WHITE PAPER

Sustainability in construction

How autonomous technology stands to significantly impact job sites, the planet, and the people on it

Between growing government mandates and consumer watchdog groups calling for stricter guidelines to reduce carbon emissions, contractors must be increasingly mindful of sustainability on the jobsite. Autonomous solutions can help them achieve that goal. Procedures and processes are being inspected more closely today in regard to their carbon footprint, chemical use and draw on natural resources. Some environmental benefits of autonomous tech are easier to measure than others, but even the more-measurable still require longer-term analysis before broad-reaching autonomy-centric conclusions can be drawn.

One thing experts agree on is that the sustainability benefits of autonomous technologies can be seen from both environmental and productivity/fiscal sustainability perspectives, which is one of the main reasons Trimble adopted some ambitious climate goals and a net zero future last year.

Where are the sustainability benefits within construction?

Autonomous solutions in construction enable a myriad of sustainability benefits. From getting the job done with less reliance on a shrinking labor force to reducing wear and tear on machinery itself — which also reduces maintenance costs — to neutralizing the repeated stopping and restarting of machines, being able to do more with fewer machines reduces fuel usage and resulting greenhouse gas emissions. And for the contractors themselves, maximizing efficiencies and productivity offers additional fiscal benefits as a result. Autonomous technologies like assisted/horizontal steering and machine control are destined to play a role in meeting more stringent sustainability measures.

Autonomous technologies and solutions are opening new doors for construction to reduce the number of passes machines like compactors make, reducing fuel consumption and carbon emissions while also optimizing the speed a machine travels and neutralizing errors and wasteful actions such as revving.

While the industry has historically been reluctant to let go of labor-intensive methods for work and recording data — leading to excess use of materials, fuel and natural resources — the fundamental economics are changing, making it an industry that stands to benefit greatly from sustainable autonomous advancements.

> *For decades, Trimble solutions have contributed to reducing greenhouse gas emissions and combating climate change. The nature of Trimble's technologies, which connect the physical and digital worlds, provides efficiencies and promotes sustainability in our end markets such as construction...*
>
> — Rob Painter,
> president and CEO, Trimble

Data supports the need for better approaches

In 2021, global management consulting firm McKinsey[2] estimated that construction accounted for almost 40% of global emissions, 28% of which came from raw-material manufacturing, shining a spotlight on the industry to step up their efforts.

The European Union has pledged to reach carbon neutrality by 2050[3], meaning organizations across the continent are setting their own targets to meet corporate, national, continental, and global goals. Further cementing the need for construction to continue setting the bar higher, professional services firm PwC reported in their Global Infrastructure Trends blog[4] that "multilateral development banks (MDBs) are prioritizing inclusive, resilient, and sustainable technology-driven infrastructure."

In the US, the number of LEED-certified projects surpassed 100,000 in 2019, up from just 296 in 2006. Construction companies have been looking for ways to get onboard with this shift toward sustainability, and data analysis can be part of the solution, like that offered through digital twinning / 3D modeling, which 60% of organizations[5] are leaning on to improve operational performance and fulfill their sustainability agendas.

All this reflects an increasing motivation from global industry to support an increasingly autonomous industrial workforce as a means to achieving a more sustainable future — not only for better profits, but for the planet as a whole.

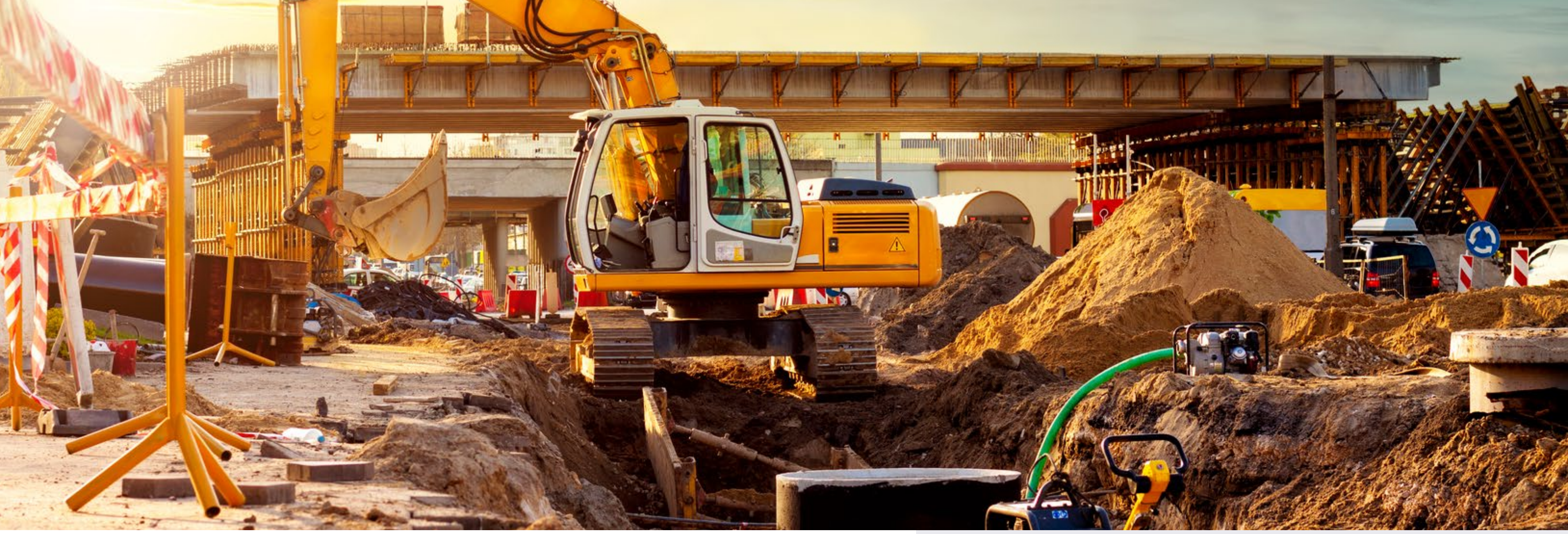
56%

The US Chamber reports that 56% of US contractors struggle to meet project deadlines as a result of skilled labor shortages. [1]

Better solutions for data are at the core of autonomous sustainability

Timble Construction Cloud powered by Microsoft Azure is an ecosystem of connected solutions, licensing and data services to streamline construction. It does this in part by providing one centralized and common data environment that connects the office with site operations for data that is less fragmented, and in fewer silos.

As reported in an article in International Construction featuring an interview with Trimble CEO Rob Painter, Trimble has spent around $2 billion USD in recent years on research and development, the lion's share of which has been invested in data and autonomy. An example of that investment would be the Trimble Construction Cloud, powered by Microsoft Azure. In this article, Painter put the sustainability of autonomous construction in simple terms, explaining that the more efficient a project, the fewer emissions are produced. "The first place where you achieve [construction] sustainability benefits is through productivity," he said.



Sustainability case study: Autonomous compaction

In compaction, the idea is to perform the exact number of passes with just the right degree of overlap for optimal results, minimizing fuel use and reducing machine operator hours while achieving a more reliable result. Too little machine overlap leads to gaps or bulges of material at the edges. Too much can produce unwanted changes in the mechanical properties of the compacted material, risking the possibility of costly rework, resulting in excess fuel consumption, operator hours and resources.

In a lab utilizing data collected in 2022, Trimble sought to document the reduction in carbon emissions through autonomous technologies such as horizontal steering control that reduce overlap. This productivity and sustainability study examining how horizontal steering control for Trimble Earthworks Grade Control Platform for Soil Compactors drives sustainability while reducing overall operating costs unearthed some impressive insight and results. Key focus areas related to measuring productivity, moving and idle time; total compacted area compared to pass counts per hour; and to calculate CO_2 emissions.

Methodology

- Trimble executed 80 total timed trials using two operators — one skilled, one novice; 20 manual and 20 assisted by each operator
- Area to compacted: 300 ft x 30 ft (836.127 m^2)
- Machine used: Dynapac CA2500D compactor
- Material: a common soil composition
- Auto assist drive mode path planner was preset to a 15% overlap for passes
- Data Analysis of Variance (ANOVA) tool found Trimble technologies reduced fuel consumption and duration at the 99.5% confidence level

Two randomly selected compactor operators performed the manual and assisted steering operation 20 times, using the same machine and test area to ensure statistical relevance.

Recorded observations for both manual and automated functionality included fuel burn start, fuel burn end, pass count and total time.

Results

Overlap in the assisted steering mode stayed very close to the preset 15%, while the manual overlap varied from 30-50% between operators. As shown in *Table 1*, manual drive mode led to significantly longer paths and, consequently, significantly longer engine run times which resulted in lower productivity and sustainability.

Metric	Operator 1 Manual	Operator 1 Auto	Operator 2 Manual	Operator 2 Auto
Cumulative Trial Time, s	9676	7821	8609	5203
Cumulative Time Reduction vs Manual, s	-	1855	-	3406
Cumulative Time Reduction vs Manual, %	-	19.2	-	39.6
Average Trial Time, s	484	365	453	274
Average Time Reduction vs Manual, s	-	119	-	179
Average Time Reduction vs Manual, %	-	24.5	-	39.5

Table 1: *Time reduction for the automated assist drive mode as compared to manual*

Further, operating in assisted mode dramatically reduced the time to complete the compaction operation (by about 25% and 40% for Operators 1 and 2, respectively).

The numbers were equally impressive from a fuel use and emissions reduction perspective:

Metric	Operator 1 Manual	Operator 1 Auto	Operator 2 Manual	Operator 2 Auto
Total fuel used	5.7 gal 21.58 ltr	4.7 gal 17.79 ltr	6.5 gal 24.60 ltr	4.2 gal 15.90 ltr
Total fuel reduction vs Manual	-	1.0 gal 3.78 ltr	-	2.3 gal 8.7 ltr
Total CO2 emission	127.97 lbs 484.42 kg	105.52 lbs 399.44 kg	145.93 lbs 552.41 kg	94.29 lbs 356.93 kg
Total CO2 emission, reduction vs Manual	-	22.45 lbs 10.18 kg	-	51.64 lbs 23.42 kg

Table 2: *CO2 Emissions: Sample Manual Drive Mode vs Automated*

Results Continued...

The cumulative results of all trials (20 automated/20 manual) found that the use of assisted steering in the study led to an average time reduction of 43.8 minutes (29.4%) and an average reduction of fuel consumption of 1.65 gallons (26.46%) compared to manual steering.

Further, the potential carbon savings using the average (26.46%), equates to an average saving of 680 gallons (26.46% x 2,569) across the testing scenario, which is equivalent to a carbon savings of over 15,262 pounds.

To read the full report:
https://heavyindustry.trimble.com/resources/white-paper/white-paper-quantifying-productivity-and-sustainability

Future labs are planned to validate similar findings across the Trimble Earthworks portfolio including machine control for excavators, dozers and motor graders.

In summary

Using automatic steering in the experiment led to considerable time and fuel reduction, as well as significant carbon savings compared to manual steering:

- 54.49% less overlap
- Task took 29.36% less time
- 26.46% less fuel was used
- Assisted-steering closed the skill gap, enabling both to maintain a 17% overlap and uniform compaction quality

Footnotes

1. US Chamber of Commerce, 2021.
https://www.uschamber.com/infrastructure/new-report-finds-construction-contractors-struggling-find-workers-building

2. McKinsey & Company, 2021.
https://www.mckinsey.com/capabilities/operations/our-insights/global-infrastructure-initiative/roundtables/sustainability-in-the-construction-ecosystem

3. European Commission, 2020.
https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2050-long-term-strategy_en

4. PwC, 2020.
https://www.pwc.com/gx/en/industries/capital-projects-infrastructure/publications/infrastructure-trends/global-infrastructure-trends-developments-in-sustainability.html

5. Capgemini Institute, 2022.
https://www.capgemini.com/ca-en/news/press-releases/digital-twins-are-a-catalyst-to-fulfilling-organizations-sustainability-agenda/#:~:text=The%20research%20also%20found%20that,Social%20Governance%20(ESG)%20promises

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