill technologies and do not include technologies developed and used for other environmental services such as due diligence, land remediation, general air, water, and soil testing, mitigation/prevention, and compliance.

EBJ: How has technology changed the way in which SCS operates on a day-to-day basis?

Hostetter: One big change I've seen is the proliferation of remote monitoring and control (RMC) technologies. The underlying technologies are not new this year, but we've seen the technology's capabilities improve and the cost drop. We're now where these technologies are the starting point, not an afterthought. We're using these technologies to lower operations and maintenance costs, decrease greenhouse gas emissions, lower environmental risks for our clients and their local communities, and improve the quality of life for the people that interact with the facilities and live around them while lowering the health

and safety risks associated with our industry. The main challenge that we've faced with this is keeping up with the demand to provide these technologies.

Brynda: Technology has equipped us with better tools to perform our jobs. It has allowed easier and quicker access to data, incorporating multiple tools for collecting data and the subsequent review and analysis of that data. This speed and accuracy allow us to perform complex and comprehensive troubleshooting, assessments, and deeper data dives from which we can make better operational, compliance, and financial decisions.

EBJ: Which parts of SCS' environmental practice have reaped the greatest advantage from technological change?

Hostetter: The two major areas in our environmental practice that have had the greatest advantage due to adopting RMC technologies are our operations and maintenance group and our engineering group. Both groups benefit from knowing how facilities are operating at any time from anywhere and having the critical data to make intelligent decisions on how to operate and design these facilities.

Beyond this, our O&M team can remotely control the equipment from anywhere. The days of driving several hours in the middle of the night on a holiday weekend in a snowstorm to restart a critical piece of equipment are gone.

Brynda: We easily upload and securely store data from multiple monitoring sources within our internal landfill gas wellfield data management application. Once uploaded, data integrates with historical data for a site. In turn, we can review landfill gas data with liquids data, surface emissions monitoring data, and the location of gas collection system piping and extraction devices. The ability to query the data for specific parameters also helps us manage our client's wellfields and maximize landfill gas extraction.

EBJ: Which digital platforms has SCS adopted to improve collaboration among employees and with clients?

Hostetter: We use Microsoft Teams to communicate with our internal and external teams. Yesterday alone, I had Teams meetings with people in California, Alaska, Wyoming, Kansas, New York, Pennsylvania, Wisconsin, and Alberta, Canada. Beyond meetings, we use it to share files, collaborate, and communicate effectively. We use SharePoint with limited AI developed by SCS for our intranet. The AI helps SCSers find internal resources, training, or staff with specific skill sets. After over 50 years, we've accumulated valuable insight, practices, and culture to pass along to our younger professionals and for them to share their ideas with those with tenure. Having access to knowledge and open communications helps us continue innovating.

We also use our SCSRMC.com platform to enable our distributed engineer-

ing and O&M teams to have one source of truth for their facility data. We use the platform to review and analyze data, make intelligent and proactive decisions, and then implement those decisions via remote operational adjustments.

EBJ: How rapidly are the industry and public agencies adopting these types of platforms?

Hostetter: The industry is quickly adopting both of these platforms. Teams is the de facto leader for online meetings and engagement. Similarly, public agencies and private enterprises nationwide are adopting the SCSRMC.com platform.

We can create images from the integrated data to view underground conditions, pump locations, liquid levels, and gas concentrations. Then we can virtually walk through a landfill and view each well.

One of the biggest ways we see the public engaging with this type of technology is via response to aerial methane monitoring surveys. The public is very interested in the results presented. This engagement seems to drive public agencies to adopt new methane monitoring technologies and regulations. We've collected data via satellite, drone, and hand collected at the same landfills. The results show all three methods work, and the data is consistent.

EBJ: How does the data ecosystem need to evolve and expand to support the next generation of compliance and problem solving?

Hostetter: We've seen the data ecosystem expand greatly due to the accessibility of field data through RMC systems. That said, we need more data and more tools to process this data. We need lower-cost hardware so that we can continue to achieve this.

We're encouraged to see regulators moving toward working with industry to

approve newer monitoring technologies that enable the industry to continue lowering greenhouse gas emissions. Currently approved technologies give an incomplete picture of emissions and drive the industry toward meeting regulations, not holistic greenhouse gas emissions reductions.

EBJ: How is advanced imagery adding value to our industry? What new technologies are coming to market, and how will they evolve over the next five years?

Hostetter: Continuing with the theme from the previous question, tunable diode laser (TDL) methane monitoring technology, particularly when paired with drones, is an industry-changing technology enabling facilities to routinely get an accurate picture of where they emit methane. Facilities can then use this data and the pictures and topographical data from the drone to rapidly repair the identified issues.

In the next five years, drone-based monitoring will become ubiquitous. We'll also see states and some large county governments and corporations implement their own satellite-based methane monitoring technologies. Using data, who would have thought we could see underground conditions three years ago? Now we see in 3-D the locations of pumps and liquid levels, silt, and other conditions that could interfere with capturing methane.

Brynda: Images are extremely valuable now and will only get better as technology improves. We are a very visual species. Data tells a story, and data mapping paints the picture. We can often see issues through data mapping first, which leads us to dig deeper into the tabular data. For example, we can create images from the integrated data to view underground conditions, pump locations, liquid levels, and gas concentrations. Then we can virtually walk through a landfill and view each well. We know what is wrong and where and who to send to fix it. Diagnosing and fixing more common issues creates more value and convenience for more clients.

EBJ: How is the industry leveraging emerging capabilities in artificial intelligence to lower costs and increase insight?

Hostetter: AI is coming to industry, but it's not quite ready for wide-scale adoption due to several factors, including the validity of the produced "intelligence," costs, intellectual property, and data security concerns. Before wide adoption, we need to get accurate AI systems that don't produce incorrect responses, are less expensive, and have addressed data ownership concerns. We have always been very protective of our clients and their data. We are studying how to apply AI's potential to our work and systems, but as with everything we do, it must prove to work safely and scale for industry.

EBJ: Tell us about the technologies that SCS has developed recently for the solid waste industry and renewable energy?

Hostetter: Our SCS Remote Monitoring and Control (RMC) technology was conceived and developed specifically within the solid waste industry. From its beginnings here, it is useful in the wider renewable energy and environmental industry.

It's a cloud-based system that allows users to operate and manage their facilities from anywhere with an internet connection. It's their one source of truth and one location that they go to understand their facilities and make changes to how their facilities are operating. It's their facility dashboard and control room.

To create this technology, we combine capabilities from supervisory, control, and data acquisition systems (SCADA), geographic information systems (GIS), and remote monitoring technologies (e.g., drones, satellites, planes, etc.) into one packaged seamless system.

Users access the system from their phone, laptop, PC, tablet, or anything with an HTML-5 web browser. They view live and historical data, aerial imagery, and data, receive alarms and automatic reports, and use this information to control their facilities from anywhere proactively. We've seen simple payback periods of as short as three months with SCS RMC systems.

Brynda: We have continued to add data review tools to our landfill gas well-field data review applications through customizable analytic reports, parameter and filter maps, and trend charts. These tools

help SCS and our clients track compliance and maximize wellfields for odor control, migration control, and provide fuel for renewable energy projects.

EBJ: Are jobs at SCS changing as more technologies become available to perform tasks previously done by employees? What training has your company implemented to help employees adapt?

Hostetter: Overall each employee is doing more because of technology. For example, we used to send employees out to facilities to get readings on equipment; now, those same employees can access the cloud-based SCSRMC.com system for the facility and review the data from anywhere. Instead of just being a data collection person, they now review the data and figure out what to do about it. We've increased their capacity and their capabilities. We've moved most of our training online. Each month, several new online courses are available. This helps us invest in our employee-owners, providing even more value to our clients! And it is convenient. We also provide libraries of blogs, papers, articles, and videos free to our clients on our website.

Brynda: I do not believe that technological improvements have led to a loss of jobs. I believe we have created new positions that did not previously exist to help us provide better technical solutions for clients. From a landfill gas wellfield management perspective, our technicians are now better equipped with advanced analytical tools that did not exist until recently. Utilizing these tools has resulted in SCS winning more work, and we have added staff. Landfill technician jobs are a combination of hands-on work and learning and using technology – as with all SCS technology, each enhances the other.

EBJ: How have SCS' IT & R&D budgets grown in recent years?

Hostetter: Our R&D budgets have increased over the last several years, and I expect that to continue. Technology is changing quickly. If you don't understand and know how to apply it, you'll fall behind and not be able to serve your clients and create efficiencies for them as well as you can. □

SEAFARING DRONES PROPELLED BY RENEWABLE ENERGY GATHER DATA FOR OCEAN MAPPING, MARITIME SECURITY, AND CLIMATE SCIENCE

Saildrone (Alameda, Calif.) is a data company providing comprehensive turnkey solutions for maritime defense and security, ocean mapping, and ocean data. The company enables real-time access to critical data from any ocean and uses proprietary software applications and machine learning technology to transform that data into actionable insights and intelligence. Saildrone has a fleet of uncrewed surface vehicles (USVs) powered by wind and solar, making ocean data cost-effective at scale with a minimum carbon footprint. Saildrone vehicles operate around the clock without the need for a crewed support vessel and have sailed almost 1 million nautical miles from the Arctic to the Antarctic and spent nearly 25,000 days at sea in the harshest ocean conditions. Saildrone has 241 full-time employees, up from 84 in 2021, and also operates an office in Washington, D.C., in addition to an Ocean Mapping and Deployment facility in St. Petersburg, Fla. Saildrone has remote pilot teams in three major time zones in California, London, and Perth, that supervise the vehicle fleet.

Tom Foldesi, Chief Revenue Officer of Saildrone, leads global sales, sales operations, business development, partnerships, and marketing. Tom brings to Saildrone more than 25 years of experience in strategy, enterprise sales, and the federal sector. Most recently, he served as SVP of Global Partner Sales at DataStax, where he led the development of the company's cloud partner ecosystem and related channel sales. Previously, he was Director of Commercial Engagement for Defense Innovation Unit in the Department of Defense, where he led the team that deployed the first sustainable DOD engagement model for innovation ecosystems. Prior to DIU, Tom held senior executive roles at LVMH and Intel. Earlier in his career, he served honorably in the United States Navy as a SEAL officer. Tom holds a BS in Quantitative Economics from the University of Pennsylvania.

EBJ: What technological advances over the past five years have enhanced Saildrone's ability to collect maritime data?

Tom Foldesi: Saildrone continues to evolve its fleet. In the past five years, the 7 m Explorer has transitioned from performing proof-of-concept and demonstration missions to operational missions for a variety of customers. We have added the 20 m Surveyor and 10 m Voyager, both of which offer more advanced data collection and security capabilities, and are scaling production of both of these vehicles. We are extending the capabilities of our two larger vehicle platforms by integrating best-in-class third-party components. For example, the integration of Starlink enables high-resolution data offloading in near real time.

Recent advancements in edge computing devices have enabled Saildrone to run increasingly powerful machine learning algorithms onboard the vehicles. These al-

gorithms, which can prioritize and generate insights over high volumes of data in real time, ensure that our customers have actionable and quality information about remote maritime environments anywhere on Earth.

EBJ: How is technology changing, and what major problems will be addressed in the near future that would have been unimaginable a few years ago?

Foldesi: Saildrone is already delivering ocean insights and performing a number of missions that were unimaginable just a few years ago. Explorer-class vehicles, equipped with a specially designed "hurricane" wing, are collecting never-before-seen data for **National Oceanic and Atmospheric Administration** (NOAA) from inside hurricanes. Saildrones, paired with underwater gliders and aerial assets, create a complete picture of the exchange of energy and momentum between the ocean and the atmosphere from 30,000

feet above the sea surface to several thousand feet below. While buoys collect similar metrics to saildrones, they are stationary and consequently require a storm to pass over them. Saildrones can sail into storms, creating not only a temporal but also a spatial time series of how the ocean and the atmosphere are interacting.

EBJ: What makes Saildrone's technology unique, and what problems can it solve?

Foldesi: What makes Saildrone technology unique is the persistence of our platforms. The use of wind power for propulsion allows our vehicles to stay at sea virtually indefinitely. Saildrones can consequently gather vast amounts of data over long periods of time to support multiple use cases.

- **Maritime defense and security:** There are a number of maritime challenges ideally suited to using uncrewed systems, including combating illegal, unreported, and unregulated fishing, drug interdiction, safety of life at sea, border integrity, and asset protection. Saildrone has developed proprietary machine-learning models that run on GPU compute processors at the edge to deliver real-time visual detection of targets that are otherwise not transmitting their position. These detection events are then fused with other data sources, including AIS and radar, to deliver a fully informed picture of the surrounding maritime domain.

- **Ocean Mapping:** Accurate and up-to-date topography of the ocean floor is essential to understanding how ocean currents move heat and carbon around the planet, sustainably managing resources, forecasting tsunamis and storm surges, safety of navigation, telecommunications, developing and maintaining coastal infrastructure, and establishing new offshore energy sites. Oceans cover more than 70% of Earth's surface, but less than 24% of the global ocean has been mapped using modern technology. The U.S. Exclusive Economic Zone (EEZ) is one of the largest in the world, but it is largely still unmapped, unobserved, and unexplored. Saildrone USVs represent a paradigm shift in how we explore our oceans, carrying the same cutting-edge sonar equipment as survey

ships to deliver high-resolution data to the global community. We are able to deliver these capabilities at a fraction of the cost and carbon footprint.

- **Ocean Research Data:** Humanity has been observing Earth's oceans for centuries, but we've only just begun to learn about the carbon cycle, how hurricanes intensify, how a change in sea surface temperature creates an El Niño or La Niña year on land, how the shape of the ocean floor affects the distribution of heat around the planet, and much more. We are not scientists and defer to experts on the interpretation of the data we provide. But we see increasing evidence that humanity's current understanding of our oceans is insufficient to confront the global challenges we will face in the coming decades. Oceans are the final frontier of exploration here on Earth. Saildrone USVs are equipped with a payload of oceanographic and meteorological sensors to collect measurements at the air-sea interface. These measurements are necessary to address research on air-sea exchanges of heat and carbon dioxide, ocean dynamics, and populations of fish and marine mammals.

EBJ: When was Saildrone founded, and how did you find your niche?

Foldesi: Saildrone was founded by Richard Jenkins in 2012. After successfully working for 10 years to break the land speed record for a wind-powered vehicle (126.1 mph), Jenkins applied his innovations to the design of an autonomous ocean vehicle. An early Saildrone Explorer prototype sailed from San Francisco to Hawaii in 2013. Saildrone partnered with the NOAA Pacific Marine Environmental Laboratory in 2015 to develop and refine the Saildrone sensor suite for oceanographic and meteorological data collection. Once the Explorer platform was proven, Jenkins designed the larger Voyager and Surveyor class vehicles to expand the company's data offerings.

EBJ: How have you grown the company?

Foldesi: Saildrone has grown organically as we repeatedly demonstrate the ability to perform persistent ocean operations and operate in increasingly challenging conditions. This rugged persistence is accom-

panied by the integration of new, more sophisticated sensors and components, opening up new possibilities for data collection for different types of customers.

Saildrones, paired with underwater gliders and aerial assets, create a complete picture of the exchange of energy and momentum between the ocean and the atmosphere from 30,000 feet above the sea surface to several thousand feet below

EBJ: How has growth been financed?

Foldesi: In 2021, Saildrone closed a Series C funding round of \$100 million to bring total investment to \$190 million.

EBJ: Tell us about Saildrone's company culture and the traits you look for in employees.

Foldesi: Saildrone's culture is cross functional, collaborative, and community based. We work at an efficient, fast pace and look for employees who show enthusiasm for our product and space, have grit (no task is too small), and are, overall, team players. The company has grown from 75 to 245 in two years with an extremely low turnover rate. We consistently focus on employee engagement and use continuous feedback loops to ensure we are keeping up with employee sentiments.

EBJ: Where are Saildrone's personnel located, and what type of presence is required for a project?

Foldesi: Saildrone is based in Alameda, California, with remote pilot teams stationed around the world. Saildrone's vehicle operations technicians (VOTs) and vehicle assembly and service technicians (VASTs) are primarily based in Alameda and travel to remote deployment locations as necessary. Depending on the complexity of the mission requirements and number of vehicles, two to four technicians are re-

quired to deploy a mission fleet.

EBJ: What do you consider to be some of Saildrone's outstanding projects?

Foldesi: Saildrone has sailed nearly 1 million nm from the Arctic to the Antarctic and spent more than 25,000 days at sea.

Highlighted missions:

• **2019 Antarctic Circumnavigation:**

When a Saildrone uncrewed surface vehicle (USV) circumnavigated Antarctica in 2019, it marked a technological triumph over some of the most extreme marine conditions on Earth. The Southern Ocean has long been thought to play a significant role in the uptake of CO₂ from the atmosphere. However, previous assumptions were based on ship-based data, which are temporally and spatially limited, given the harsh ocean conditions. The Saildrone USV was deployed from Bluff, New Zealand, on January 19, 2019, returning to the same port on August 3 after sailing over 11,879 nautical miles around Antarctica. The 196-day mission provided data that alters the science community's understanding of the Southern Ocean as both a source and a sink for atmospheric CO₂.

• **Atlantic Hurricane Monitoring (2021 – ongoing):**

Hurricane track forecasting has steadily improved in recent years. However, predicting rapid intensification—when wind speeds increase at least 35 mph over 24 hours—is still a significant challenge. To understand how these large and destructive storms grow, scientists need to collect data about the surface fluxes—the exchanges of energy in the forms of heat and momentum—a task that Saildrone's uncrewed surface vehicles (USVs) are uniquely equipped to perform. As part of this mission, Saildrone has sailed several vehicles into the eye of major hurricanes, notably Hurricane Sam in 2021 and Hurricane Fiona in 2022. 12 vehicles are deployed for this year's mission.

• **2022-2023 Aleutian Islands Exploration:**

Saildrone Surveyor SD 1200 departed Saildrone HQ in Alameda, Calif., to sail across the North Pacific to the survey area in July 2022. Between August and October, it mapped 16,254 square kilometers (4,739 square nautical miles) of unknown

seafloor around the Aleutian Islands over 52 days. During the second half of the mission off the coast of California, the Surveyor mapped an additional 29,720 square kilometers (8,665 square nautical miles) of the US EEZ and discovered a previously unknown seamount standing approximately 1,000 meters (3,200 feet) high. Identifying such seamounts improves our understanding of the physical processes of the ocean and identifies areas needing further exploration as unique habitats.

• **2021-2022 Eurosea:**

The EuroSea project, coordinated by GEOMAR Helmholtz Centre for Ocean Research Kiel, is a multi-national effort to enhance the European ocean observing and forecasting system. Two of EuroSea's primary goals are to: 1) Deliver ocean observations and forecasts that will advance scientific knowledge about ocean climate, marine ecosystems, and their vulnerability to human impacts; and 2) demonstrate how the ocean is an essential part of an economically viable and healthy society. The mission was conducted in a biologically productive and nutrient-rich area of the ocean but an incredibly difficult area for navigation, with extremely strong currents and light winds. This is an incredible testament to the endurance of the Saildrone Explorer class of vehicles. SD 1079 sailed 11,910 nautical miles and spent 370 days at sea collecting CO₂ data to improve global carbon projections and help enable sustainable ocean resource management.

• **2020 Alaska Pollock Survey:**

A 6,000 nautical mile round trip mission on behalf of NOAA Fisheries' Alaska Fisheries Science Center to perform an acoustic survey of Alaska pollock in the eastern Bering Sea. This data was intended for use in the formal stock assessment and to continue the existing time series. The mission was conceived as a contingency plan after NOAA's ship-based surveys were canceled due to the COVID-19 pandemic. All three vehicles functioned as expected, and the resulting data set will be used by the Fisheries Management Council to inform the sustainable management of the Alaska pollock fishery.

• **2017-ongoing TPOS mission:**

The Tropical Pacific Observation System was

developed to monitor oceanographic and meteorological conditions to improve early predictions of major weather events like El Niño and La Niña, critical for emergency management and economic planning. In September 2017, Saildrone partnered with NOAA to launch a series of six-month missions to the Tropical Pacific to test how unmanned surface vehicles (USVs) could augment TPOS data collection and improve long-term weather forecasting.

EBJ: Tell us about Saildrone's partnership with NASA.

Foldesi: Saildrone has worked with **National Aeronautics and Space Administration** on several missions, notably the MISST and S-MODE. NASA's Multi-Sensor Improved Sea Surface Temperature project (MISST) is an international and inter-agency collaboration to improve weather and climate research and prediction by providing better-quality ocean temperature measurements from satellites. Over a period of five years (skipping 2020), Saildrone will send a group of vehicles to the Chukchi Sea to collect surface and sub-surface data, including air temperature, sea surface skin and bulk temperatures, salinity, oxygen and chlorophyll-a concentrations, barometric pressure, and wind speed and direction.

The Sub-Mesoscale Ocean Dynamics Experiment (S-MODE) is an ambitious project led by scientists at NASA, Woods Hole Oceanographic Institution (WHOI), and the Applied Physics Laboratory at the University of Washington to understand how ocean whirlpools and eddies affect the vertical transport of heat, carbon, and nutrients that impact climate and are important for biological productivity. In October 2021, a wide variety of platforms were deployed from San Francisco, including aircraft equipped with remote sensing equipment, the research vessel *Oceanus*, surface and underwater gliders, floats, and a group of five Saildrone Explorers. The experiment took place about 75 nautical miles off the coast of California, in the California Current system. The area is historically significant as the site of several early, influential studies of submesoscale variability. A similar experiment was performed in 2022 using Saildrone vehicles. ■

ANCHOR QEA IT EMPHASIS & ORGANIZATION BUILDS AN INTEGRATED DATA ECOSYSTEM

Anchor QEA is a national firm of 500 staff with an annual revenue of \$100 million. Anchor QEA believes a multidisciplinary approach and partnership mindset are essential to solve multifaceted environmental challenges. Anchor QEA brings a full range of engineering, environmental sciences, planning and restoration, and analytics services to strategically formulate, design, and implement solutions which assess, remediate, restore, redevelop, and improve the resiliency of communities.

Mark Meyers, Principal Scientist & Data Solutions Lead, has multidisciplinary expertise in biological oceanography and information management with a 30-year career in research and consulting. Mark leads Anchor QEA's Data Solutions division and Mark's specialties include water quality and eutrophication, marine and estuarine ecology, contaminated sediment issues and organic contaminant bioaccumulation, and environmental data management. Anchor QEA's data systems include real-time monitoring, digital data collection, automated data loading, analysis, notifications, and dashboards that provide information, reporting, and visualizations.

Jill Oliver, Senior Managing Geospatial Scientist, Geospatial Science Lead, has 23 years of experience applying GIS technology in the environmental arena, including government, research, and consulting. She provides technical expertise for ArcGIS Enterprise Portal/infrastructure and supports projects with environmental geographic data management, geospatial analysis, and development of geographic web applications and StoryMaps. Jill leads Anchor QEA's Geospatial Science Group, supervising digital data collection, enterprise geodatabase management, geospatial analysis, and engagement with project teams.

EBJ: Anchor QEA has a Technology and Innovation practice. Can you tell us about it? When was it created and how has it evolved since then? And what new components will be incorporated in the near future?

Since our inception more than 25 years ago, Anchor QEA has been at the forefront of environmental research and innovation, deploying technology and data science-based solutions to meet our clients' environmental challenges. We have driven innovation in environmental data management, systems development, geospatial science, and visualization – all of which are core services at Anchor QEA. Our expertise resides in a coordinated team of chemistry, field services, database management, and geospatial staff.

Our experience gives us insight into the issues that affect data quality and the knowledge to address those issues. Furthermore, we excel at visual representation of site data to facilitate communication of complex concepts and the overall story of a project. In 2018, we established our

Innovation & Technology practice into a unique area called Shared Technical Services. As the name implies, the group serves the entire company, providing innovation and technology to all of our service areas. This group focuses on quickly assessing and deploying the latest environmental technologies.

Anchor QEA additionally promotes technology and innovation with a specialized Science, Technology, and Innovation Group which shares ideas among all facets of our company, from Shared Technical Services to our technical experts and performs R&D for emerging concepts. By sharing what we do and growing in our industry, we strive to constantly innovate and identify research and development opportunities.

EBJ: How have technologies in data solutions, geospatial science, information management, modeling, UAS, visualization, communication and computational fluid dynamics evolved over the past 2 years and how are you using them for your environmental projects?

Our biggest evolution has been integrating our different technical expertise to provide better connection across our technology platforms—primarily through the centralization and management of our digital data—from enabling our field staff to more efficiently collect data and our scientists, engineers, and planners to more easily analyze gathered data. Moving our technology and innovation group under one “roof” in our organization helped this tremendously. For all the areas listed below, our staff are actively engaged in current technologies through active participation in national working groups and internal innovation groups. Technology is not stagnant—we must constantly stay abreast of its changes.

Data Solutions: Anchor QEA uses an industry-leading commercial application and custom-developed applications during all project phases, from field data gathering to web-based presentation. We deploy the latest techniques and technologies to collect data, including low-detection-level sampling, a variety of GPS-enabled applications, unmanned aerial systems (UAS, or drones), and remote real-time monitoring systems. We manage data using EarthSoft EQuIS Enterprise, Esri Enterprise ArcGIS, and custom databases developed with Microsoft SQL Server, and we develop rich 2D and 3D visualizations using a variety of custom and commercial applications.

Geospatial Science: With a dedicated and diverse team of geospatial professionals, we innovate to solve crucial location-oriented problems. Our team specializes in web-based data management and applications, data collection, geospatial analysis, and visualization. Select examples of our geospatial science services include the following:

- Customized web application development, such as online living documents and ArcGIS StoryMaps
- Direct database connections, primarily with EQuIS chemistry for real-time visualization of project data
- Geospatial analysis including advanced Python tool deployment for client/agency use

- Remote sensing with elevation interpretation from drone data
- Visualization of data from the web to the desktop for multiple audiences
- Understanding the importance of centralized communication around data, Anchor QEA's GIS infrastructure has migrated from a private cloud to AWS over the last 2 years to better facilitate communication of data around geography.

Information Management: Our data management professionals are ecologists, engineers, chemists, database analysts, and software developers who work closely with clients to deliver data management services tailored to the needs of the project. We apply appropriate software, designing rigorous data models (relational tables that comprise a database), defining data rules that limit the risk of data entry error, and developing automated procedures for data loading and reporting. Our projects range from small, periodic collections of sediment for dredge material management and water samples for routine monitoring, to large site investigations involving extensive soil, sediment, water, biological, and air sampling, to construction management with real-time and rapid analytical turnaround with ongoing regulatory-driven data assessments. In each of these cases, we design efficient start-to-finish data workflows, coordinating field teams, laboratories, data users, and managers.

Modeling: Environmental modeling has been a core specialty of Anchor QEA since our inception. Our scientists and engineers have developed and applied a wide range of modeling tools, from simple spreadsheet-based models to extremely complex models of multiphase systems, each with the purpose of better informing critical risk management and remedial decision-making processes. Key models to address chemical fate, transport, food web, and bioaccumulation are used to understand and predict current and future site conditions. Anchor QEA has also developed and applied high-resolution, 3D hydrodynamic, wave, and sediment transport models to directly simulate erosion, deposition, sediment transport, the effect of wind waves, and the resulting feedback

on morphology. These detailed models allow refinement of project designs and can optimize the layout and configuration of capping, sediment removal, and bank stabilization actions to improve the overall cost efficiencies of cleanup remedies.

UAS: Anchor QEA uses UAS, or drone technology, in multiple ways to add value for our clients, including aerial mapping, estimation of volumes at project sites, site monitoring and surveys, agency correspondence, and video production. Utilizing drones and mapping software to program flights, our team captures photographs along specified track lines to generate to-scale maps, 3D models, and elevation models. Maps can be loaded into GIS and CAD software for analysis and reporting, including cross-section evaluations, earthwork volume estimates, and design drawing overlays. Example applications we offer to our clients include pre-construction surveys, progress tracking and post-construction monitoring, turbidity monitoring, stakeholder updates and public outreach, wetland and vegetation surveys, and habitat restoration monitoring. Our staff members are Federal Aviation Administration (FAA) Part 107 UAS certified for commercial operations within the United States. Our drone pilots are trained to conduct pre-flight checks and operate according to Part 107 rules, including consulting aeronautical charts, Notices to Airmen, temporary flight restrictions, and weather conditions.

Visualization/Communication: Effective visualization can bring clarity to the complex, whether this involves data, concepts, or project coordination and workflows. Anchor QEA has skilled staff who are experienced in creating technical and conceptual graphics that elucidate the *why*, in addition to the *how* and the *what*. Our scientists, engineers, and graphic and web designers have expertise with programming languages (e.g., Python, R, MATLAB) and applications (e.g., ArcGIS, Autodesk, Earth Volumetric Studio, Adobe Creative Suite) to create compelling and informative visualizations. They use these tools to uncover the mechanisms and phenomena that affect a site and to communicate solutions and paths forward for clients, stakeholders, and regulators.

Computational Fluid Dynamics (CFD): Anchor QEA performs multi-dimensional CFD and hydrodynamic modeling to address our clients' most challenging problems. The team uses industry-leading FLOW-3D software to simulate free-surface flows, waves, currents, and other hydrodynamics realistically and efficiently in three dimensions in natural and built environments. Multidimensional CFD modeling provides a detailed understanding of transient and complex flows, including spillway designs, fish passage, contaminant and sediment transport, river hydraulics, and wastewater system design.

By explicitly solving multidimensional equations and eliminating simplifying assumptions, CFD models allow users to unlock insights not available through other modeling methods and provide optimized solutions for free surface, pressurized, sub-critical, and supercritical flow conditions.

Example applications include the following:

- Design optimization
- Fish passage evaluation
- Sediment transport and scour modeling
- Thermal plumes
- Bank stabilization and infrastructure evaluation
- Shoreline evolution and wave modeling

EBJ: Which other technologies have you incorporated over the last two years that have had a great impact on Anchor QEA's operations and efficiencies?

Over the past few years, we have invested in our communication and connection services with key improvements just prior to COVID-19-induced remote work, mitigating work slowdowns across the company and especially in our data-intense technology and innovation service area. We migrated our CAD and GIS data and system to our private cloud. Our CAD and GIS teams access their co-located data from our datacenter. Our technology and innovation team uses our Virtual Desktop Infrastructure (VDI) that we designed and

manage. It allows our team to process, access, and store all their data in one secure location, and each team member can work from different locations effectively and efficiently. We are in the process of implementing the next generation of our VDI, which will work as well or better than our current solution, further allowing us to quickly react as we grow or accommodate workload and sprints.

EBJ: What procedures do you use to test, launch and scale innovation quickly through your organization?

Our Applications Development and Data Solutions (ADDS) Team builds our applications for internal and external projects. To ensure the best possible product, the ADDS Team works with all stakeholders prior to design and implementation to identify needs and then select a solution that will have the greatest positive impact. The ADDS Team works with stakeholders to design the solution and perform a pilot study. If the pilot is successful, they will scale the solution accordingly, implement it, and monitor it to ensure that it stays beneficial for everyone.

EBJ: How have your IT budgets changed over the past couple of years and what do you expect in the near future? And how do you see those budgets being allocated?

As we assess needs and implement changes, we have seen our IT budgets adjust to allow that kind of flexibility. Our IT budgets are fluid from year to year as we assess needs and implement changes.

EBJ: Which technologies have the potential to revolutionize our industry over the next 5 years?

Here are a few potential technologies we envision and are thinking about:

Generative Artificial Intelligence (AI): Large language models that are trained on domain-specific datasets, such as environmental engineering and science, guidance documents, or regional planning documents, to speed up information gathering, summarization, and training to guide analysis and decision-making.

Environmental Sensing and Edge

Computing: Using environmental sensors with small computers that are networked to each other and servers elsewhere. Edge computers use machine learning algorithms to monitor their own sensors to determine if a change in the environment. Coupled with local and regional data models, we hope to use this for better near-term forecasting of water bodies, smart roads, rapid transit, and other environments.

Remote Monitoring: Development of more unattended remote vehicles and robots for field measurements and/or construction in difficult environments.

Internet of Things: Connectivity of data and databases through smart connections and making field and office information sync for fewer trips into the field.

Digital Twins: Providing more virtual-based project sites that provide real-time access to data and status, which will grow as more information becomes connected from centralized data to AI.

EBJ: Are there certain type of clients that are more open to technological change? And how is the value added perceived? Which client types are more hesitant about new technologies?

We have found that most of our clients are very receptive to technology changes, especially technologies that better visually present the data to all stakeholders, help the design team understand the site model before they begin design, and provide more cost-effective long-term monitoring solutions. For construction projects, we have also found that clients want the ability to see real-time environmental and production data.

EBJ: And how is the industry adopting new platforms? How are public agencies doing it and is it generating additional public engagement?

As technology improves and our capabilities expand, we strive to find ways to improve innovation, increase cost-effectiveness, and tell our clients' stories clearly. Additionally, public agencies want to be more transparent regarding data sharing with all stakeholders, which encourages their consultants to continuously look for

ways to meet that need by leveraging technology.

EBJ: In which ways does the data ecosystem need to evolve, mature and expand to support the next generation of compliance and problem solving?

In the rapidly evolving landscape of environmental services, the data ecosystem must mature to meet new challenges, facilitate compliance with evolving regulations, and drive innovative solutions to complex and interconnected environmental problems. A few key aspects that require attention include the following:

Integration and Interoperability: Seamless integration of diverse data sources and platforms is paramount. We need systems that can easily communicate and share data with each other, allowing for robust data analysis. At Anchor QEA, our teams are deploying various data collection technologies on a given project. Enabling seamless communication between these systems allows us to quickly consolidate and analyze this data, thereby making timely and informed decisions.

Scalability and Flexibility: The data ecosystem must be able to scale up or down in response to project demands and must adapt to new technologies or data types. With our growing operations, especially in geospatial analysis and modeling, we need our systems to handle increasingly larger datasets without a proportional increase in cost or complexity.

Security and Compliance: Ensuring data security and maintaining compliance with ever-changing regulations are vital. Systems need to have built-in mechanisms for securing data and ensuring that they adhere to current regulatory requirements. We store and process sensitive environmental data, so our IT infrastructure is designed to meet stringent security and privacy standards, reducing the risk of data breaches or non-compliance.

Data Quality and Standardization: The ecosystem should encourage and enforce high standards of data quality and standardization, making it easier for diverse stakeholders to understand and use the data effectively. When we utilize drone

technology for site assessments, we employ rigorous protocols to ensure the data collected meets high standards of accuracy and consistency.

Advanced Analytics and Machine Learning Integration: To support next-generation problem-solving, the data ecosystem needs to seamlessly integrate with advanced analytics tools and machine learning algorithms. In our work on sediment transport models, integrating machine learning algorithms helps us make more accurate predictions based on large and complex datasets.

Accessibility and Collaboration: Data should be easily accessible to various stakeholders, from field staff to executives, while supporting collaboration across disciplines and industries. Our teams at Anchor QEA span multiple disciplines, each contributing unique data to our projects. Creating a central, accessible data repository enables effective collaboration, both internally and with our clients and partners.

Visualization and Storytelling Tools: The data ecosystem should evolve to incorporate more sophisticated visualization and storytelling tools that make complex data comprehensible to non-expert stakeholders. At Anchor QEA, we use a suite of visualization tools to communicate complex environmental scenarios to our clients, regulatory bodies, and the public, enabling clearer understanding and dialogue.

Sustainability and Environmental Consciousness: As an environmental company, we prioritize data operations that reflect a commitment to sustainability, opting for solutions that minimize environmental impact. Our migration to a virtual desktop infrastructure not only enhances our operational efficiency but also reduces our hardware footprint, contributing to our broader sustainability goals.

The data ecosystem needs to evolve into a more integrated, secure, flexible, and user-friendly environment. This maturation will enable companies like Anchor QEA to continue delivering high-quality, compliant, and innovative solutions in the ever-changing landscape of environmental services. ■

ECOBOT STREAMLINES DELINEATION OF AQUATIC RESOURCES, PLANS EXPANSION INTO OTHER ENVIRONMENTAL SEGMENTS

Ecobot (Asheville, N.C.) was designed from within the environmental and architecture, engineering and construction (AEC) industries as a digital solution for mandatory pre-construction environmental assessments and reporting. Ecobot streamlines the process, eliminating errors and ensuring data consistency to support quicker project turnarounds. Ecobot also provides a framework for managing and analyzing environmental data over time and in a variety of contexts. Environmental data collected during permitting is valuable both for planners and engineers as they design and build climate-resilient assets and in terms of ecological insights and long-term planning for preservation and biodiversity. Ecobot has provided a tool for collecting and managing data at scale. Ecobot has been used to generate over 100,000 regulatory reports, encompassing more than 1 million biodiversity and water-related data points. Customers range from global enterprise companies to small businesses.

Lee Lance is Co-Founder and CEO of Ecobot. Lee is a communications and operations professional with 20 years of experience driving technology development and strategy, serving regional, national and international clients.

EBJ: How has fieldwork changed, and is technology providing efficiencies that were unavailable five years ago?

Lee Lance: Fieldwork and permitting have, until quite recently, been paper-driven processes. Not only was this cumbersome, especially in an outdoor environment, but data was static and difficult to manage and use long-term. The availability of technology in the field has exploded in the past five years, from GNSS/GPS devices to field data collection applications installed on readily available mobile devices. There are lots of ways to get your data in – some better than others – and at Ecobot, our focus, beyond driving efficiency and saving time in the field and office, is on maximizing ways for our customers to utilize this data long-term, even beyond the permit.

EBJ: How has Ecobot's platform evolved since the company was founded?

Lance: Ecobot originated as a digital solution for the wetland delineation process, one of the many mandatory environmental assessments needed before construction starts. The goal at the outset was to streamline this process, driving efficiency during fieldwork and reporting. As Ecobot has grown, we've expanded the platform to

allow customers the ability to manage and utilize huge volumes of data in a meaningful way.

EBJ: Is Ecobot looking into incorporating additional products or technologies? Which problems are you trying to solve for your customers?

Lance: The most successful technology platforms across all industries are those that deeply integrate with the tools and applications already established within an organization. We believe that this is essential for technology in this space as well. We're **ESRI** partners, and our platform functions as an extension of ArcGIS FieldMaps by allowing our customers to push their data into the Esri tech stack as a feature service layer.

We are partners with all of the major GNSS/GPS hardware providers, ensuring geospatial accuracy during field data collection and reporting, which is essential to ensure further downstream value. As we expand the Ecobot platform, we are working to deepen our existing partnerships, and include others such as Autodesk and Bentley Systems. We view these integrations and partnerships as tools to help planners and engineers create a more climate-resilient built environment by pro-

viding them a platform to easily consume data regarding environmental resources occurring on a site.

EBJ: Can you share details about Ecobot's collaborations and partnerships?

Lance: We've worked closely with Esri since Ecobot's inception—we went through the Esri Startup Program, and we've since become Silver Partners. We work with GNSS providers like Hexagon/Leica, Trimble, Juniper, Eos GNSS, and more. And we're always collaborating and learning from others in the conservation and policy research fields, like EPIC and NatureServe.

EBJ: What other key technology trends do you see in our industry?

Lance: While not currently considered a tech trend, permitting reform *should* be one. Sadly, better technology (and better data) are nearly absent from this conversation when they should be the drivers behind effective regulatory policy. Policy and permitting reform will only get humankind so far and it's better technology and better data that will help us accomplish the purpose of environmental policy: to conserve natural resources and better connect people to the planet.

EBJ: What impact are new regulations having on how you use technology? How have you used it as an opportunity to expand your services? Which of these are generating more demand and profit?

Lance: Ecobot allows our customers to spend more time being scientists. As a workforce enablement platform, the field consultant handles the assessment and data collection, while Ecobot performs the calculations and provides suggestions based on the regional guidance documents.

The recent Sackett v. EPA decision by the Supreme Court to roll back federal wetland protections and the uncertainty this ruling has created is extremely concerning. Environmental policy and permitting processes will continue to evolve, but the need to collect usable data and put that data to use in a more resilient manner becomes even more critical. Market tailwinds ranging from UN climate and biodiversity initiatives to ESG promises by

companies to their stakeholders to the increasing awareness of how biodiversity and ecosystems impact capital markets are only increasing.

As we expand the Ecobot platform, we are working to deepen our existing partnerships and include others such as Autodesk and Bentley Systems.

Regulations are not the only drivers of technological advancements and integrations. Take, for example, the Infrastructure Investment and Jobs Act (IIJA) and the Inflation Reduction Act (IRA). Both are demand-drivers for technologies like Ecobot. We need to modernize our infrastructure, and these bills task us to do that with sensitivity to the environment via sustainable and resilient planning. In order to spend the money flowing out of these bills and achieve the goals for our infrastructure, we have to address the fact that – in addition to the bottleneck of permitting processes – there is a need for a larger workforce than is currently available.

Applied environmental knowledge is going to be in high demand over the next five to 10 years, and the regulated community needs the right technology to more efficiently conduct their jobs and generate data that can help us make better decisions about economic growth, especially as it applies to the built environment.

Ecobot currently provides a solution for streamlining the documentation and reporting on aquatic resources, which represent some of the most highly regulated ecosystems we have. We're in the process of expanding our platform to address all other environmental-related sectors to address the broader need. While our operating footprint is currently restricted to the United States and portions of Canada, we believe our approach has a global application. ■

Environmental Industry Webinars 3rd Friday of Every Month: Available in Audio Form

EBI Webinars are monthly strategic market segment presentations and interactive discussion panels with 90-120 minutes of audio & video content, and one combined presentation file.

EBJ Monthly Webinar Archive

August 2023: Forest Carbon:
Michael Ackerman, CEO of EcoForests,
Joshua Fisher, climate scientist at
Chapman University

July 2023 ESG Revisited
Michelle Bachir – MD, Sustainability
Advisory North America – Arcadis
Eric Wooten – Environmental
Department Manager – Terracon
Dean Slocum – President – Acorn

June 2023: Market Evolution
Scenarios for PFAS in Water,
Wastewater and Remediation
Panelists: John Simon – Gnarus
Advisors (PFAS Expert Symposium)
Frederic Andes – Barnes & Thornburg
Stewart Abrams – Director of
Remediation Technology – Langan

May 2023: AI and Human Resources
In The Era of Digitalization
Panelists: Cara Corsetti – Senior
Principal, Environmental Services –
Stantec
Paul Goudreault – Business & Career
Coach – Enorine Partners

April 2023: Growth and Strategy in
Changing Ownership Models
Tony Brindisi – Managing Partner –
RTC Partners
Jesse Kropelnicki – Chief Operating
Officer – Verdantas

March 2023: Strategic Options for
2023: Capital, Acquisition & Growth
Tom Secker, SVP of corporate
development with Trilon Group,
Steve Gido, Principal, ROG Partners

BST ENABLES LEVERAGING OF AI AND DIGITAL INNOVATION TO OPTIMIZE OPERATIONS

BST Global provides enterprise management software for the AEC (architecture, engineering/consulting and construction services) community.

Carlos A. Baldor Jr. is president & chief technology officer of BST Global. In addition to helping drive BST Global's business strategy execution, Carlos mentors the next level of BST Global's future leadership. He works closely with the operations and product delivery teams as a continuation of his responsibilities as vice president. Carlos joined BST in 1988 as part of the documentation team, and in 1990 became a member of the design team for BST RDBMIS. In 1993, he was named manager of the training and support teams, and from 1997 to 2005, manager of the product development team — when BST Enterprise was designed, developed and brought to market. In 2005, he was named director of design, and was involved in new product development. In 2016, he was appointed vice president, overseeing the operations and product delivery teams. He was appointed president in 2020, and chief technology officer in 2021. The Q&A below was shared by Environment Analyst ahead of his presentation EA's Global Business Summit in June 2023. Baldor was on a panel discussion on leveraging data and digital innovation to effect operational optimization, provide new solutions, add value and help achieve environmental & sustainability goals.

EA: There's been a lot of excitement about ChatGPT — what is your opinion about such AI applications for this industry and is it something BST Global is involved in?

Carlos Baldor: Large language models like ChatGPT are quite possibly the most impactful innovation right now in terms of changing how the AEC industry works. They're capable of synthesizing vast amounts of information into narratives or renderings that offer not just a retrieval of information but rather a novel, unique response to the prompts provided. This marks a significant shift in capability and engagement within human/computer interactions.

Examples of relevant use cases include using tools such as Midjourney and/or ChatGPT to more quickly generate conceptual renderings for architecture or civil engineering. As the versions of these tools have evolved over the past year, the renderings have become more detailed and allow for refinements to be done more easily.

At BST Global, we introduced our first AI project in April this year, as part of our Project Intelligence™ initiative, aimed at addressing the volume of labor-intensive analysis and optimizing operations by re-

placing rear-facing models with tools that are predictive. In terms of large language models, we're investigating the technology just starting to be pursued by the likes of Microsoft and Google from an enterprise use case.

Though large language models have been available for many years, the area has come into particular focus in the past six months with the introduction of ChatGPT 3.5. The surge in interest has also caused concerns to be raised about the potential issues. I am personally concerned because this technology comes on the heels of many technologies that eroded our privacy for the benefit of convenience.

EA: How can implementing digital technology alleviate the skills shortage?

Baldor: As well as potentially, eventually, increasing annual global GDP by 7%, after widespread adoption, AI is expected to raise annual US labor productivity growth by close to 1.5 percentage points over 10 years.

Estimates suggest that it could also automate up to a quarter of current work tasks in the US, with particularly high exposures in administrative and legal professions. The next tier of high exposures includes

architecture and engineering, science (life, physical and social), and operations (business and financial). The lowest exposures are in physically intensive professions such as construction and maintenance (source: Goldman Sachs – The potentially large effects of AI on economic growth).

EA: How can integrated digital solutions help tackle environmental challenges?

Baldor: A good example is the work that many of the electric companies in California are doing to help avoid forest fires as wildfire seasons are becoming longer. They are using data models to develop early warning systems and enhance power line safety settings. The program based on those data models allow them to identify which safety settings need to be enabled and when across all 25,000 miles of transmission lines in areas of high risk (source: Youtube: How Palantir and PG&E are Powering the Grid.)

EA: What new challenges and overheads does digital bring? How are these dealt with?

Baldor: To me, our biggest overhead is the general lack of focus time required to solve the significant challenges before us.

Recent surveys from Microsoft highlight that most people (68%) say they don't have enough uninterrupted focus time during the day. They back this up by looking at stats they collect through Microsoft Office 365, which indicate that communication (meetings, chat and email) comprises 57% of one's time, while creation comprises only 43% of one's time.

Focus time, which is defined as two or more hours of completely uninterrupted work time, is probably one of the greatest challenges given the multitude of attention-grabbing elements around us. According to multiple studies, the real challenge presented by interruptions is that it takes an average of 25 minutes to get back on track. The result of these constant interruptions lowers one's IQ as much as losing one night's sleep.

EA: How might the implementation of a comprehensive digital solution

typically affect a company's carbon footprint?

Baldor: One way of affecting a company's carbon footprint is by moving workloads to the cloud. At the simplest levels, cloud data centers save energy because they achieve very high virtualization ratios, typically on newer, more efficient equipment than is used in on-premise data centers. An added benefit is that, increasingly, they are using high levels of renewable energy. For example, Microsoft Cloud is between 22% and 93% more energy efficient than traditional enterprise data centers (source: The carbon benefits of cloud computing). If you take into account Microsoft's renewable energy purchases, the Microsoft Cloud is between 72% and 98% more carbon efficient.

EA: What sorts of partnerships can contribute to effective and efficient use of digital technologies?

Baldor: A great example is the partnership between local municipalities and engineering experts to help operate wastewater treatment plants. In one particular case (Palantir and Jacobs – Optimizing Plant Operations at Scale), the project's aim was to get to predictive operations — knowing what is going to happen before it happens — which allows for extra optimization. This has resulted in 20% plant-wide power savings, eliminated operational fines and reduced greenhouse gas emissions with the potential of millions of dollars of savings.

All this was achieved by breaking down data silos across ERP, maintenance systems and sensor data, and pulling data into one place so that operations could react to early leading indicators. AI models were run over this centralized data to real-time updates in the field. ■

Large language models like ChatGPT are quite possibly the most impactful innovation right now in terms of changing how the AEC industry works.

WSP SHOWS HOW DIGITAL TWINS CONTRIBUTE TO INFRASTRUCTURE RESILIENCE

When planning for infrastructure, a key challenge and need is building in resilience. Recent experience with COVID-19 has highlighted the importance of infrastructure's adaptive capability; future unanticipated events will surely retest operational resilience to short-term shocks and long-term uncertainties. In the following Q&A, WSP Insights questioned Thomas Coleman, then Manager of Technology Integration at WSP, to explore how digital twins can drive optimal outcomes for infrastructure projects and the communities they support. Tom Coleman is now Vice President of Visualization and Data Intelligence at WSP USA.

What is a digital twin, and why are digital twins important in infrastructure projects?

Thomas Coleman: A digital twin is a virtual replica of an asset that incorporates associated real-time data during operation of that asset. It provides an immersive and integrated visualization of previously siloed information and enables use of modern digital analysis techniques, such as condition-based monitoring and predictive analysis, to plan for the continued functioning of infrastructure. For example, in 2015, WSP advanced the first phase of a digital twin of Chicago to support the O'Hare express rail project. This phase allowed the analysis of multiple rail routes within a 3D model to better understand and optimize the factors that affected express rail routes to O'Hare International Airport.

Whether for an entire city, a bridge, a highway, a building, a site with numerous buildings, or an airport, a digital twin provides for well-informed decision-making throughout an asset's lifecycle. The ultimate vision for the application of a digital twin is to create a system of interconnected digital twins for infrastructure within a city, region—or nation, as envisioned by the United Kingdom, for example.

How do digital twins advance Building Information Modelling (BIM)?

Coleman: BIM is a process based on 3D modeling for planning, designing, constructing and managing infrastructure. Both BIM and a digital twin can be used to facilitate a collaborative working environment so that project teams and key stakeholders can visualize a wealth of proj-

ect data upfront from a common knowledge base; and both assist with the diverse aspects of project development. However, BIM is not designed for real-time operational response, which is the distinguishing feature of a digital twin. In this way, a digital twin is the next evolutionary step of BIM.

A digital twin for infrastructure can be continuously updated with big data from multiple sources, enabling improved testing of what-if scenarios, analysis of the interdependency of multiple systems and simulation of risks and vulnerabilities—all toward the development of the asset's resilience.

What tools support data collection for digital twins?

Coleman: Satellites, planes, drones, sensors and robotic devices are some of the geospatial tools that now provide cost effective, automated and continuous data collection beyond human capability. Typically, a digital twin starts out as a static 3D BIM model of an infrastructure asset. Drones with Light Detection and Ranging (LiDAR) can be used to generate a point cloud 3D model and accelerate the development of a 4D digital twin model, to apply the dimension of time, immersive visualization and machine learning analytics.

Potential use is expanding. The Covid-19 crisis has called attention to digital twins as a means to simulate the movement of people in buildings, transit stations and other public places, and enable heightened analysis of situational health risk—thereby highlighting digital twins as an indispensable tool for infrastructure planning and design.

Do digital twins bring gains beyond infrastructure development?

Coleman: Our global project experience with digital twin implementation demonstrates that increased data usability through geospatial techniques, big data, 3D modeling and cloud computing can lead to productivity improvements and cost savings. These gains come through analysis of the performance of processes and assets, identification of issues, and application of artificial intelligence for predictive analysis during the lifecycle of an infrastructure project.

The ease and cost effectiveness of big data collection and IoT does intensify the need to manage data well, to maximize the value of data flowing into a digital twin.

You mentioned that digital twins provide an integrated perspective to inform decisions. How can these decisions help bring about sustainable outcomes for communities?

Coleman: By seeing infrastructure as an ecosystem, or a complex system of interconnected and interdependent elements, those involved in project planning, design and implementation can consider how multiple factors might affect outcomes not only for the infrastructure asset but also the environment and all the people in each community. Key stakeholders can then share their recommendations and shape the best decisions for the design, construction and operation of an infrastructure asset, and bring lasting benefits for society.

Digital Twins Advance Sustainable Infrastructure

In WSP's work with digital twins, you note they are an indispensable tool for infrastructure planning and design. How would you characterize progress since in the last couple years?

Coleman: Cloud architecture, especially over the past two years with changes in work practices, has provided the opportunity to align everything we do as a company with a 'Future Ready®' mindset. Future Ready is WSP's global innovation programme. Today, we have greater understanding about what digital delivery

encompasses and what steps we should be taking now to implement a digital twin solution for bridges, highways, transport, and building projects. This greater understanding has enabled us to apply digital twins to more projects, such as in the IBR [Interstate Bridge Replacement] program. The IBR digital twin includes 56 bridges—54 landside bridges and two Columbia River Crossing bridges—on about five miles of Interstate 5, the main north-south interstate highway on the West Coast in the United States, stretching from the border with Canada all the way through California to the border with Mexico.

The Interstate Bridge across the Columbia River is a critical connection between Oregon and Washington states on I-5, supporting local jobs and providing a trade route for regional, national and international economies. The Washington and Oregon State Departments of Transportation seek to replace the aging interstate bridges with a modern, seismically resilient multimodal structure, or possibly structures, to provide improved mobility for people, goods and services.

How can a digital twin bridge vast distances to address project requirements?

Coleman: Digital twins are elevating collaborative capabilities as they provide an immersive and integrated visualization of previously siloed information, which may relate to a vast distance between project team members such as with the IBR project. Building collaboration is essential to meeting the objectives of our clients—two state DOTs, Washington and Oregon—plus many federal, state, regional and local partners. A digital twin base gives project team managers the awareness that enables them to communicate the vision of what can be done during the start-up of a project and to scope, mobilize and deliver digital solutions effectively.

The digital twin incorporates reality data from drones, mobile LiDAR [light detection and ranging] and aerial mapping. Once we have the reality data specific to projects, we can easily build a 3D model to create a digital twin that enables early consideration of multiple project aspects. For example, now with digital twins, we have

been able to immediately consider sustainability aspects such as how to reduce carbon emissions in the design of the project and the cost reductions or increases associated with those changes. We can model sustainability into our design workflow directly and make adjustments—corrective actions—based on what the model tells us. With the addition of machine learning, we can create a dynamic model that can simulate and predict how infrastructure assets and transport networks will perform in real life. The elements of a digital twin are reviewed and updated throughout the project lifecycle until decommissioning of the infrastructure asset.

Expand upon how digital twins are advancing effective work environments?

Coleman: Digital Twins provide a scalable, timely and effective transition from planning into design and the construction phase and then to maintenance and operations. A common data environment [CDA] aligns information systems—including CAD, GIS, 3D BIM, public outreach data, project controls, design information, traffic and sensor data, asset data and other related information—to manage a digital twin, which shows the project team the physical and functional characteristics of the whole project. In this way, the CDA enables more effective work environments and upfront project development to support sustainability pillars. We can test, validate and alter the performance characteristics of what we design to meet the different sustainability pillars we need to address such as carbon reduction. Ultimately, in the long run, we see this collaboration extending across the entire supply chain—toward even more open, evergreen infrastructure digital twins—where carbon calculation and optimization are intrinsic to and transparent in all stages of the infrastructure project lifecycle.

So... collaborative work and digital twins are mutually reinforcing?

Coleman: Yes. Before digital twins, we had one path of information and transferred that information from a person or group of people to another person or group. Now, with digital twins, we can converse across disciplines, such as design and asset management; we can assess dif-

ferent characteristics early in the project at the concept design stage and enable timely modifications and updates throughout a project's lifecycle.

Also today, we can use IoT and artificial intelligence [AI] to add data to visualizations and make decisions across departments; we can put ourselves inside of the virtual model of a city, for example, and interact with it—a process now called the metaverse; we can better relate the design to the context of the world around us. We can test and validate elements of infrastructure—bridges, roadways, transit, and buildings—before construction; we can create dynamic models that simulate and predict how these assets will perform in real-life contexts. Three-dimension reality models provide the basis for visualizing, collaboratively managing, and monitoring changes to infrastructure during the project and when the asset is in operation.

What benefits can digital twins bring to client organizations across infrastructure sectors over the long term?

Coleman: Digital twins allow us to be more informed and take a systems approach to our projects, which expands our universe of understanding about the environments in which we live and work.

With this systems approach, digital twins enable understanding of how elements of infrastructure interact before investing. For example, through linking visualization to actionable data we can determine how to make a bridge stable in a seismic area or understand how a flood-gate responds on a bridge under certain circumstances, especially important as the world increasingly deals with climate change impacts. The need to mitigate risk and build resilience is common to all infrastructure projects, and we can do that with digital twins.

Concerning sustainability, in addition to building resilience and supporting decarbonization, how can digital twins advance social equity?

Coleman: A digital twin provides a platform to evaluate factors that support social equity. For example, in order to address the underlying factors that impact acces-

sibility in transportation, a 3D view can be evaluated with AI to identify and fill gaps in transport services. All kinds of valuable data can be generated from the project models to promote increased transparency and understanding of infrastructure planning, design, maintenance and operational issues with project stakeholders.

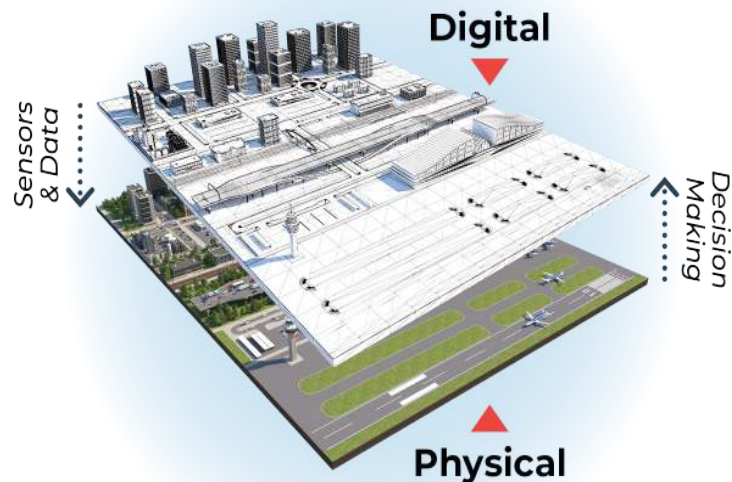
The digital twin perspective also allows early consideration of the short- and long-term impacts of infrastructure-related decisions on human health and wellbeing as we now have the capability to apply the re-

sults of economic, social and environmental impact studies in projects well before construction. In terms of supporting and advancing sustainability, it is worth repeating that digital twins can inform the entire lifecycle of a project from concept to design, into construction and through operation. Sensors, IoT and real-time data enable the analysis of essential considerations and the ability to simulate potential impacts of decisions, which is game-changing for advancing sustainability outcomes including social equity. □

What we're dealing with is a tipping point in our industry.... We used to do our work based on paper ... [now] we've had to refocus our whole digital mindset. Digital twins can inform the entire lifecycle of a project from concept to design, into construction and through operation. Real-time IoT data and sensors on operations and facility behaviour enable the analysis of these considerations and the ability to simulate potential impacts in decision-making.

Tom Coleman, WSP USA Vice President, Visualization and Data Intelligence

**Isometric View of 3D Objects Embedded With Data—
Applied In the Development of a Digital Twin**



Elements of a digital twin - A digital twin is a virtual replica of an asset that incorporates associated real-time data during operation of that asset. It provides an immersive and integrated visualization of previously siloed information and enables use of modern digital analysis techniques, such as condition-based monitoring and predictive analysis, to plan for the continued functioning of infrastructure.

Source: WSP Insights, WSP Global Inc.

NV5 USES TECHNOLOGY INVESTMENTS TO EXPAND NEW PRACTICES AREAS AND DEEPER INTO KEY CLIENT SEGMENTS

NV5 Global Inc. (NASDAQ: NVEE) is a provider of technology, conformity assessment, and consulting solutions for public and private sector clients supporting sustainable infrastructure, utility, and building assets and systems. NV5 focuses on multiple verticals: Construction quality assurance, infrastructure engineering, utility services, buildings & technology, environmental health sciences, and geospatial technology services to deliver innovative, sustainable solutions to complex issues and improve lives in communities. NV5 operates out of more than 100 offices nationwide and internationally. Gross revenues for the six months ended July 1, 2023 were \$407 million compared to \$393 million in 2022. Gross revenues in 2022 were \$786.8 million compared to \$706.7 million in 2021, an 11% increase.

Lisa Kay is Chief Growth Officer at NV5. Ms. Kay has over 30 years of experience leading and growing companies in the AEC industry. As Chief Operating Officer of Environmental Health Sciences at NV5, Lisa provides leadership to ensure clients experience exceptional client service and project solutions developed by the best and brightest technical experts in the industry. Lisa joined Long Beach-based Alta Environmental as a partner and its President in 2014, building and growing the firm to win Best Firm to Work For and Hot Firm Awards from Zweig Group. In June 2019 Alta was acquired and is now an NV5 Company.

EBJ: How has the growth strategy of NV5 evolved?

Lisa Kay: NV5 provides technology, conformity assessment, and consulting solutions for public and private sector clients supporting infrastructure, utility, and building assets and systems in six business verticals: infrastructure support services, construction quality assurance, utility services, buildings & program management, environmental health sciences, and geospatial technology services. NV5 has thoughtfully and deliberately expanded our service offerings to meet the future demands of resiliency for the infrastructure and the natural environment through the six service verticals.

In addition to our engineering and consulting services to develop and deliver resilient solutions, our acquisition and organic expansion of our geospatial services and technologies supports this vision, as does NV5's growth and acquisitions in the energy efficiency and clean energy consulting services. Five 2022 acquisitions included **GEO1**, and growth strategy in the geospatial sector focuses on three of the largest markets for geospatial services: the federal government, state and local governments, and electrical utilities.

EBJ: How have you added to the capabilities and practice areas of the firm, particularly in the technology area?

Kay: Core competencies in engineering, program management, environmental health sciences, and construction quality assurance are supported by expertise in big data services, geomatics, business solutions, cloud services, infrastructure security, analytics, and professional services. Our technology solutions include Lidar, HD Video, Ortho imagery, Hyperspectral, Forestry Biometrics, Hydrologic Modeling, Emergency Management, Natural Resource Mapping, bathymetric Lidar, Digital Twin, Software, and Robotics.

NV5 is one of 12 U.S. firms that have earned Esri Platinum partnership, and the only firm with active participation on both the Esri Chief Technology Officer

and Partner Advisory Councils. We are the only firm to achieve Platinum Partnership with both Esri and Cityworks.

Earlier in 2023 NV5 acquired **Axim Geospatial** and the Visual Information Solutions commercial geospatial technology and software business ("VIS") of **L3 Harris**. The acquisition of both of these companies strengthened NV5 technology service platform to its clients. The VIS acquisition included 16 U.S. Patents for geospatial data analytics. NV5 also received ownership of an additional 13 U.S. and non-U.S. Trademark Registrations for leading geospatial software applications with approximately 500,000 global users. These software products include prominent applications such as ENVI, IDL, Jagwire, Amplify, and Helios, which are relied upon by the United States Department of Defense and federal civilian agencies for the analysis and management of geospatial data.

EBJ: What is your investment philosophy regarding technology and ownership of technology-related assets?

Kay: NV5 is committed to the investment in and use of innovative and emerging technology. Getting good data to develop sound solutions means having the best tools and technology. We invest in and deploy the latest and most advanced sensor, platform, and survey technologies on the market to acquire geospatial data. We utilize satellites, drones, fixed wing aircraft and helicopters to collect data as well as remote operated robotic devices. NV5 owns three oceangoing vessels to support our clients demand for nearshore and offshore surveys to support coastal resilience and energy infrastructure.

EBJ: How are you using technology to provide new services and to incorporate new business models?

In addition to our engineering and consulting services to develop and deliver resilient solutions, our acquisition and organic expansion of our geospatial services and technologies supports our vision, as does NV5's growth and acquisitions in the energy efficiency and clean energy consulting services.

Kay: In addition to our utilization of technology for new developments such as clean energy projects, helping our clients achieve regulatory compliance requirements has also driven our use of technology. Water conservation in California has resulted in our deploying geospatial technology to track water usage as well as utilize low flow monitoring devices to detect real time irrigation overflow in conveyance systems.

Clean buildings performance standards which have been put into place in several states have resulted in building owners seeking our use of building and campus scale digital twin technology and advanced analytics to improve energy efficiency, building system management, and reduce operational costs.

EBJ: In which ways are you using augmented or virtual reality and deploying digital twins?

Kay: Digital twin is the hottest topic, but it seems to mean different things to different people. We have found it needs to be defined in terms of scale and use case for clients. We use augmented virtual reality and digital twins to support a variety of applications. NV5 has been utilizing scan to BIM to support our clients in mitigation of construction risk at a variety of facilities and buildings.

We have utilized digital twins at the regional scale, city scale and building scale to support client information storage, analysis, infrastructure planning, and management needs. Scan to BIM has been highly useful and is increasing in demand.

Digital twins at a city or community scale, while slow to take off, have been recently of increased interest to clients as they look to model and manage sustainable infrastructure in consideration of a variety of concerns; from disaster mitigation to infrastructure maintenance to climate resiliency, we are experiencing growing interest in use cases for digital twins at a larger scale. The investments in technology made by NV5 have advanced the solutions we are able to provide, and we continue to seek new opportunities for using technology to efficiently serve our clients' needs. ■

NV5 2023 Acquisitions Add to Technology Portfolio

NV5 Acquires Red Technologies, Strengthens Data Center and Mission Critical Services in Asia Pacific

In August 2023, NV5 acquired **Red Technologies**, a provider of information technology and utility infrastructure services for mission critical data centers. Red Technologies clients include large international technology and financial services companies that depend on data centers and cloud services for their operations. The data center market is experiencing rapid growth, particularly in the Asia Pacific, as deployment of 5G service, increased reliance on smartphones, and demand for connectivity drive the expansion of cloud service. 'Red Technologies' information technology and utility infrastructure design and implementation services complement NV5's existing MEP design and commissioning services to provide a distinct value proposition throughout the entire data center lifecycle and a competitive advantage.

NV5 Completes the Acquisition of L3Harris Subscription-Based Geospatial Software Business

In April 2023, NV5 acquired **L3Harris Technologies, Inc.**'s Visual Information Solutions commercial geospatial technology and software business ("VIS"). The acquisition supports NV5's expansion in a subscription-based geospatial product and service model and strengthens its role in supporting the nation's defense and intelligence communities through geospatial information management and analytics. The VIS acquisition includes 16 U.S. Patents for geospatial data analytics. NV5 will also receive ownership of an additional 13 U.S. and non-U.S. Trademark Registrations for geospatial software applications with approximately 500,000 global users. These software products include prominent applications such as ENVI, IDL, Jagwire, Amplify, and Helios, which are relied upon by the United States Department of Defense and federal civilian agencies for the analysis and management of geospatial data.

NV5 Acquires Axim Geospatial, a Leading Provider of Geospatial Solutions to Support Defense and Utilities

In February 2023, NV5 acquired **Axim Geospatial LLC**, which expanded NV5's capabilities in the federal defense and intelligence sectors and strengthens NV5's leadership position in geospatial utility solutions. Axim's industry-leading enterprise geographic information systems (GIS) also strengthen NV5's GIS capabilities through cloud managed services, delivering secure and scalable offerings to meet the growing need for GIS data and analytics.

In June 2023, NV5 announced that its acquired subsidiary, Axim Geospatial was awarded a prime contract with the National Geospatial-Intelligence Agency (NGA) under the GEOINT Enterprise Operations Service and Solutions Program with Industry, Core Mission Operations. GEO-SPI B is a seven-year, multi-award contract vehicle valued up to \$900 million and focused on delivering trusted geospatial intelligence (GEOINT) to NGA's Analysis and Source Directorates. The GEO-SPI B award is Axim Geospatial's largest contract win to date. GEO-SPI B is the follow-on contract to NGA's Multi-Intelligence Analytics and Collection Support Services (MACSS) contract, the largest geospatial staff augmentation program in the agency. Under the GEO-SPI B contract, Axim will apply domain expertise, automation, and innovative solutions to improve outcomes and enhance NGA performance across multiple mission sets. Axim's automation will include process automation, computer vision capabilities, and algorithms to address mission specific challenges, capabilities that are now coupled with NV5's broader capabilities to deliver high-end machine learning analytics and maritime domain analysis.

SWCA USES IMAGING TECHNOLOGY TO GET BOOTS OFF THE GROUND AND FRONT-ENDS PROJECTS WITH ChatGPT

Since 1981, SWCA has helped public and private clients overcome environmental challenges and move their projects forward. Our 100% employee-owned firm offers comprehensive sustainability advisory, environmental planning, regulatory compliance, and natural and cultural resources management services. We work together to understand the full life cycle of any project, from inception to completion. In the face of rapid environmental, economic, and societal changes, our purpose is simple: to preserve natural and cultural resources for tomorrow while enabling projects that benefit people today. We do that by offering a suite of environmental consulting services combined with local knowledge, regulatory expertise, and high-quality service. We build long-term, trusting relationships with our clients and guide their projects to successful completion. With a global presence, SWCA is able to rapidly pool resources and respond to our clients' needs.

Linda Lannen, Chief Technology Officer. Ms. Lannen has more than 20 years of experience in the AEC industry, tackling the most daunting of technology projects, including ERP system replacements, wide area network migrations, data center to cloud migrations, and implementations of enterprise security programs. She has previously worked for a variety of firms, ranging from dot-coms to Fortune 500 companies, and across industries including environmental engineering, telecommunications research, and food manufacturing.

EBJ: In which ways is advanced imagery adding value to our industry? Which new technologies are coming out and how do you think that those technologies will evolve over the next 5 years?

Linda Lannen: We have developed unique capabilities to leverage imaging from a variety of sources – satellites, fixed wing and rotor wing aircraft, drones, and people on the ground. Satellite data is great for monitoring site changes over time, whether it's construction, vegetation, or damage from natural disasters.

We currently employ a variety of sensors, as well, from LiDAR to multi-spectral and infrared, to meet our clients' needs on diverse projects. One of the most exciting new services we offer is methane gas leak detection from our UAVs. The ability to pinpoint which fitting on a well is leaking provides actionable information to our clients. Other services we've seen can show which field has a leaking well, but they can't identify the specific fitting. The level of specificity we provide saves the client money, and it's good for the environment because we can address issues promptly.

We are shifting from the literal boots-on-the-ground model for some of our fieldwork – which is the most expensive for our clients – to offering incredibly high-resolution and near-real-time satellite data that's approaching 30cm/pixel. Our clients constantly remark on the high quality of the imaging we can provide without having people on the ground. Having this actionable information on a timelier basis enables our clients to make better decisions that positively impact their business and our planet.

EBJ: Tell us about Artificial Intelligence. How is the industry leveraging emerging capabilities to lower costs and increase insight?

Lannen: "Artificial intelligence" includes a wide set of tools – some have been in use for decades, but the ChatGPT craze has brought others out of the shadows. Five years is a lifetime in the technology world – but I do think that machine learning will be more fully integrated into our workflows. I look at tools like ChatGPT as having a research assistant who can start that presentation or report. It saves time on tasks we'd rather not do ourselves, and it can identify trends that we might miss. The experts can then assess what these

tools produce, fact-check, fine-tune, and deliver a faster and higher quality service.

Over the past few years, we developed several computer vision and audio models to identify field items and species, which have been very useful with endangered species, invasive species, and cultural artifacts. Those are useful in a somewhat limited manner. Real insight provided with AI will be in complex mathematical models and in identifying trends – think of greenhouse gas emissions and similar scientific insights – as well as in mapping the impact of coastal erosion and sea-level change. For example, one of our scientists has developed a model predicting where oyster beds are likely to be along a coastline. The results help paint a large picture of where oysters are probably located. That information can then assist scientists on the ground who are inspecting and ground-truthing those locations. When you combine these AI tools with maps, the issues come to life for people as they relate to geospatial data more than charts and spreadsheets.

The industry absolutely needs to shift to leveraging more technology – whether simple automation or more complex AI large language models (LLMs) to automate mundane, repetitive tasks. This frees our experts to focus on the truly innovative, creative thinking that goes into protecting and restoring the environment.

EBJ: Is ChatGPT just the latest technology flavor of the month? Or is it and other Natural Language Processing platforms generating real usable outputs suitable for work products? And please provide some examples of where AI is contributing real short-term value, and to what types of project work?

Lannen: ChatGPT and other LLM tools are demonstrating the value of Artificial Intelligence in a more "consumerized" version. Previously you needed to understand data science, some R programming language, and a bit of advanced statistics to be able to leverage AI tools. I see these LLMs as some of the first tools that anyone can use for a wide variety of tasks.

SWCA is leveraging these and other AI tools for a wide variety projects, from species identification to assisting with re-

port writing. We have an AI task force that is a fantastic combination of data scientists, project leaders and field scientists who are collaborating and prioritizing the many requests our Technology team receives for using tools on projects and in corporate services. We are using it to sift through public comments databases, and for a number of geographical delineation projects. The speed with which you can process data and identify trends is remarkable – and the secret sauce in using AI is to pair it with our scientific expertise. Using it alone gets you a certain distance, but you need to have expertise to train the models.

EBJ: How have your IT budgets changed over the past couple of years and what do you expect in the near future? And how do you see those budgets being allocated?

Lannen: Most firms' technology budgets have shifted a lot of capital expense to operating expense as we have adopted more cloud and SAAS technologies. It's not necessarily cheaper, but it's a change. I also see IT evolving from a pure cost center to becoming a hybrid P&L as we work with our consulting colleagues to deliver data-driven solutions to our clients.

EBJ: How did you get involved in the Environmental industry in the first place and what were some of your early Inspirations or mentors or leaders that inspired you further?

Lannen: I first got involved in the Environmental industry when I went to work for a technology startup/subsidiary of MWH Global in 2002. They were later absorbed into MWH. This is where I met the late Dr. Vic Gulas, who was a tremendous mentor and sponsor for me. He was the Chief People and Knowledge Officer (best title ever!) at MWH Global. His work included that intersection of people, knowledge and technology – and we did some notable work on social networks (how work gets done and how you develop trust among teams) that influences and inspires me today. Another great mentor and friend for me is Kathryn Simon, who taught me that you can be a manager, leader and a friend, and how to juggle those hats with your team.

EBJ: What evidence of climate change or environmental degradation have you experienced personally in your lifetime?

Lannen: One impact of climate change that I've experienced – I moved to Southern California 12 years ago, and am blessed to have two homes in a coastal region and in the mountains. When I first

moved here, most people didn't have air conditioning in either place. Now, people are installing A/C in droves in both areas as the temperatures rise for longer periods during the summer. Clearly this is a first-world "problem," but it is remarkable to me that it's happened in both places and only over a decade or so. ■

ECOFORESTS FINDS FAMILY OFFICES ARE KEY INVESTORS IN SUSTAINABLE TIMBER; FORTUNE 500 SHOWS INTEREST IN CARBON PROJECTS

EcoForests (Toronto, Ontario) is a boutique forestry investment management firm managing high class tropical timber plantations on behalf of investors with two types of projects: sustainable forestry projects; and reforestation and afforestation carbon capture projects with fuel conservation and watershed protection. Michael Ackerman is the president and chief executive officer of EcoForests Asset Management. Ackerman is originally from Honduras and has served as CEO at EcoForests for twenty years, expanding from timber to carbon sequestration. Ackerman also applies his expertise of the economic and environmental benefits of managed-forestry investments as an advisor for the Green and Transition Finance Council for the Canadian Chamber of Commerce.

EBJ: When was EcoForests founded, and how did you find your niche?

Michael Ackerman: EcoForests was founded in 2003. Our company began developing small forest farms with a group of high net worth individuals (HNWIs), through my own family's business network, and soon after a number of family offices gained interest in our projects. By word of mouth, we have been developing projects for family offices, mainly from Europe, across Costa Rica and Honduras with some other projects in Panama and South America.

EBJ: What type of investors have demonstrated interest in EcoForests?

Ackerman: HNWI, family offices, and most recently funds have invested in our sustainable timber projects. Family offices are focused on wealth preservation and wealth transfer, and because of their ability to hedge against inflation, forestry is an ideal investment for them. In addition, newer generations in family offices have a stronger concern for the environment, and seeking alpha is not the most important factor; they place the environment and net zero goals before profits. In addition,

a slew of Fortune 500 corporations have expressed interest in our newly established carbon offset projects.

EBJ: How is investment money allocated, and what is the real value that EcoForests provides to the communities where investments are made?

Ackerman: Investment funds are utilized to purchase deforested farms. We mechanize the soil and add nutrients such as calcium and potassium to prepare for planting. Meanwhile in our own nurseries work is being undertaken to select the right seeds and saplings. After 2-3 months in the nursery the trees are brought to the farms and planting begins. We are committed to the communities from where we operate, and we dedicate 3-5% of the invested capital to building schools, sponsoring local sports teams, and offering scholarships to students. A portion of the invested capital remains in escrow for management costs over the lifetime of the investment.

In Honduras, we donated early fire detection sensors to a national park that is prone to forest fires in the summer months – we hope to continue expanding the ways in which we give back in the future.

EBJ: Please describe EcoForests’ financial models and the type of yields generated for investors.

Ackerman: The investment models for our two products vary significantly. For our sustainable timber projects, we manage the planting and maintenance of a variety of species of timber. We then conduct sustainable harvests that produce dividends for investors throughout the investment cycle.

As a boutique manager every investor has their own tailor-made project cycle, which as a result, has different yields. The rule of thumb is that the shorter the investment cycle, the smaller the yield. This is because the timber harvested in shorter-term projects is close to maturity, and investors pay premiums to invest for a short term. The longer the period of investment, the higher the return.

In addition, investors can opt to have a timber portfolio, meaning that they have various species in the portfolio, diversifying your timber exposure. The average return in sustainable timber ranges from 4% to 15%.

Returns on EcoForests carbon capture projects generally range between 8%-12%. However, the ROIs for carbon capture projects are directly related to the carbon credit market for voluntary credits. EcoForests carbon capture projects are in the higher tier of credit pricing because the projects have multiple co-benefits that position us on the high end of the carbon credit market index.

EBJ: How has growth been financed?

Ackerman: EcoForests was initially self-funded and subsequently funded its growth with private debt. The appetite for forestry has grown exponentially along with the growth of the green economy, which has driven increasing interest in impact investing and ESG initiatives. As a result, we are now experiencing an oversupply of investor interest.

EBJ: What technologies are being used for your projects?

Ackerman: We primarily utilize a variety of drone technologies in the manage-

ment of our forestry projects: automated fertilizing drones are used to fertilize the ground or kill the weeds one week prior to planting, saving us time and avoiding emissions released from traditional fertilizing methods that require diesel/gas powered tractors; we use drones equipped with Lidar for mapping; and drones outfitted with Micasense cameras detect the health of our plantations by way of infra-red imagery capable of detecting the pixelation of the leaves. We have also experimented with Katam technology, which uses android tablets or phones to produce accurate measurements of tree height and circumference. And notably, we are deploying a pilot installation of early fire detection sensors which detect combustion and send a signal to a control center preventing large-scale fires.

EBJ: How have you been able to increase profit yields by implementing these technologies?

Ackerman: In many cases where these technologies are implemented, operational costs drop, and there is a reduction in process implementation time making our projects more efficient, thus more profitable. In addition, these technologies enhance accountability and improve accuracy of the measurements of our growth rates. And perhaps most importantly, technologies, specifically the infrared sensors and early fire detection systems, allow us to mitigate the risk of pests and fires, thus reducing risk to our investors.

EBJ: How is the forestry industry being revolutionized by new technologies?

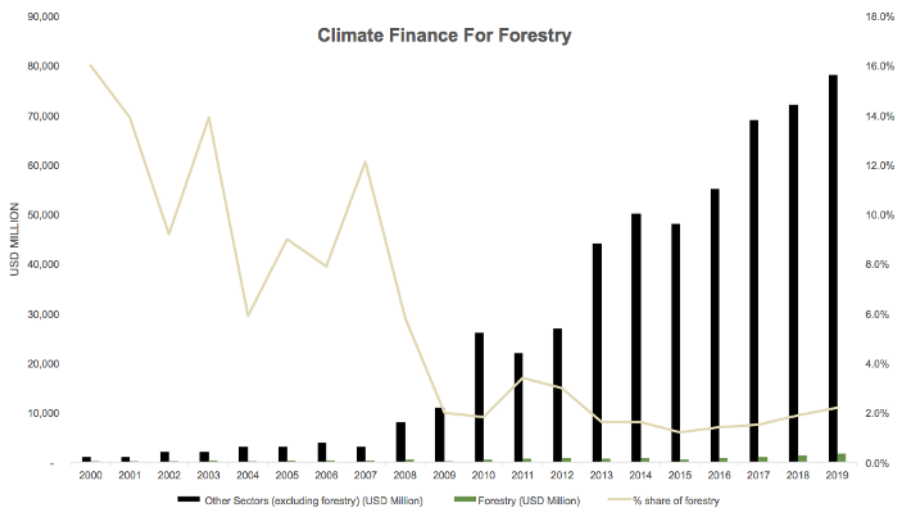
Ackerman: The immense amount of technology applications now available for forestry and agriculture is disrupting the industry – increasing our efficiency and mitigating risk. Our team is expanding our thinking and applying technologies to assist us outside our existing project management as well. We are exploring the possibility of using a drone for planting smart seeds which would allow for reforestation of remote areas that otherwise would be difficult to access. In addition, upcoming drone or digital technologies can assist with more accurate data recording and reporting that allows for better forecasting for our investors.

EBJ: Trends in the forestry industry?

Ackerman: The ratification of the international building code now allows for 15-story wood structures to be built; consequently, there is an increased interest in building with wood because it is sustainable. Countries like Canada, Sweden, Norway, and the UK are at the forefront of wood structure building. In addition, there is a trend in reforestation based on carbon capture initiatives. Companies are striving to meet their net zero goals, and by doing so they invest in reforestation projects, via operators like us, to generate carbon credits to compensate for their emissions. ■

Note: Ackerman was a panelist on EBJ’s August 2023 monthly webcast.

Forest Carbon Grows But Has Lost Ground in Climate Finance



SOURCE: Organisation for Economic Co-operation and Development DAC Climate-related Development Finance database, compiled by FAO.

LOCUS TECHNOLOGIES EVOLVES COMPLIANCE AND ESG SOFTWARE TO SERVE CHANGING CLIENT NEEDS

Locus Technologies (Mountain View, California) is a global provider of environmental, social, governance (ESG), sustainability, and EHS compliance software that empowers companies of every size and industry to generate credible ESG reporting. Since 1997, Locus Technologies has pioneered enterprise software-as-a-service (SaaS) for EHS compliance, water management, and ESG reporting. Locus apps and software solutions improve business performance by strengthening risk management and EHS for organizations from medium-sized businesses to Fortune 500 enterprises such as Chevron, Sempra, Corteva, DuPont, Chemours, Port of Seattle, The Port Authority of New York and New Jersey, and Los Alamos National Laboratory.

Neno Duplan, Founder and CEO at Locus Technologies, has spent his career combining an understanding of environmental science with a vision of how to gather, aggregate, organize and analyze EHS and water quality information to help organizations better manage their ESG scores. Locus evolved from his work as a research associate at Carnegie Mellon in the 1980s, where he developed a prototype system for environmental information management. This early work led to the development of numerous databases at some of the nation's largest environmental sites and to the formation of Locus in 1997.

EBJ: Congratulations on adding Foster Farms to Locus Technologies' broad customer base. Being in the poultry business and located in California, what are the most challenging regulatory standards faced by Foster Farms?

Neno Duplan: The most challenging part is always water as it relates to all other elements of environmental management and ESG in particular. Close second is air.

EBJ: Locus' cloud platform now includes an ESG and sustainability module. When was this added? Can you comment on how the term ESG and the ESG movement have changed how the regulated community approaches environmental compliance and investment in environmental information systems for internal management and external compliance purposes.

Duplan: Locus ESG app results from evolutionary development and our long-term involvement with EHS compliance and sustainability. There was no aha moment when we figured out that ESG is a sexy new acronym and we must have an app for it. We leave that excitement to startups that jump on opportunities like this, burn tens of millions of dollars and

disappear, leaving disappointed investors and customers behind.

Locus Technologies' ESG apps evolved from our long-term sustainability and EHS compliance software offerings. Until recently, it was common to refer to sustainability and ESG interchangeably. But over time, their meanings have grown apart. Sustainability can mean many different things depending on the discussion context, whereas ESG has become the preferred term for capital markets and has frequently appeared in the headlines. The transition from sustainability to ESG performance indicates a maturation of business practices leading to more precise measurements of a company's performance, its impact on the environment, and the risk it carries for investors when there is a low environmental performance or spotty compliance with EHS regulations. As a result, companies need to improve how they collect and track metrics for ESG reporting.

The ESG reporting software from Locus integrates a suite of products that help capture and manage all ESG data in a single system of record and report with confidence, knowing that data is auditable with finance-grade scrutiny.

These products allow organizations to report in alignment with external frameworks such as GRI, SASB, GRESB, CA AB32, the UN SDGs, and others by consolidating questions from these frameworks into one platform in an easily exportable format. All this is made possible by a powerful Locus engine that automates ESG data capture and tracks performance over time, allowing Locus customers to meet ESG reporting commitments quickly. Key features across the Locus ESG reporting suite of products include:

- Integrated EHS compliance and ESG reporting.
- Report to multiple frameworks from one place, such as GRI, SASB, SFDR, UN SDGs, CA AB32, and TCFD (and future U.S. SEC standards when they are published).
- Integrations with third-party systems like ENERGY STAR® and NABERS for scores and ratings (optional).
- Access to EHS compliance and management reporting templates.
- Input once and use it many times.
- Single Locus Platform for value chain stakeholders to report their ESG metrics.
- Integration with third-party apps and streaming data via Locus IoT technology.

EBJ: The Locus client list spans Chevron, the electric power utility Sempra, and the ports of New Jersey and Seattle. Does your platform technology and tools related to data tracking, reporting and even visualization differ greatly between such diverse customers?

Duplan: That is an excellent observation. Our fully configurable multitenant SaaS platform's architecture allows us to serve customers in diverse industries with the same single instance of cloud software. To put it simply, we do not build apps to acquire customers. We acquire customers to build apps! Across all customers, regardless of their industry, there is about 60 to 70 percent of commonality for every app, whether waste, water, or air emissions. The challenge is to recognize the common core

of app build-out across different industries and separate it from the rest. Our dynamic database architecture allows us to do precisely that.

For example, Microsoft uses the same spell checker in Word, Excel, and other Office 365 products. Similarly, Locus uses the same calculation engine, unit conversion engine, facility management information, chemistry, materials databases, GIS, etc., across all apps serving different industries. By categorizing the obvious, we got the upper hand on our competitors, who typically focus on one vertical app in one vertical sector and a single tenant model. Competitors inherited this approach from the client-server industry that does not work well on the web. They keep merging and rolling up, thinking that size solves their software deficiency. But that makes the problem even worse for them and their customers. Most of the time, stitching together single-tenant applications to serve multiple industries is mission impossible. For that reason, we celebrate every new rolup announcement.

EBJ: What is your opinion of the digitalization of project management across the environmental consulting community? We refer to such things as machine learning and AI, visual displays and automation across complex remediation projects, water delivery systems, water/wastewater system upgrades, and air quality issues like dispersion models and ongoing reporting.

Duplan: This is a complex question requiring a research paper to answer. Locus already supports this type of market (integrated and unified software across media, regulatory frameworks, and ESG). Integrating dispersion modeling, groundwater flow modeling, or any analysis, visualization, and animation becomes much easier when the company has well-organized and verified data sets.

Much has been talked about how artificial intelligence (AI) will affect various aspects of our lives. Still, more needs to be said to date about how technology can help to make EHS and ESG management better. The recent growth in AI spells a significant opportunity for the environmental industry. There is enormous potential

for AI to be an essential tool in improving the management of EHS compliance and climate change issues. But before AI can help us improve, there are some prerequisites: uniform reporting standards, consolidated databases with large and verified data sets, and multitenant cloud software. Locus cannot control standards, but we have all other prerequisites. The number one requirement is integrated databases, a condition for AI and machine learning. Single-tenant systems cannot deliver it and only multitenant software is capable of effectively integrating AI. We are at the early stage of injecting AI into web-based EHS compliance and ESG reporting software.

Only multitenant software is capable of effectively integrating AI. We are at the very early stage of injecting AI into web-based EHS compliance and ESG reporting software.

Over the last several decades, I have written extensively about SaaS, Big Data, multitenancy, and IoT. All these technologies have been an integral part of Locus' SaaS offering for many years now, and they have proven their usefulness by rewarding Locus with contracts from major Fortune 500 companies and the U.S. government. And these technologies will be even more helpful in facilitating the injection of AI into our SaaS offerings.

Overall, the most significant industry challenge is uniform reporting standards, which we still need to have after all these years. For example, no uniform reporting standards like water quality or air emissions exist for elemental reporting. With those standards, everything would be more accessible. ESG reporting is even more complicated. To complicate matters, the number of ESG standards worldwide grew from around 700 in 2009 to over 1,700 in 2019. That includes more than 360 different ESG accounting standards set primarily by various financial institutions or rating agencies.

More effort is needed to standardize reporting and compare climate risk for companies in different industries. Once we address the above obstacles, two disruptive megatrends of digital transformation and decarbonization of the economy could come together. Artificial intelligence will improve our ability to sift, parse, edit, authenticate, verify, organize, and report information. AI could make a significant dent in global greenhouse gas (GHG) emissions by providing better tools for data reporting.

When selecting its software system of record for EHS and ESG reporting, a company should strive to "enter once, report many times." The gold standard is configuring a system to report to multiple agencies from a single dataset. Before selecting software, companies should review their reporting requirements to see if their software handles them.

For example, when selecting GHG management software, the company must ensure their software includes XML exports, a standard format for Environmental Protection Agency (EPA) and California Air Resources Board (CARB) reporting, and an option for reporting to other agencies. Such outputs easily generated from the software will save time and money during the reporting season. The XML report generation capability allows facilities to directly upload their GHG data instead of completing the complex web forms in the EPA Electronic Greenhouse Gas Reporting Tool (e-GGRT) and CARB reporting worksheets (Cal e-GGRT).

Companies implementing integrated EHS compliance and sustainability management systems may already have most of the ESG data they need to report within their existing EHS compliance applications. If they do not, or if they have a "mutual fund" portfolio of EHS software already installed in unconnected silo applications, this is the time to clean house and switch to a unified reporting platform that integrates EHS and ESG into a single system of record and reporting. Companies that head down this path would not just be "killing two birds" but more: they would lower their costs, meet their new reporting needs, gain a better understanding of

FOSTER FARMS SELECTS LOCUS TO MANAGE EHS COMPLIANCE AND ESG REPORTING

In May, **Locus Technologies** (Mountain View, Calif.) announced that **Foster Farms**, a top U.S. provider of poultry products and a leading brand of fresh chicken in the Western United States, had selected Locus's enterprise Software as a Service (SaaS) to organize and manage EHS compliance and ESG reporting.

Foster Farms subscribed to an integrated set of apps offered in the Locus Cloud Platform, including: EHS Compliance Management, ESG and Sustainability, GHG Emission Factor and Calculation Management, Inspections, Configuration Workbench, Air Emissions Management, Storm Water, Wastewater, and well data management and reporting.

Locus Cloud is a fully integrated multitenant platform created from the ground up to allow organizations to manage their environmental, energy, water, waste, carbon, air, health and safety, remediation, water quality, and compliance information in one place. The Locus Platform allows companies to configure their own management, tracking, visualization, and reporting through a graphically driven user interface. This feature enables organizations to configure the software to their needs without worrying about the expensive programming outlays usually associated with customization and single-tenant deployments.

"The accurate tracking and reporting of critical environmental resource usage is a necessary part of our compliance responsibilities, and a major component of our efforts to ensure that we are a sustainable producer. The Locus application software will make a significant contribution to our resource management capabilities," said Don Hill, Foster Farms Director of Environmental Affairs.

"We are delighted that Foster Farms recognized the power of the Locus Cloud platform. Businesses do not want to shop for point solutions from different vendors only to be left with the nightmare of integration, security, synchronization, and vendor management. They want one-stop shops and to avoid having to deal with vendors that don't integrate well with one another or have spotty service and limited support," said Neno Duplan, President, and CEO of Locus.

"Locus will provide Foster Farms single platform through which they can accomplish all their environmental and compliance management needs on a single, fully customer-configurable platform," said Duplan. "Keeping the end user's perspective in mind, we've packed the same 26-plus years of domain expertise that Locus has been offering all along into a highly configurable and scalable software platform built from the ground up on the latest web technologies."

Environmental Industry Webinar Archive (continued)

February 2023: Business Outlook and Regional Market Snapshot
Mike Schwerin – CEO – Helix
Environmental Planning – CA
Curt Thalken – CEO – Normandeau Associates – NH

January 2023: Perspectives on Strategic Planning in the Environmental Industry
Beth Myers Graham – Chief Growth Officer, Environmental – TRC
Frank Sweet – Chief Executive of the Environment & Energy – AECOM

November 2022: Live from Washington DC Environmental Industry Summit

October 2022: Election Preview and Q&A with WSP Earth & Environment
Joseph Sczurko, President of Earth & Environment at WSP USA

September 2022: PFAS Markets and Developments in Water Markets
Jim Claffey – National Technology Innovation Leader – Brown & Caldwell
Matt Burns – Vice President and Technical Fellow – WSP USA
Steve Woodard – Chief Innovation Officer – ECT2, a Montrose Environmental Group company
Angus McGrath – Senior Principal – Stantec

August 2022: IJIA: What's the hold up? Plus IRA review
Andy Paterson, EBI Political Analyst
Jeremy Harrell – Chief Strategy Officer – ClearPath

Richard Harmon – Strategic Funding & Advisory Lead – Woodard & Curran

July 2022: ESG & SEC Climate Disclosures
Josh Nothwang – Global MD, Sustainability Advisory – Arcadis
Elizabeth Logan – ESG & Climate Strategy – AECOM
Leslie Shoemaker – Tetra Tech
Masjood Jafri – Resiliency Director, Atkins, SNC-Lavalin Group

their environmental impacts, leverage AI and other new technologies more effectively, and potentially enhance their ESG reputation.

Companies should never publish any environmental information that is not scientifically measured. Misinformation or greenwashing is rampant online. New technologies allow us to compile data quickly, correct errors, find facts and dispel falsehoods. Science, supported by an

open internet, is the process by which we reduce misinformation and approach the truth. ▣

To put it simply, we do not build apps to acquire customers. We acquire customers to build apps!

Macro Market Freeze Chills Climate Tech Investing in 2023: Venture Funding Down 40% in the First Half of 2023

As venture capital funding fell across the startup landscape in late 2022 and 2023, the dollars flowing into climate tech companies dropped 40% in the first half of 2023. Climate Tech VC asks ‘Was the climate tech VC frenzy a peak or is it a wave?’ CTVC is an independent firm that has expanded its newsletter and VC tracking database into a market intelligence platform and raised \$1.75 million in pre-seed funding in May 2023.

Investors spent a lot of money in 2021 and 2022. With zero interest rate policy (ZIRP) days in the rearview mirror, deployments of real assets suddenly look real expensive again. Yet, dollars-and-cents demand from customers for better, faster, cheaper climate technology products only continues to grow—along with the talent flows, regulatory accelerants, and evolving capital stack. If climate tech is truly a resilient trend, what’s going on with the current funding slump?

Macro gravitational pull: The overall venture market dropped 53% YoY in Q1, a further 10% decline from the prior quarter. Climate’s 40% decline is somewhat more insulated, but not immune to macro realities like the frozen exit markets. In fact, late-stage and growth investments in climate tech saw a greater drop-off than the market as a whole, potentially exacerbated by the relative capital-intensity of the physical asset climate tech businesses.

Growth investors already picked their horses: Investors made their biggest bets in 2021 and 2022. Now they could be waiting to see how those companies’ fortunes play out before going big again (and they certainly don’t want to compete with their own portfolio by doubling down in maturing climate verticals). Many growth assets were scooped up during the market peak, creating a current dearth of companies ready for growth-scale financing. A new cohort of early climate tech companies founded at the start of the CT boom are now climbing the ladder, but not yet seasoned enough to warrant mega-checks.

Earlier, enabling tech shift: Thus, the uptick in early stage funding during the

first six months of this year could be a sign that investors are allocating capital toward earlier technologies up (or down) the value chain from their existing investments, either to support big prior bets or because of updated learnings.

Pending a strategic boost: Announced funding activity is a lagging indicator of market sentiment. The tailwinds from the Inflation Reduction Act and other government incentives are just beginning to show up in the market—at the same time that strategic corporate investors are leaning into the space.

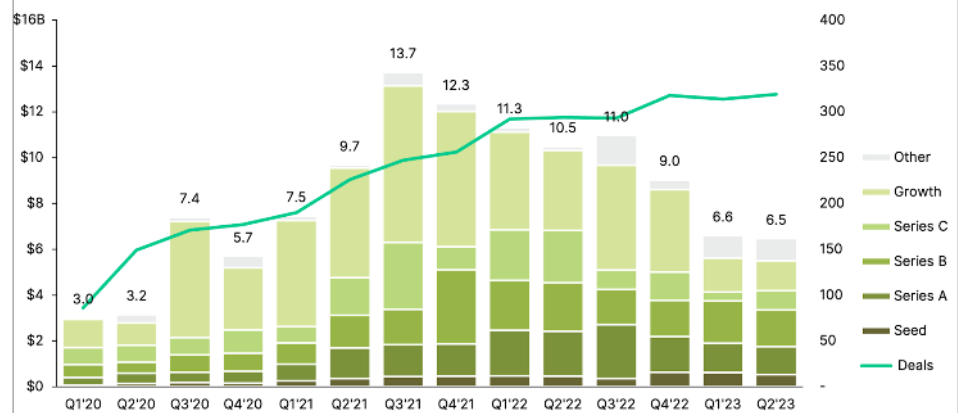
2023 Highlights So Far

H1’23 funding: Funding in the first six months of 2023 totaled \$13.1B, down 40% from H1’22 and down 35% from H2’22.

- Deal count: Overall deal activity increased, with deal count up 8% vs H1’22.
- Growth Stage: Growth funding bore the brunt of the market contraction and plummeted 64%, while deal count dropped 43%.
- Early: Breakout Seed funding grew 23% in H1’23 compared with H1’22, and Seed deal count increased 34% during the same period.
- Round size: Average deal size decreased 44%, with Growth rounds in particular down 37% on average. As total deal count actually rose in H1’23, all fingers point to the significant downsizing of rounds as the cause of the climate tech total dollar funding decline.

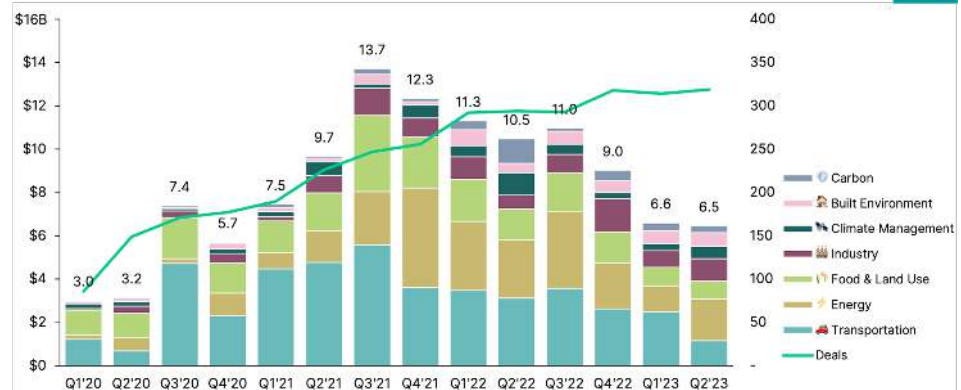
\$13B in climate tech funding in H1’23, down 40% compared to prior year

Venture capital investment (\$B) and deal count (#) in climate tech by stage



Transportation, Energy, and Food funding down ~50% YoY

Venture capital investment (\$B) and deal count (#) by climate tech vertical



- Vertical: Funding to Transport, Energy, and Food—the “Big Three” verticals—each dropped by ~50% compared to the prior year.
- Fewer repeat investors: The number of investors who have done 4+ climate deals in H1'23 slumped ~40% vs the same period last year.
- Cumulative: Since the start of 2020, ~2,500 climate tech companies have raised \$117 billion of venture funding across 3,332 deals.

As the market freeze hit all sectors and climate, H1'23 marks the first time that quarterly funding has decreased over two consecutive quarters since the start of the climate tech boom in 2020. The decline should come as no surprise given the backdrop of the overall venture market, the telltale downtick in CTVC's 2022 funding report, and the sentiment from our investor pulse check, which anticipated a 50% slowdown in capital deployment.

2023 total of \$13.1B, down 40% from H1'22 and 35% from H2'22.

Quarterly investment totals dropped to \$6.6B and \$6.5B in Q1'23 and Q2'23, respectively. Each quarter marked a ~40% decline from the same period in 2022 and a return to 2020 quarterly funding levels.

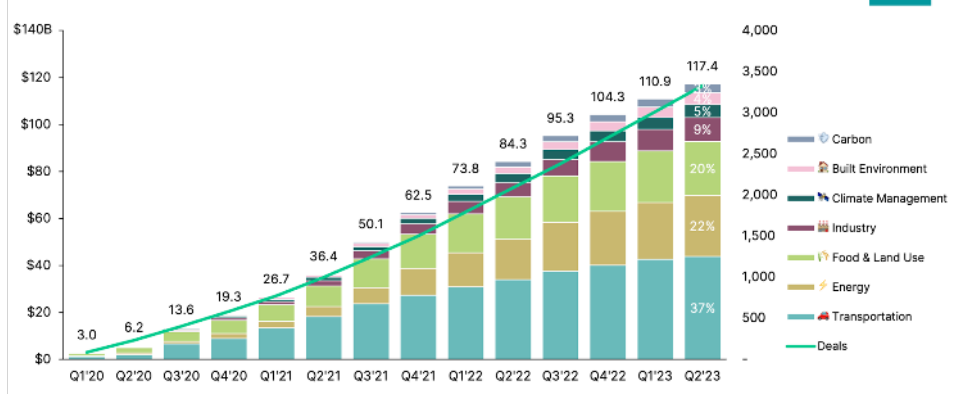
With 633 deals in the first six months of 2023, overall deal count increased slightly, up 8% compared with H1 and H2 2022. The higher activity level coupled with an overall funding decline means that average deal ticket size is way down.

While a 40% funding drop is certainly not for the faint of heart, next quarter will tell the true story. Q3 consistently ranks as the top quarter for funding (as investors and founders return in a flurry from the summer lull).

If Q3 funding ticks back up, it could indicate a recovery and resetting to a more sustainable base from the frenzy of 2021 and 2022.

~2,500 climate tech cos have raised \$117B of venture capital since 2020

Cumulative venture capital investment (\$B) and deal count (#) by climate tech vertical



Should funding drop further next quarter, it could suggest a true climate slowdown, with investors reevaluating their strategies and slowing their pace—waiting on returns and results from their previous bets before making next moves.

Early Stage Counts Up

The conventional wisdom that earlier-stage investments have been insulated from the public and growth market freezes seems even more true in climate tech. Early stages (Seed, Series A) fared better than Late stages (Series B, C) and Growth (Series D, Growth) in the first half of 2023.

With a drop-off in IPOs (and disappearance of SPACs), Growth funding plummeted 64%—making up only 21% of total funding in H1'23, compared to ~50% share in previous years. The decline in climate Growth funding was double the ~30% drop in the overall VC Growth-stage market, so climate was hard hit.

Breakout Seed climate tech funding grew 23% in H1'23 compared with H1'22, even as overall funding of the Angel/Seed venture market dropped >50% during the first three months of this year. Deal count at the Seed stage healthily increased compared to both the front-half and the back-half of 2022, while Series A and Series B activity remained relatively flat.

Meanwhile, later-stage deal activity slowed significantly, with a ~40% drop in both Series C and Growth deals. Many growth-ready assets were scooped up dur-

ing the 2021-2022 market peak, leading to a short supply of growth opportunities today. As the new cohort of startups founded in the early days of the climate tech boom begins to reach maturation, expect more growth (in growth) to come to market over the next few years.

Variations by Segment

The overall funding drop owes largely to the “Big Three”: Transportation, Energy, and Food & Land Use. These have historically made up the lionshare of blockbuster rounds (e.g. Northvolt's \$2.7B, Rivian's \$2.5B, and Commonwealth's \$1.8B raises), and 80%+ of total funding for each of the previous three years.

Zooming out puts things into perspective. Since the start of 2020, ~2,500 climate tech companies have raised \$117B of venture funding across 3,332 deals, with cumulative industry growth averaging ~30% each quarter. The relative slowdown brought the cumulative industry growth rate to 6% over the past two quarters—indicating a flattening of the curve rather than an all-out retreat like what happened to a degree in the cleantech VC market 15 years ago.

Mature vs. emerging

In H1'23, the “Big Three” took a ~50% funding haircut compared to the prior year. Carbon, which was 2022's climate tech darling, took the largest YoY funding plunge (down 56%) as investors started to slow their roll in carbon removal bets.

However, up-and-coming verticals Built Environment and Industry, which have historically been underinvested in relative to their climate impact, actually saw dollars increase (both 7% respectively), likely owing to enthusiasm from IRA and EU subsidies.

An uptick in early-stage activity amid the larger downturn could be a sign of a wave of recalibrated investor interest, focused less on direct emissions-reduction tech and more on the enabling tech necessary to make those transitions work. Take Transportation as an example.

Capital raised in Series A and B rounds made up the majority of funding in Transportation over the past 12 months, in stark contrast to H1'21 when >75% of funding came from Growth exclusively. Two years later, Growth's share of Transportation funding has evaporated to just 18% of the total.

Autos alone account for 12% of total climate tech VC dollars tracked since 2020. Now that large automakers have started making big bets in EVs and battery manufacturing (just look at Ford/SK On), it's unlikely that an upstart startup could outmaneuver their resources. In other words, the opportunity for the next Tesla has mostly played out. In response, investors are scouting further up and down the value chain for the next bottlenecks to unlock decarbonized transport.

Backers of previous transportation mega-darlings, like Rivian and Quantumscape, have matured their sub-sector preferences from EVs and battery tech towards emerging tech enablers like mining efficiency, EV charging optimization, and fleet management—supported by policy tailwinds.

Average Deal Size Down

Average ticket size decreased to \$22.5M—a 44% drop from H1'22 that was driven by the steep decline in the size of Growth rounds.

With deal count actually up 8% in H1'23 vs H1'22, it was the significant downsizing of rounds, especially for large deals, that drove the overall market funding decline.

The slight increase in average round size at Series B and C could be driven by the prioritization of runway extension and more frequent bridge rounds, rather than graduating to attempt to raise a mega-sized Growth round. In other words, flat is the new up!

The prized \$100-500M deal size category has historically commanded the largest share of climate tech venture funding (typically 40-50%).

But as the double whammy of average ticket sizes and Series B+ deal counts declined, the \$100-500M cohort plummeted 60% in both funding and deal count between H1'22 and H1'23.

These \$100-500M deals at the Series B+ stage typically happen when companies raise venture capital or growth funding for their first of a kind (FOAK) or demonstration scale facilities. This is the key valley of death for climate hardtech where tech readiness level (TRL) isn't mature enough to raise non-dilutive project finance or debt but companies still need a significant pool of capital to prove their tech at scale. Often the riskiest stage for climate tech investors and startups alike, the market downturn appears to be steepening the valley in the near-term.

VC Activity Varies

The tally of unique investors participating in at least 2 climate deals remained surprisingly steady between H1'22 and H1'23 (404 and 397, respectively).

But the number of investors who have done 4+ climate deals in H1'23 is down ~40%, compared to the same period last year, and consistently down across verticals.

As the rate of capital deployment has slowed, many previously high-velocity in-

vestors are sitting it out and not doing as many climate deals. In H1'23 the most active investors included Breakthrough Energy Ventures, (BEV) Lowercarbon Capital, Climate Capital, Temasek Holdings, Collaborative Fund, MCJ Collective, Energy Impact Partners, SOSV, Fifth Wall, and S2G Ventures.

The usual climate-generalist suspects like Lowercarbon and BEV are still actively deploying dollars, as are recently announced funds with sizable new pools of capital to put to work, like the \$1.5 billion Aramco Ventures Sustainability Fund and \$7.3 billion TPG Rise Climate.

Major strategic investors, like corporate entrants Microsoft, Aramco Ventures, SK, and Exor, are becoming frequent participants in Late-stage and Growth rounds.

Corporate participation in later-stage rounds sends a positive signal—a strong strategic partner committing to collaborate on a pilot project or act as a future supplier or offtaker can help lower the perceived risk profile for other investors, and catalyze the fundraising round. Anecdotally, strategics are increasingly being pulled into deals to “lead” for relatively small check sizes and attract additional investor interest.

For example: Amogy's \$150M Series B funding led by SK Innovation, Boston Metal's \$120M Series C round led by ArcelorMittal, and EnergyX's \$40M Series B led by GM.

Growth funding in these mature verticals may have dropped off, but Transportation and Energy still dominate when it comes to megadeals. Of note, many of these giant deals went to companies that took a non-traditional startup development path. ABB E-mobility and Zeekr are spin-offs and Northvolt was incubated by Vargas Holding.

Strategic participation in VC and 3rd or 4th PE rounds are often a precursor to M&A and IPO, so while climate tech is established, maturity is a long way off. ⚙️

2022 VC Summary

The market slowdown officially hit climate in 2022. Total funding was down 3% from 2021, but investors still poured more than \$40 into what Climate Tech VC terms CTVC. But even a global slowdown isn't slowing the rate of climate innovation - deal activity in deal count gained 40% versus 2021 (lots more deals, but mostly smaller ones), with more 1,000 venture and growth-stage climate tech deals closed worldwide in 2022.

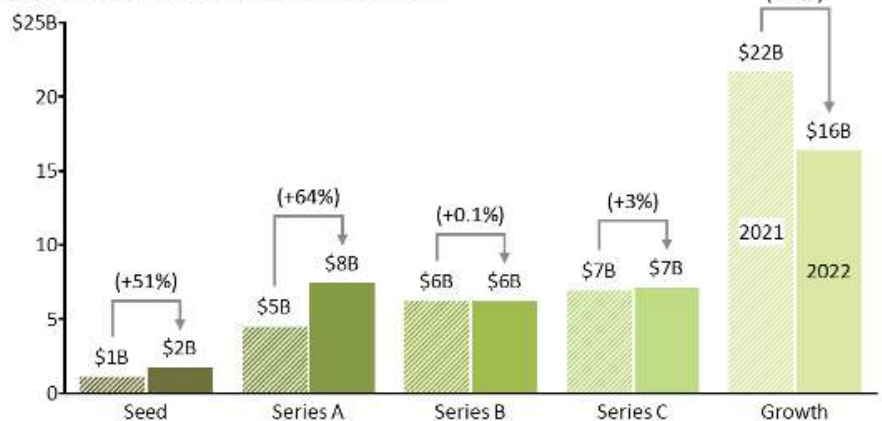
CTVC admitted tightening its methodology, with the intention is to be the most accurate source of climate venture funding data. The CTVC 2022 market report findings validate its market survey sentiment and dry powder predictions of a slower second half of 2022. CTVC anticipates more, smaller deals, continued diversification into emerging climate technology sectors, and specialization as the mid and growth-stages stay dry into 2023.

2022 VC Highlights

- Climate tech companies raised +\$40B across ~1,000 venture and growth deals in 2022
- 2022 funding was 3% down from 2021's peak, driven by a 24% drop in Growth stage funding
- A tale of three stages: while the Growth stage dropped, the Middle of the market flattened, and (Seed, Series A) Early stage activity accelerated 61%+
- Round sizes were smaller at every stage, with sharper 30%+ declines in Later-stage
- Meanwhile, deal count grew ~40% up and to the right across every industry
- Carbon and Built Environment are emerging stars, multiplying 2.4x and 3.8x in funding respectively since 2021
- 2,000+ investors joined more than 1 climate deal in 2022. Of those, 613 invested in more than 5 climate deals last year
- Specialist investment firms led the most deals in their respective industries

Total growth stage funding declined, as early-stage gained compared to 2021

Venture capital investment by stage in 2021 vs 2022



Climate Tech Segment Funding

Subtle changes in 2022 underlie the story of slow steady diversification away from "clean tech" industries (63% of total count into Food & Land Use, Energy, Transportation) and towards fast-growing emerging areas like Climate Management, Built Environment and Carbon.

By count, the hottest sectors include alternative proteins (8%), EV charging (5%), batteries (4%), and emissions & sustainability reporting (4%).

Compared to their share of 60% of deals, Transportation, Energy, Food & Land Use make up 80% of total dollars deployed.

Mega deals in just 5 capital-intensive sectors including autos, batteries, alternative proteins, nuclear, and EV charging made up 40% of total funding over the last three years.

CTVC previously called out the mismatch of venture dollars to GHG impact. Disproportionate dollars continue to flow into Transportation and Energy deals, versus other critical emissions solution gaps in Built Environment and Industry.

CTVC did pass 1,000 deals in 2022. Market slowdown has not slowed the pace of innovation. Deal activity grew substantially (+38%) in 2022 vs. 2021, with steady deal growth quarter-over-quarter and even distribution between industries.

More Deals at Earlier Stages

The overall decline in 2022's funding can be entirely attributed to Growth's \$5.2B loss, which offset the \$3.7B gain across all other stages particularly in Seed and Series A.

2022 was a Tale of Three Stages: early (Seed, A), mid (B, C), and Growth. Overall later-stage funding decreased, while the middle of the market has frozen.

Early stage activity continued to accelerate (+61% and +40%), with the slight contraction in round size not holding back the growth of overall early stage dollar deployment (+51% and +64%) compared to the same period in 2021.

The middle funding valley of death (B, C) stayed relatively flat in terms of funding, but faced a small decline (-13%) of deal activity in the later half.

The market slowdown corrected 2022 Growth stage deal size and therefore total dollars deployed by -24% compared to 2021. Interest rate rises and stalled public markets dried up the once white-hot pipeline of pre-IPO and SPAC mega rounds.

Round sizes were significantly smaller at every stage in H2'22, with sharper declines the later the stage. Series C and Growth median deal sizes dropped 33% and 30% respectively in the second half of 2022. In H2'22, the popularity of smaller

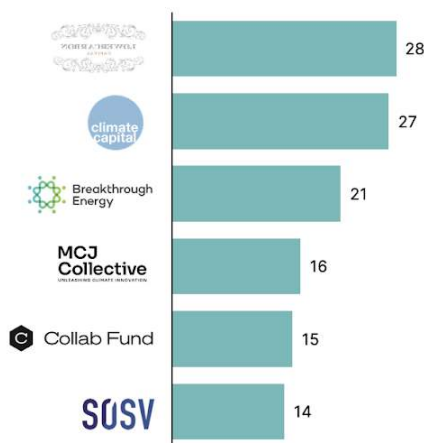
sized deals (<\$5M) emerged from a year-long trough. Larger deal sizes (>\$20M) appear to have given way to a higher count of smaller deals as of Q2'22.

Seven of 10 climate mega deals concentrated in the more mature Energy and Transportation industry segments, though battery and EV OEM mega-rounds in 2022 were notably more scarce compared to 2021. Emerging industries Carbon, Climate Management, and Industry posed a few notable mega exceptions via Clime-works' \$600m+ round, EcoVadis' \$500m+ raise, and EnergyX's \$450m for lithium extraction.

Climate Tech VC Profile

More than 4,000 unique investors participated in at least one climate deal in 2022, with 2,000 firms invested in >1 deal. 14% of all investors (613 firms) deployed into 5 or more deals in 2022. Compared to prior years, 2022 saw broader participation of generalist investors across industries while specialist climate investors continue to dominate emerging and more technical industries like Carbon and Built Environment. Apart from a few climate-generalist giants (BEV and Lowercarbon), 4 out of the 6 sectors were led by specialist investment firms like Fifth Wall in built environment, Volta and Trucks in transportation, S2G in food & land use, and Carbon Removal Partners in Carbon. ⚙️

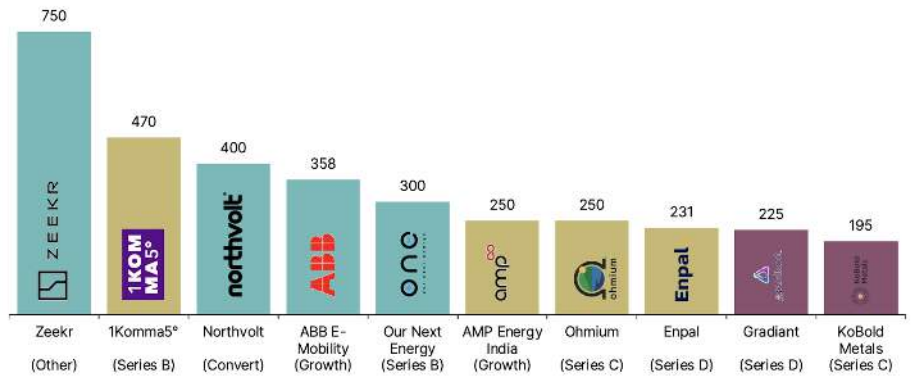
Early Stage Leaders Since 2021



*Pre-seed, Seed, Series A

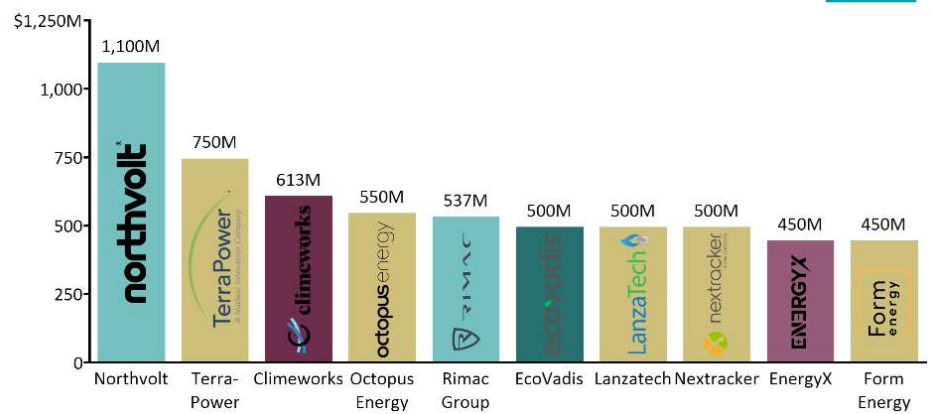
The top 10 deals from H1'23 clustered in Transportation and Energy sectors

Deal size (\$M) for the 10 largest individual transactions in H1'23



Top 10 deals of 2022 concentrated in mature industries

Size of 10 largest climate venture deals in 2022 (\$M)



CTVC Industry & Sector Methodology

- Energy. Sectors: new technologies (nuclear, solar, geothermal), energy storage, hydrogen and low-carbon fuels, renewables software, marketplace, and grid management platforms, DER and demand response tools, utility transmission and distribution services.
- Transportation - The movement of people and goods. Sectors: battery technologies, EV autos, EV charging and fleet management, electric micromobility and ridesharing, zero-emission planes, boats, and trains, urban public transport
- Food & Land Use - Nutrients and resources. Sectors: alternative proteins, regenerative farming, vertical farming, sustainable fertilizer and feed, nature restoration and ecosystem services, sensing for yield, autonomous equipment, water, and food waste reduction.
- Industry - The goods and raw materials we use every day. Sectors: low-carbon cement, chemical and plastics, steel, manufacturing, metals and mining, circular economy commerce, sustainable textiles and packaging, waste and recycling
- Climate Management - The data, intelligence, and risk associated with a changing climate. Sectors: emissions and sustainability reporting, ESG investing and fintech, earth observation through remote sensing, climate risk and intelligence platforms
- Built Environment - The places we live and work. Sectors: sustainable building materials, low-carbon heating and cooling, prefab construction, energy efficiency, building electrification and energy optimization
- Carbon - The avoidance and removal of emitted carbon. Sectors: carbon offset marketplace and procurement platforms, carbon utilization, carbon removal and storage technologies, point-source CCS, verifiers and ratings enablers

CTVC Methodology

Climate tech is a theme not an industry. CTVC has two filters: 1) climate impact and 2) climate vertical. Companies must tick the box in at least one category for both filters in order to make CTVC's cut.

Climate impact: Climate tech companies must fulfill one or more of:

- Mitigation - directly decarbonize across key emissions sectors (electricity & heat, ag & land use, industry, transportation, buildings)
- Adaptation - adapt to a changing climate with new products and economic models (new insurance products, producing food to use, geo-engineering)
- Monitoring - gather information / data about emissions or climate risks and impacts to generate insights (emissions and sustainability reporting, climate risk and intelligence)
- Removal - remove existing emissions from the atmosphere (carbon removal, nature-based solutions, reforestation)
- Regeneration - enhance environmental "positive externalities" and "do more good, not just less bad" (regenerative ag enhances biodiversity & sequesters carbon)

Climate vertical: In addition to climate impact, companies must categorize into at least one of the 7 broad climate verticals.

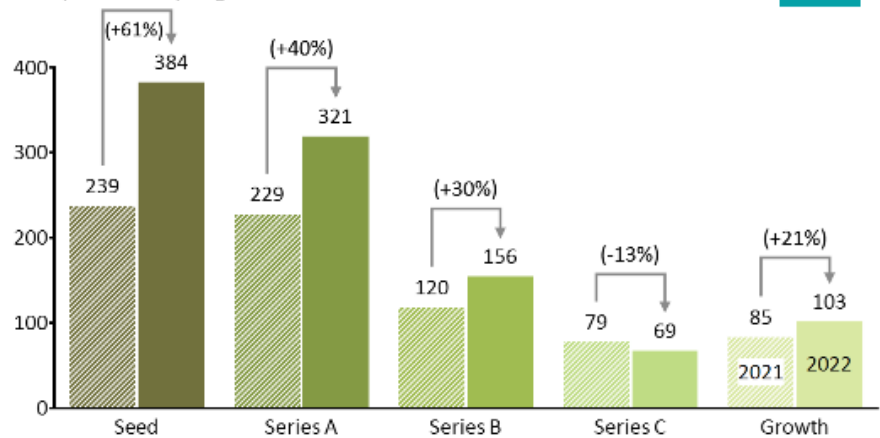
Asset class: This funding report captures defined Venture Capital and Growth Equity only. Where other market observers may promote larger climate market sizes, CTVC stays true to its Climate Tech VC name and excludes:

- Country/state-level funding (e.g. State-owned enterprise funding)
- Non-dilutive funding (e.g. debt, loans, asset financing, grants)
- Project finance
- Private equity
- Post-IPO funding

Deal activity increased across almost all stages

CTVC

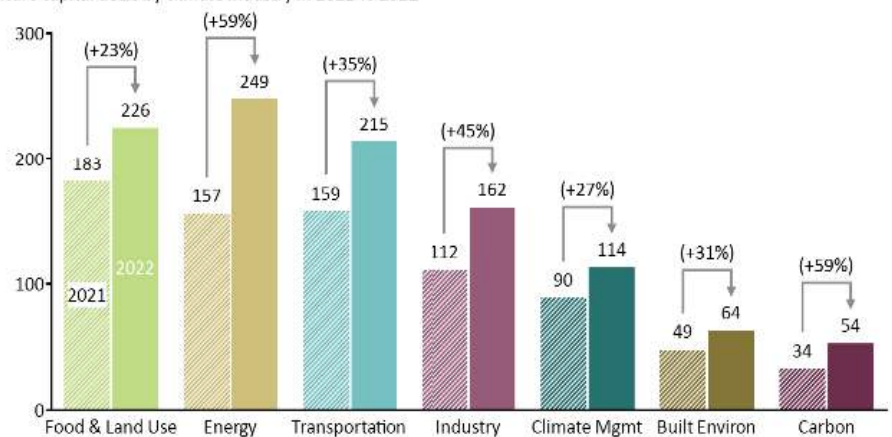
Venture capital deals by stage in 2021 vs 2022



More deals were done in 2022 vs 2021 in every industry

CTVC

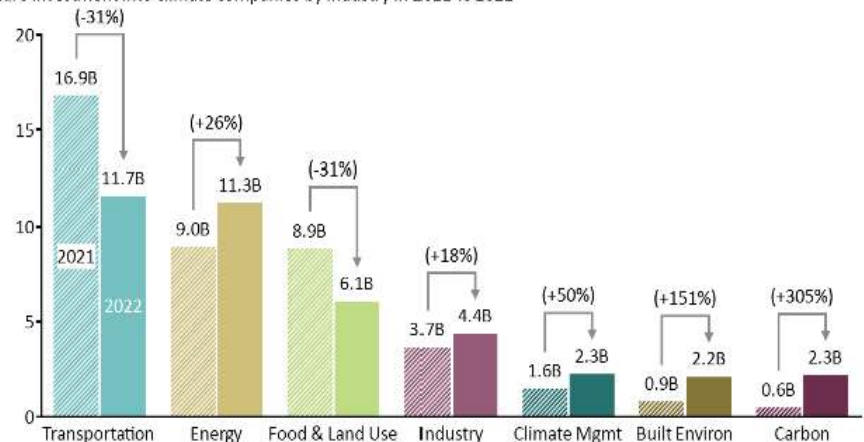
Venture capital deals by climate industry in 2021 vs 2022



Though total investment declined between 2021 and 2022, investment into emerging industries grew

CTVC

Venture investment into climate companies by industry in 2021 vs 2022



Source: Climate Tech VC 2022 climate tech market report, www.ctvc.co

Environmental Industry Summit Series

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Texas Environmental Industry Summit May 2024

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