

# **Application of Autonomous Equipment in Heavy Civil Construction**

**Roman Ruffino**

California Polytechnic State University

San Luis Obispo, California

The prevalence of autonomous vehicles in our everyday lives is continually growing. Automobile manufacturers such as Tesla have made great strides in building a car that can safely navigate the world around it and respond to sudden changes. There is great potential in the heavy civil construction industry for equipment such as bulldozers, scrapers, and transport vehicles to add another level of safety and efficiency to the worksite. The goal of this research will be to determine whether a contractor would actually apply this technology, or if it isn't practical for everyday use. This paper will examine the current state of all autonomous vehicles, the early development of autonomous construction equipment, and how they can benefit the industry. Qualitative interviews with a project engineer, project manager, and superintendent at DeSilva Gates Construction was used as a data collecting methodology. It was determined that it is most practical for autonomous equipment to work side by side with human operated equipment. As the development of these vehicles continues, there is great potential in conducting future research as to if autonomous vehicles out-perform traditional construction vehicles in various categories such as safety, productivity and affordability.

**Key Words:** Autonomous, Equipment, Safety, Productivity, Affordability

## **Introduction**

The concept for this paper was developed over two summer internships with the bay area-based general contractor, DeSilva Gates Construction. DeSilva Gates is a heavy civil contractor who specializes in residential subdivision grading and site excavation, as well as the grading and paving of highways, roads, and airports (Construction Services, 2009). The use of large earthwork equipment such as bulldozers, skid-steers, and scrapers are an integral factor for delivering a successful project. Most importantly however, is that these pieces of equipment are being used in an efficient and safe way so the contractor can truly maximize their profitability. On several projects it was noted just how vital production budgets were to maintaining a profitable project. There was extensive record keeping

to ensure that the planned amount of daily production was matching the actual production being performed.

## General Background

### *Safety*

Hazardous conditions are a byproduct of almost any construction site, even sites that have excellent coordination and spacing. Whether it's the large equipment, uneven surfaces, or constant loud noise, there is a lot that can add to the already dangerous work being performed. Although there currently isn't much use of fully autonomous equipment being employed in construction operations, the application of autonomous features to assist an operator is becoming more frequent.

Large heavy civil equipment such as motor graders and dozers have many blind spots that increase the likelihood of collisions with people on the ground or dangerous utilities. A 2001 study by the Center for Disease Control (CDC) showed that 90% of all fatal construction collisions involved trucks or large construction equipment (Teizer, 2010). While PPE and good communication can help, it will not ever solve the problem. There is ongoing development of radio frequency technology that acts as a final preventive measure that will stop collisions. How it essentially works is that each piece of equipment and each worker on site will have a device that alerts them when they have entered another worker or equipment work radius (see Figure 1 below). The trials showed that a piece of heavy equipment was notified when a person or object was about 25-35 meters away, this gives the operator plenty of time to make adjustment in order to avoid collisions.

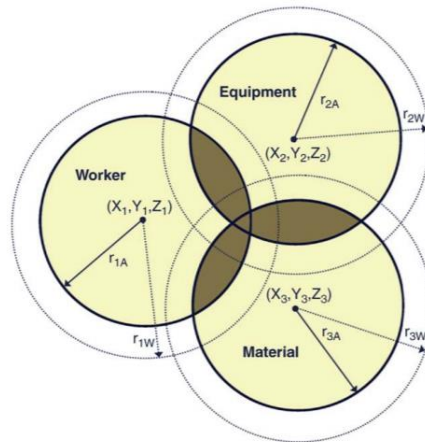


Figure 1: Idealized proximity warning and alert mechanism between construction resources. (Teizer, 2010)

### *Productivity & Affordability*

The easiest way to convince a contractor to upgrade their equipment is by showing them how it will earn them more money. Autonomous construction equipment provides a huge opportunity to dramatically reduce construction times. Even the best construction worker can only work for so long before fatigue begins to set in, they will have to take periodic breaks. There are mental factors that will reduce productivity, such as working on a Friday or approaching the end of work day. On the

other hand, an autonomous piece of equipment can work 24 hours a day as long it is well maintained. This will severely reduce construction schedules, providing higher profit margins to the contractor.

Automation has already begun being used in road construction with crack sealing robots. They are showing much higher rates of productivity as “the machine can fill cracks at up to five miles per hour. In comparison a manual sealing operation would take a large crew all day to complete two miles” (Elattar, 2008). While there is presumably a high initial cost of purchasing the equipment, contractors will see labor cost savings that will repay them for their investment.

### *Built Robotics*

Built Robotics is the current leader in developing fully autonomous equipment for use in heavy civil construction. So far, they have an autonomous dozer, excavator, and skid-steer which they claim “has worked over 10,000 hours with a perfect safety record” (Home, 2020). Their machinery uses sensors to alert the equipment of any potential hazards surrounding it. Additionally, they can be remotely stopped at any time by anyone with access to their computer program.

What makes Built unique is that contractors can set boundaries for the equipment to work in, Built refers to this as a “Geofence”. A projects’ elevation and coordinates can be sent to the equipment, giving the equipment limits to how far or how deep it should be working. When equipment is assigned a task, it gives the contractor feedback as to how much work will be done in cubic yards. This is how it tracks progression and keeps the contractor updated as to how much percent complete the job is.

### **Purpose**

The purpose of this paper is to gain a better understanding of whether or not a heavy civil general contractor who uses lots of heavy equipment would be interested in replacing their equipment with autonomous construction equipment. This baseline knowledge could help a contractor make a decision of whether or not autonomous construction equipment would be a good fit for their company. Additionally, the manufacturers of autonomous construction technology would have added insight into the concerns that contractors have. This would help them make corrective changes that would allow the vehicles to reach the marketplace sooner.

### **Methodology**

The information gathered in this paper was collected through qualitative interviews with a project engineer, project manager, and superintendent at DeSilva Gates Construction. These interviews were performed during a summer internship in August of 2020 and during the fall quarter of 2020. The advantage to interviewing employees from different positions in the company is that have varying perspectives to offer. The following questions were asked of each member of the project management team:

- What is the biggest risk you see in the use of autonomous construction equipment?
- What are some advantages that autonomous construction equipment could bring to the jobsite?
- Do you think autonomous construction equipment would improve or worsen the quality of work performed?

- Do you predict there will be widespread use of autonomous construction equipment in the future?

## **Results**

### *What is the biggest risk you see in the use of autonomous construction equipment?*

The superintendent responded that “A simple technological malfunction or breakdown could cause severe project delays which would lead to huge losses in profit”. This is a good point because since this technology would be so new to a worksite, it is almost expected that there will be a significant learning curve until the equipment can be used efficiently. This learning curve has financial impacts that many contractors won’t be able to afford.

The project engineer is concerned for damage to people or property. Even when all preventive measures are taken, it is not uncommon for underground utilities to be struck and damaged when excavating. Most of the time, excavating above or around utilities is a two-man operation: one in the excavator and one by hole making sure there isn’t a pipe that’s about to be broken. If an autonomous excavator was working by itself, it would know how deep to dig but it wouldn’t know what it is digging.

The project manager thought that it would be risky to swap out an entire fleet of traditionally operated equipment with autonomous operated. Unless that contractor sold all of their equipment up front and bought new equipment it would probably take years to be able to afford an entire new fleet. And how efficient would a combination of autonomous and traditional equipment work together?

### *Do you think autonomous construction equipment would improve or worsen the quality of work performed?*

The superintendent thinks that “Using automated machinery will create a detachment from work that can hurt the quality. Most of the operators take great pride in doing good quality work because it reflects how skilled they are, by removing them from the seat of their vehicles there is less incentive to do top-notch work”. At DeSilva Gates Construction, superintendents usually reach their position through being promoted from operator, to foreman, to superintendent. This gives them a deeper bond with the labor crew than what would typically be found with a project manager. For this reason, it is to be expected that they will be less open to new technology that would possibly replace the labor workforce.

Both the project engineer and project manager felt that autonomous equipment could do just as good of a job as traditional equipment, but only to a certain of finish. A human operator will make sure that whatever they were working on has clean lines and is neat. An autonomously operated machine may just see that it did what it assigned and will move on, this may create even more re-work than the industry already sees.

*What are some advantages that autonomous construction equipment could bring to the jobsite?*

The third question asked of the superintendent was *what are some advantages that autonomous construction equipment could bring to the jobsite?* Nate's response was "I see immediate use in the transportation of construction materials and debris". The hauling of materials to and from a jobsite is such an important factor in DeSilva Gates' business that they own a trucking company. On days when a project is importing lots of material to the jobsite, there is high labor costs for the many truckers that spend all day doing drop-offs. Thousands of dollars could be saved by eliminating the use of drivers.

The project engineer is responsible for the daily management of a project whether it be documentation, correspondence, or budgeting. The project manager liked the idea of being able to plan the operations of a week more correctly, "If we're planning on doing task A on this day and task B the next day, we have to make sure task A gets completed on time". There would be fewer times where the project team would have to eat into its float days and push subsequent activities back.

The project manager is responsible for overseeing many projects in a given area and ensuring they all operated under budget and complete on time. The project manager felt that autonomous equipment would provide more accurate scheduling due to less variance on a day-to-day basis. This would also lead to better relationships with clients because there would be less occurrences of the client getting their hopes up about a completion date that would later be changed. The project manager also noted that the average age of skilled labor is increasing and it's becoming harder to find young talent. Autonomous equipment would help to ease that burden.

*Do you predict there will be widespread use of autonomous construction equipment in the future?*

All three members of the project team thought that there will be widespread use. The superintendent answered "Yes, but not in the near future, and not for every piece of equipment on a jobsite. The human touch is irreplaceable." The technology is still in a primitive stage so there is probably going to be many years until the industry has a better idea of how it will work and what the correct applications will be. Autonomous equipment has also begun to appear in the pouring of concrete. There are machines that will form and pour curb and gutters, and it will adjust the form to pour driveways seamlessly.

Both the project engineer and the project manager think that the use of autonomous equipment in heavy civil will be for much more than just specific, small tasks. They could both envision a scenario where huge rough grading sites are entirely autonomously operated on, with a handful of people overseeing the work is being performed correctly.

## **Conclusion**

The question of whether the heavy civil construction industry will see the use of automated construction equipment is both yes and no. The use of robotics such as the earlier mentioned crack sealing machine on tasks that don't yield high productivity rates is already in use. But the entire replacement of human operated heavy equipment with autonomous excavators, scrapers, and other vehicles is highly unlikely. Rather, humans and robots will work together to increase productivity

while still delivering on excellent quality. An example of this can already be seen on the use of motor graders during the grading of roads. The angle of the blade is primarily computer controlled for most of the cutting, however, during the last tenth of an inch the computer turned off because it isn't as skilled at making small, precise cuts. The experience and knowledge of an operator is irreplaceable when performing finishing touches. With labor shortages across the country, autonomous equipment offers an interesting solution to combat the problem while also saving costs.

A possible issue with autonomous vehicles is the liability. If there is a technological malfunction and a piece of equipment damages property or injures someone. This could result in serious lawsuits which would stop work on a particular project and potentially bankrupt a contractor.

The most immediate new impact that autonomous equipment could have in the construction industry would be for delivery or hauling of materials. For example, in the heavy civil industry, large trucks such as 10 wheelers or transfers could be given a preset route to transport aggregate or asphalt from the plant and then to the jobsite.

### **Future Research**

There are lots of opportunities for future research once the development of autonomous equipment is fully fledged out. A case study comparing the safety and productivity of autonomous equipment versus traditional human operated equipment would prove critical to the mass implementation of autonomous vehicles to the worksite.

Additionally, a life cycle comparison between autonomous and human operated equipment would be beneficial for contractors. It would be interesting to see whether or not autonomous vehicles manage their wear-and-tear better than a traditional piece of equipment. The purchase of new construction equipment is a huge investment as some pieces of machinery cost well over \$1 million and have massive maintenance costs such as tire replacement and fuel. If an autonomous vehicle can save a contractor thousands of dollars a year in maintenance from not overwearing tires or driving in the most fuel-efficient manner, contractors will more seriously consider the switch.

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