

Experts' Panel Final Report Otto Tech Systems SmartLadder™ Pilot Project

Prepared for



Submitted by
Chuck Easterly
Experts' Panel Moderator
May 21, 2024

Table of Contents

Executive Summary 3

Introduction 4

Pilot Purpose 4

Planned Pilot Design..... 4

Actual Pilot Roll-Out 5

Florida and Massachusetts Pilot Adjustments 6

New York City Full-Scale Pilot 7

 Observations at the NYC Site 7

 Additional feedback from Otto regarding the onsite experiences in NYC..... 8

 Ladder Sensitivity Adjustments..... 9

 Analysis of New York City Data 10

 Independent Data Analysis by MEM Insurance 11

 Feedback from workers and foremen about the SmartLadders™ 14

 Review of Data compared to Scripted Actions on Ladders..... 17

Overall Conclusion..... 18

Experts' Panel Assessment of the SmartLadder™ Pilots 18

Appendix A: Otto Experts' Panel Members 22

Appendix B: Otto Tech Systems Response 23

Executive Summary

An independent panel of construction, insurance, government, and academic safety experts evaluated data from more than 1,300 hours of field testing on construction sites of 32 ladders with embedded technology intended to detect, analyze, and issue warnings of risky behavior. More than 460,000 records of worker behavior while using ladders were recorded.

The Experts' Panel concludes that the technology:

- Collected, utilized, and transmitted the data at scale, and was unaffected by harsh conditions on any of the test sites. Some issues, related to data batching, alarm sensitivity, and data accuracy, were also evident.
- Was highly effective at reducing the incidence of “near misses.” Once audible alerts were activated, the number of near misses dropped by 30% and remained at that level for the duration of the test. This was the first quantified look at “near misses” which have been suspected to be a significant leading indicator of ladder accidents.
- Needs refinement in several ways. Foremost of these is deeper insights into the precise timing of risky and other behaviors. Looking at batches of data in 30-minute increments provides little guidance for safety professionals.

With these few improvements, the “smart ladder” and the Otto data system holds great promise for construction safety.

Introduction

An independent panel of experts was assembled to provide Otto with a wide variety of perspectives in the assessment of the SmartLadder™ system. All Experts' Panel members served without any compensation from Otto. A listing of all panel members is provided at the conclusion of this report (Appendix A). Panel members came from the following types of organizations:

- Construction industry executives and safety professionals
- Construction industry associations
- Insurance companies
- Occupational safety and health professionals
- Academic researchers from public universities
- Government researchers
- Firefighters

Pilot Purpose

The purpose of the Otto Experts Panel Pilot was to field test the alpha version of Otto's SmartLadder™ system. The Experts Panel was tasked to do the following:

- (a) affirm that the Otto technology operates in accordance with its design, i.e., (based on the data and observations provided to the panel members) that the Otto ladder reliably gathers data on weight distribution on the ladder (implying worker positions while on the ladder as well as some workplace conditions relating to level work surfaces), transmits the data accurately to the cloud, and processes the data correctly in the back-end,
- (b) analyze data produced during the pilot to assess its potential for improving worker safety, and
- (c) make suggestions for potential improvements to the Otto system before its commercial launch.

Planned Pilot Design

The ladders being used in the pilot were manufactured by Little Giant with the Otto technology added. This technology included sensors in the feet of the ladder, covered communication cables along the rails, and an accelerometer and a Wi-Fi/cellular data transmission unit in the top cap. Otto designed and built the technology, supervised the installation of the equipment at the Little Giant factory in Utah, and then performed final calibration at the Stress Engineering Services site in Ohio before the ladders were deployed.

The Experts Panel met for the first time on October 13, 2022 to receive an overview of the Otto SmartLadder™ and how it is being designed to work. Subsequent Experts' Panel meetings in November and December provided additional details about the data dashboard, audible alarms, and the plan for pilot testing the ladders on a single job site in early 2023. However, in January 2023, the launch parameters for the pilot shifted to include multiple, smaller job sites in Tampa, Florida, Worcester, Massachusetts, and Springfield, Massachusetts.

Initially, the plan was to deploy approximately 45 ladders, but a decision was made to pull back a portion of the 6-foot ladders and work on converting the technology for use on 10-foot ladders at a future project site. That plan was intended to enable Otto to expand the pilot to additional users in work

environments where the 6-foot ladders are not tall enough for the type of work being conducted. Although this was a shift from the original design, this change created opportunities to expand the pilot to include different trade groups and tasks.

The original pilot design included an initial 3-week period (Phase-1) where the ladders would be used with the alarms turned off (but with data still collected). Phase-2 was planned for a subsequent 3-week period where workers would be informed of what types of actions specifically trigger alarms and those audible alarms would become active. [Note: Phase-1 occurred in Florida and Massachusetts, but for a variety of reasons explained later in this report, Phase-2 never occurred.]

A more complete pilot project was identified and launched in New York City in the summer of 2023. This pilot project was at a single, new-construction job site using 6-foot and 10-foot SmartLadders™. The ladders were provided to two groups of workers: electricians and carpenters. Again, the pilot design was to deploy the ladders without the audible alarms turned on during the initial phase of the pilot and then activate the audible alarms during Phase-2 to gauge the impact of those alarms on how the ladders were being used by the workers.

Actual Pilot Roll-Out

The pilot process eventually occurred in two different deployments. The first deployment involved 14 ladders at four different sites in Florida and Massachusetts between February and May 2023. The second deployment involved 18 ladders at a single job site in downtown New York City between July and November 2023.

Time frames for the various pilot projects in 2023 involved:

Deployment 1:

- 2/20/23-3/30/23: Tampa, FL: General Contractor (2 ladders)
- 3/1/23-5/1/23: Tampa, FL: Painters (3 ladders)
- 3/8/23-5/10/23: Worcester, MA: Drywall, Electrical, Plumbing (5 ladders)
- 3/10/23-5/10/23: Springfield, MA: Drywall, Electrical, Plumbing, Carpentry (4 ladders)

Deployment 2:

- 7/10/23-11/24/23: NYC Field Trial: Electrical and Carpenters (18 ladders)
 - 9/21/2023: NYC "Phase-2" began with audible alarms activated

Otto personnel were on site at each of the first deployment locations to provide site managers and workers with an overview of the ladders and the technology integrated into them. Key aspects of the overview sessions with workers included:

- Cell phones were provided by Otto to enable workers to badge-in using phones provided for this task. Workers were given instructions on how to badge-in and badge-out using the phone and a QR code on the ladders.
- Workers also watched a live video feed from Little Giant in Salt Lake City, Utah, where Kenyan Allan provided an overview of the various features of the "Signal" ladder the workers will be using for this pilot. This included the two "comfort steps," the "ground cue" on the last step (that clicks to audibly confirm that the user is on the last step), the intentional removal of the

top step (which is not intended as a step anyway), and the ladder's designed ability to be locked in a closed position so it can be used while leaning against a wall in an approved way.

- Otto staff followed-up the video training with a live demonstration of the ladder. All ladders were put into use with the audible alarms turned off. Workers were advised that the ladders had technology to record situations where the ladders were not level, were overloaded, or workers were leaning too far, standing on the back, or standing on the top cap. Workers were also advised that the sensors are not tracking the worker and that the data will not be used to get anyone "in trouble."
- Workers were asked to return the SmartLadders™ to a designated, secure site each evening to 1) provide the ladders with access to a Wi-Fi connection to upload ladder data to the cloud, and 2) protect the ladders from possible theft.

Florida and Massachusetts Pilot Adjustments

Within the first two weeks of the Phase-1 launches in the Florida and Massachusetts locations, it became clear to the Otto team that firmware enhancements would be needed to adjust the frequency that data should be transmitted from the ladders. The technology on the SmartLadder™ can collect and transmit high volumes of data at intervals of several times per second, but the initial pilot deployment revealed that this level of detail isn't particularly helpful for analyzing usage trends, warnings, and alarms. The Otto team worked with some Experts' Panel members who provided guidance and perspective to help fine-tune how often ladder signals should be reported. The goal was to eliminate unnecessary duplication of data while also determining what is the most appropriate interval for the ladders to transmit any event codes to provide meaningful and actionable data.

That work took about eight weeks to fully test and complete. During that time period, workers continued to use the ladders, but Phase-1 had essentially been suspended and Otto used this time period as more of a field test of the ladders and their ability to accept the firmware enhancements. In mid-April, Otto began preparations to restart Phase-1 data collection in Florida and Massachusetts on May 1 with the additional goal of moving to Phase-2 (with audible alerts turned on) beginning May 22.

Unfortunately, the Otto team was unable to begin Phase-2 as planned because the two jobsites in Massachusetts had concluded most of their construction work by mid-May. At this point, there were only three ladders still in use in Florida, and that was deemed too small a sample from which to draw any meaningful conclusions, so no ladders moved into Phase-2 status for any of the Florida or Massachusetts locations. Instead, all ladders were returned to the Stress Engineering Services location in Ohio to be inspected by engineers, recalibrated as needed, and prepped for delivery to a new project site in New York City. Some of the technology was also used to equip new 10-foot ladders for this same project.

The end result of these developments meant that the initial pilot projects in Florida and Massachusetts could not be used by the Experts' Panel as initially designed. Instead, they were essentially "field tests" of the new SmartLadder™ technology. However, these field tests did provide Otto with previously unknown information, such as:

- The collection of more than 85,000 data points that helped tell a previously unknown story about how ladders are used on job sites;
- The durability of their ladders in real-world construction environments;
- Validation that their SmartLadder™ firmware updates can be deployed successfully;

- Feedback and insights from workers and their supervisors who worked with these ladders for several months.

All the experiences from the initial deployment were used in preparation for the second deployment of ladders at the New York City location. This became the pilot project that would serve as the primary basis for the Experts' Panel assessment of the SmartLadder™ system.

New York City Full-Scale Pilot

The initial roll-out in New York City was handled in a similar manner as the pilots in Massachusetts and Florida (described previously in this report), but the general contractor did not want workers to have to badge-in to a specifically-assigned ladder for this pilot project, so no phones were issued and no individually identifiable worker data was collected. In addition to the processes used in the previous pilot projects in Massachusetts, Otto personnel interacted with workers and their foremen onsite in New York at least weekly to talk with them about what they were experiencing throughout the entire five-month pilot project on this site.

Additionally, Otto personnel provided weekly briefings to the general contractor about ladder usage and ladder events (warnings and alarms) and supervisors were provided this information so they could share key safety-related information with their workers during morning briefings. Unlike the Massachusetts job sites, the New York City job site was inside a secured high-rise building and had ready access to Wi-Fi throughout the day.

The new pilot project was conducted at an office construction project on 14th Street in New York City. The project was given the name "Game Changer." A large general contractor had just started work on the 17th and 18th floors of new construction inside a high-rise building in lower Manhattan. Otto provided 25 ladders (six 6-footers, nineteen 10-footers) on the site, 18 of which were distributed between two crafts: carpenters and electricians. The remainder were held in reserve at the site. The mix of ladder sizes was requested by the general contractor.

Phase-1 began on July 10, 2023, and Phase-2 began on September 21. Data from the ladders was made available to construction management and to the Experts' Panel via the web-based Otto Dashboard, weekly distributed reports, and the availability of all raw ladder data via weekly .csv files.

The Otto team also ran weekly scripted tests on randomly selected ladders at the jobsite which they video-recorded with a time stamp. These scripted tests were designed to trigger various ladder alerts (such as leaning too far, standing on the back of the ladder, using the ladder in an unlevel status, etc.). These videos were made available to the Experts' Panel who could then compare the scripted actions recorded in the videos with the .csv file data for the same date and time in each video to assess whether the ladders were accurately capturing worker actions on the ladders.

Observations at the NYC Site

Experts' Panel members were offered the opportunity to observe the job site in-person in late September. On September 27 (one week after audible alarms were activated as part of Phase-2), two panel members (Chuck Easterly and Corey Rimmer) travelled to New York City and met with Ellen Giuntini and Brian Jones from Otto to observe the pilot project in action.

Summary of the onsite observations by Experts' Panel members:

- The ladder technology is clearly capable of producing warnings and alerts based on specific programming.
- The ladder technology also demonstrated that it could consistently deliver data regarding worker usage and warnings and alerts. The technology also proved capable of delivering a software update to switch “on” the alarms on all the ladders from their previous “off” state.
- Workers like the concept and overall design of the 6-foot Little Giant ladder, even though they would prefer it to be lighter. Workers were less receptive to the 10-foot ladders (partially due to weight, but mostly due to this specific work environment that is more conducive to an 8-foot ladder).
- It was unclear during this brief observation period if the audible warnings and alerts were modifying any worker behavior. Workers were often observed ignoring the alarm tones while they continued to work. Alerts were also occurring so frequently (and while workers were working in seemingly “normal” positions on the ladder) that workers commented to us that they were often ignoring the audible alerts. One worker commented, “It seemed like anything you did caused it to set the alarm off, to beep. It was happening so often that you just blocked it out.”
- It is possible that worker behavior was already being modified by the knowledge that the ladders were tracking and recording how the ladders were being used. We observed what we would consider to be very safe work practices by all the workers using the Otto ladders during our 2-hours on the job site. The only truly at-risk behavior we observed was by an employee using a ladder that was not part of the Otto pilot.
- The alarm tones make it difficult to distinguish what specific action triggered the tone. For example: It’s not easy to tell if the alarm tone is occurring because the ladder isn’t level or because the worker is leaning, especially because we observed that the ladders apparently triggered alarm tones while workers were behaving within normal parameters on level surfaces.
 - Some other types of audible tones are likely necessary to better distinguish Alarm-1 risks from Alarm-2 risks. Perhaps even some kind of graduated audible tone that gets louder and/or faster as you continue to lean (for example).
- Many of the alarms appeared to be from workers shifting their weight to one side of the ladder, but they were keeping the frame of their body inside the ladder rails. Workers were often standing on one side of the ladder, and they sometimes slightly lifted one foot as they pulled electrical cable in the ceiling area. This action may have been enough to transfer more than 80% of their weight onto the two right (or left) feet of the ladder, but we did not observe this action to be “at-risk.”
- Additional study is needed to determine more precise calculations for determining “leaning too far” and whether the ladder is level. Based on our limited observations, alarm status is being activated when workers are using ladders under fairly optimal work practices.
- Based on Chuck and Corey’s observations and feedback from workers, Otto staff met with workers and their foremen to conduct a 10-minute refresher training session about the SmartLadder™ and what triggers a warning or alarm.

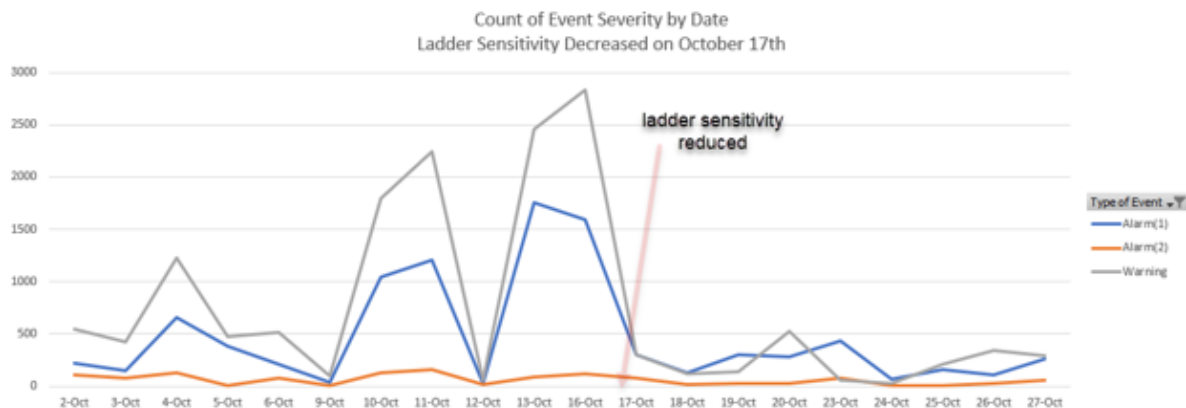
Additional feedback from Otto regarding the onsite experiences in NYC

On October 12, 2023, the Experts' Panel met via Zoom to receive an update on the New York City pilot project and to gather feedback from the Panel members. In addition to the observations by Chuck and Corey (above), Ellen Giuntini also shared the following:

- Audible alerts were activated on September 21. In the week that followed, initial data shows a 40% decrease in warnings for electricians; the data did not reflect a significant change for carpenters.
- Otto staff are onsite weekly and have built a good working relationship with the workers. Ellen said they are getting “full and unfettered truth from these guys.” The most common feedback is that the ladders are too heavy. (The ladders are rated for 375-pounds, and other ladders are only rated for 300-pounds.)
- The workers really like the larger “comfort steps” on the ladders and would like to see them on all the steps because they reduce fatigue (even if they add a little bit more weight). The workers also really like not having the top step on the ladders because it enables them to lean into the ladder, get closer to their work, and it provides greater stability while they are in that position. The workers also love the ability of this ladder model to lock in a closed position so it can be leaned against a wall (with a specially-designed top cap) for work in tight places. A team of trainers from SEIU also tested that particular feature of the ladder and loved the stability it provided.
- As a follow-up to worker feedback and Experts' Panel member observations that the ladders may be triggering warnings and alarms prior to a true at-risk condition, Mike Johnson shared that current data usage is telling the team that they can adjust the set points for “leaning” and “unlevel” warnings and alarms to indicate at-risk conditions more accurately.

Ladder Sensitivity Adjustments

On October 17, 2023, the Otto team updated the software on the ladders to slightly adjust the calculations that would trigger an alarm or warning for “leaning” or for working on the ladder when it is unlevel. There was an immediate and significant reduction in the total number of warnings and “alarm (1)” events as depicted in the graph below.



The positive implications of this change were that workers were now primarily receiving audible alerts when they were performing an action that was at-risk, and the data would be more actionable as it better reflected true at-risk conditions. The downside to this change was that it no longer made it possible to make a direct comparison of Phase-1 data to Phase-2 data.

Analysis of New York City Data

Throughout the New York City pilot, Otto personnel provided data analysis to the general contractor and to the Experts' Panel through an online dashboard and through weekly PowerPoint reports. These reports enabled users to see weekly and cumulative trends (by trade) regarding ladder usage, number of alarms, and the overall percentage distribution of alarms and warnings by event type.

Throughout the pilot, "leaning" created the greatest number of warnings and alarms, resulting in approximately 90% of all warnings and alarms throughout the New York City pilot:

July 31-August 4, 2023:					August 29-September 8, 2023:				
Detection Code	Description	% Total	% Electricians	% Carpenters	Detection Code	Description	% Total	% Electricians	% Carpenters
2	High Weight	0.18	84	16	2	Overweight	0.4	96.1	3.9
3	Back Side Climb	0.27	93	7	3	Back Side Climb	0.8	96.6	3.4
4	Upper Height - Top	0.50	96	4	4	Upper Height - Top	3.1	96.2	3.8
5	Lean Alarm Right	30.85	92	8	5	Lean Alarm Right	23	90.1	9.9
6	Lean warning Right	40.65	92	8	6	Lean Warning Right	30.7	84.1	15.9
7	Lean Alarm Left	8.97	77	23	7	Lean Alarm Left	13.2	91.2	8.8
8	Lean Warning Left	15.99	82	18	8	Lean Warning Left	24.6	86.1	13.9
10	Walking / Hopping	0.25	72	28	10	Walking / Hopping	0.2	85.7	14.3
11	Disembarking Early	2.08	86	14	11	Disembarking Early	3.1	86.9	13.1
12	Disembark w Tip	0.14	83	18	12	Disembark w Tip	0.6	88.7	11.3
13	Lean To	0.15	56	44	13	Lean To	0.4	70.9	29.1
September 15-28, 2023 (audible alerts were activated 9/21):					November 3-10, 2023: (ladder sensitivity was adjusted on 10/17)				
Detection Code	Description	% Total	% Electricians	% Carpenters	Detection Code	Description	% Total	% Electricians	% Carpenters
2	Overweight	0.3	93.0	7.0	2	Overweight	0.3	58.5	41.5
3	Back Side Climb	0.7	94.0	6.0	3	Back Side Climb	0.7	86.9	13.1
4	Upper Height - Top	2.1	93.5	6.5	4	Upper Height - Top	2.4	88.2	11.8
5	Lean Alarm Right	15.7	86.3	13.7	5	Lean Alarm Right	15.4	57.9	42.1
6	Lean Warning Right	22.6	79.1	20.9	6	Lean Warning Right	23.9	60.4	39.6
7	Lean Alarm Left	23.4	93.9	6.1	7	Lean Alarm Left	22.5	75.8	24.2
8	Lean Warning Left	31.0	86.1	13.9	8	Lean Warning Left	30.1	66.1	33.9
10	Walking / Hopping	0.1	65.9	34.1	10	Walking / Hopping	0.1	44.8	55.2
11	Disembarking Early	2.9	74.3	25.7	11	Disembarking Early	3.2	59.6	40.4
12	Disembark w Tip	0.6	84.2	15.8	12	Disembark w Tip	0.6	68.9	31.1
13	Lean To	0.6	67.5	32.5	13	Lean To	0.8	48.2	51.8

Source: Otto "Game Changer" distributed weekly reports

It was interesting to note that the overall percentage of alerts and alarms for leaning remained consistent with what had been reported throughout the life of the pilot project even after the audible alerts were activated on September 21 and the adjustments to the software criteria for what would trigger a lean warning or alarm were made on October 17. The actual *number* of alerts had been greatly reduced, but leaning still accounted for the same basic overall percentage of all warnings and alarms.

Independent Data Analysis by MEM Insurance

Brandon Jones (an Experts' Panel member and the Director, Safety Research and Risk Services, for MEM Insurance) and Taylor Miles (an MEM Insurance Data Scientist) agreed to conduct an independent data analysis of the pilot projects.

Methods

Data: Ladder severity messages were as follows: Informational, Alarm (1), Alarm (2), Warning. Event names were as follows: Back Climb, Front Load, Hopping, Leaning Left (Alarm), Leaning Left (Warning), Leaning Right (Alarm), Leaning Right (Warning), Missed Last Rung, Normal Usage, Not Upright, Overweight, Tip with Load, Too High, and Unlevel. Technical definitions for what triggered the alarm were given for each severity code.

The date, time, the type of event (alarm, warning, informational, etc.), ladder number, and reason for the event were recorded.

While data was captured in the Florida and Massachusetts pilots, these pilots ended early and alarms were never turned on for comparison data. It's believed these earlier pilots primarily allowed for seeing the data in "real world" activities, how much data was generated, the sensitivity of the ladders, and worker behavior with respect to badging into the ladders. It's believed this data was more useful for Otto to evaluate the overall capturing of the data versus its evaluation of worker behavior.

With respect to the NYC pilot, data capture began July 12, 2023 and ended, for purposes of this review on November 29, 2023 (the date the last alarms and warnings were detected in the data). There were 23 ladders in the overall pilot (with data), with some either taken out of service at different points in time or no data recorded. Over 380,000 events were recorded during the NYC pilot and only the data from the NYC pilot is being evaluated here due to the limitations with the other jobsites. Ladder 10 and ladder 19 were removed from the analysis to smooth the data as they appear to be outliers with 2.5-5 times more alarms produced than the next 10 ladders over the same time periods.

Analysis

During the analysis phase, it became apparent the data needed significant massaging (such as removing redundant data) to glean any insight. To help correct for data flaws, events were flagged as redundant if another warning or event had occurred within 5- or 10-seconds prior.

Limitations

Various factors make it extremely difficult (and maybe even impossible) to provide meaningful data interpretation without very time-consuming manual methods on our end to correct. We thus kept our analysis high-level for this study. Additionally, because of these data limitations, we were unable to accurately assess whether the ladder had any impact on worker behavior. The following challenges were observed:

- Malfunctioning ladders that recorded bad data
- Event triggers that were too sensitive, creating overly abundant alarms or warnings
- Batch loading of events, forcing events to incorrectly have the same timestamp
- Employees did not badge into ladders; therefore, the data is only specific to the ladder and not any employee

- On or around October 16, 2023 software adjustments were made to reduce the signal-to-noise ratio with the ladders, thus making them less sensitive and the data prior to this data difficult to compare.

These factors make it extremely difficult (and maybe even impossible) to provide meaningful data interpretation without very time-consuming manual methods on our end to correct. We thus kept our analysis high-level for this study. Additionally, because of these data limitations, we were unable to accurately assess whether the ladder had any impact on worker behavior.

Results

Our analysis produced the following key findings:

- 74% of alarms or warnings were produced within 5 seconds of a prior alarm or warning, jumping to 84% when expanding that window to 10 seconds. Many of these events appeared to be recording a worker repeating a behavior.
- The underlying data is not recorded often enough to allow any true insight. Batch loading of data creates the same timestamp, making it virtually impossible to decipher worker behavior.
- Total number of alarms dropped by approximately 50% (~30,000 vs.~14,000) when comparing two weeks *prior* to the alarms being turned on, to the two weeks after the alarms were turned on. However, this could be due to the training of the employees being more aware of what triggers an alarm versus the alarms triggering a behavior response. The timeframes beyond this can't be compared due to the sensitivity of the alarms being reduced on or around October 16th.

Issues With Timestamps

The following screenshot shows an example of multiple warnings and a flag for normal usage with the same timestamp. This is likely due to the aforementioned issue with batch loading. Examples like this are abundant throughout the data.

Event ID	Date	Time	Shift	Category	Count	Description	Event ID	Date	Time	Shift	Category	Count	Description
124741	9/19/2023	2:05:28 PM	Shift 14	Alarm(1)	7	Leaning L A	3051	OTA-019					
124742	9/19/2023	2:05:28 PM	Shift 14	Alarm(2)	11	Missed Last run	3054	OTA-019					
124743	9/19/2023	2:05:28 PM	Shift 14	LST			3057	OTA-019					
124744	9/19/2023	2:05:28 PM	Shift 14	Informational	1	Normal Usage	3058	OTA-019					
124745	9/19/2023	2:05:44 PM	Shift 14	Alarm(1)	7	Leaning L A	3272	OTA-019					
124746	9/19/2023	2:06:52 PM	Shift 14	Alarm(1)	7	Leaning L A	3279	OTA-019					

Issues With Behavior Duration

It is also difficult to understand how long a behavior will trigger an event. Once a “bad” behavior is corrected, should the ladder immediately record a “normal usage” event? Will a “bad” behavior continue to log alarms every centisecond?

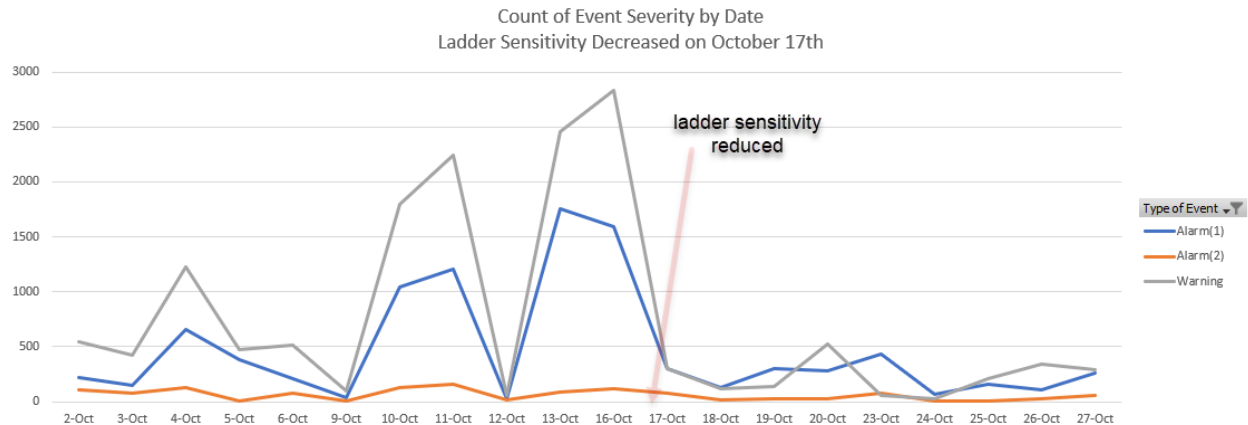
The first screenshot below shows back and forth between normal usage and leaning, while the second shows 10+ second gaps in events after a warning. It is difficult to understand what is happening here, particularly in the second scenario.

76	7/19/2023	10:53:54 AM	Shift 10	Warning	6 Leaning R W	667	OTA-005
77	7/19/2023	10:53:56 AM	Shift 10	Informatic	1 Normal Usage	668	OTA-005
78	7/19/2023	10:53:57 AM	Shift 10	Warning	6 Leaning R W	669	OTA-005
79	7/19/2023	10:53:58 AM	Shift 10	Informatic	1 Normal Usage	670	OTA-005
80	7/19/2023	10:54:27 AM	Shift 10	Alarm(1)	5 Leaning R A	671	OTA-005
274966	8/28/2023	10:42:22 AM	Shift 10	Informatic	1 Normal Usage	3160	OTA-042
274969	8/28/2023	10:42:26 AM	Shift 10	Warning	8 Leaning L W	3161	OTA-042
274970	8/28/2023	10:43:24 AM	Shift 10	Informatic	1 Normal Usage	3162	OTA-042
274971	8/28/2023	10:43:25 AM	Shift 10	Warning	8 Leaning L W	3163	OTA-042
274972	8/28/2023	10:43:30 AM	Shift 10	Informatic	1 Normal Usage	3164	OTA-042
274973	8/28/2023	10:43:33 AM	Shift 10	Warning	8 Leaning L W	3165	OTA-042
274974	8/28/2023	10:43:44 AM	Shift 10	Informatic	1 Normal Usage	3166	OTA-042
274975	8/28/2023	10:43:45 AM	Shift 10	Warning	8 Leaning L W	3167	OTA-042
274976	8/28/2023	10:43:54 AM	Shift 10	Informatic	1 Normal Usage	3168	OTA-042

Event Counts by Month or Date

The first screenshot below shows the trend line for the data filtered for Alarms 1 and 2 and Warning. Ladders 10 and 19 were removed for reasons previously discussed. The total event count during this timeframe is 111,929. No discernable trends are noted and it is not fully understood why there is a climb up to September. The drop afterward is better understood (alarms turned on, workers trained on what triggers an alarm, and the sensitivity of ladders reduced) and shown by the two graphs following.





MEM Recommended Next Steps

- Decrease the sensitivity of the ladders to only alarm or warn when necessary
- Ensure events are recorded with the proper timestamp
- Re-deploy the pilot once these factors are corrected

Feedback from workers and foremen about the SmartLadders™

Feedback was collected by Otto staff from workers and foremen at the conclusion of the two initial pilot projects in Springfield and Worcester, and near the end of the pilot in New York City.

Massachusetts Pilots - Summary of Worker Feedback

Worcester: The overarching theme from workers was the ladder is very well built, and the ability to use the ladder in a locked/leaning feature was extremely useful. The chief complaint is that the ladder is too heavy. When we asked what they normally use, the group responded that they use a 300-pound rated ladder. The head of safety for this contractor confirmed this in the meeting. He said what is required is called a 1A standard (300-lbs) versus the current Little Giant Signal ladder which is 1AA standard (375-lbs). There was a lot of discussion about the weight rarely ever exceeding 300-lbs in actual use conditions.

The biggest comment was that if the Little Giant ladder was lighter (and even a pound or two more than the 300-pound competition ladder) they would use this ladder over any other and it would be their “go to” ladder. The workers like this ladder far more and prefer it over a platform and a podium ladder.

Another issue that was very important was the bottom rung (first step) is about ¼ to ½ inch too high so workers were consistently hitting the bottom rung with their boots. Otto staff believes that could be because the ladder feet with sensor raised the ladder up about ¼ to ½ inch. The contractor’s safety director reinforced the point that it was annoying and a little dangerous because workers with 20 years’ experience using ladders daily were continuously hitting their boots on the bottom rung due to the height being abnormally high.

Springfield: Overall, the feedback from the Springfield crew was very similar to what was shared in Worcester. The Springfield crew really liked the ladder and said it was superior to anything else they have ever used. They felt it was comfortable, sturdy, and had great features. They loved the design-feature of the ladder that allows it to be used while leaning against a wall instead of only in its fully

extended position. The two main suggestions were to fix the height of the bottom step and make it lighter.

Audible alarms: Due to circumstances described earlier in this report, the audible alarms were never activated at the Worcester or Springfield pilot sites. Many workers stated that they would not like the beeps, but foremen, supervisors, safety officers, and everyone above the worker level like it, want it and want it to serve up the training on a phone app.

New York City Pilot - Summary of Worker Feedback

Experts' Panel members submitted several questions to Otto personnel to learn about worker and foreman experience during the New York City pilot. Ellen Giuntini interviewed two electricians and their foreman and recorded their responses on video for the Panel members to view. Their responses were transcribed by Chuck Easterly for inclusion in this report.

In general, the two workers shared similar feedback to what had been shared in Worcester and Springfield regarding liking the wider "comfort steps" and the ladder's ability to be leaned against a wall or into a corner area while in a locked/closed position, and they agreed that the downside to the ladder was the weight. Unlike the Massachusetts sites, the New York City workers had several weeks of ladder usage with the audible alarms turned on, so they were provided valuable feedback about that experience.

The following is a summary of their responses to these questions:

Q1: When the audible alerts were first activated, did hearing the audible alert cause you to change anything you were doing?

- One worker commented that prior to the October 17 sensitivity adjustment for "lean" and "unlevel" warnings and alarms, the high number of audible alarms was "annoying" and that he "kind of blocked out" the alarms because "it was too constant." But the other worker noted that the audible alarms did make him question if he was using the ladder correctly.

Q2: When you continued to use the ladder for multiple days, and I know we've already covered the fact that there were a lot of alerts, did your reaction to the alerts change at all during the span of those days? Did you pay more attention? Less attention?

- Both workers agreed that did change over time, but it was primarily due to the refresher training that helped them understand what causes an audible alert. "When she explained it and we understood the differences in the warnings and alerts, it made you more conscious of how you were standing on it, the way you position your ladder, the way you position yourself. So, it helped us understand more about why it's doing what it's doing."

Q3: When you did hear alerts, was it clear to you what was causing it?

- Both workers said it was not initially clear. Both agreed that this was partially due to the high frequency of the audible alerts (when "it seemed anything you did caused it to beep") and partially because they didn't fully understand what actions trigger the alerts.

Q4: We also did another training once the audible alerts were active to help you understand the cases and the behaviors that trigger alarms. Was that helpful?

- Both workers agreed that the refresher training was helpful. That training also enabled them to understand that the floor was not perfectly level and that was contributing to some of the alarms they were hearing.

Q5: Did a foreman or a supervisor ever talk to you about the beeps or the data that we're collecting?

- Neither worker recalled much interaction with their foremen or supervisors. Only one of the workers said he had been present for one meeting "where they kind of explained a little bit of what was going on and what would cause it to beep."

Q6: On this pilot, we're not collecting data on individual workers; we're just saying, 'how are the electricians doing' and 'how are the carpenters doing?' In the future we'll be able to say, this is your data profile and this your data profile. How does that make you feel to know that this will be identifiable?

- The two workers expressed very different opinions. One worker said he wouldn't mind. "If it helps for future safety, I'm OK with it." But the other worker expressed reservations about "being watched or monitored all the time." He said it "kind of throws me off to know I'm being watched" and that it "almost feels like they (his supervisors) are in my head."

Q7: Based on your experience with this ladder and the audible alerts, would you say this is going to have any impact on safety for an individual worker, or their firm, or for safety on a project site as a whole?

- Both workers agreed that these ladders would have a positive impact on safety. "I think having these features kind of gives you that extra security knowing that sometimes there's not someone with you that can give you a head's up that the ladder's about to lean or tilt over, but the ladder will let you know and you're aware of what happening and why it's doing it and it keep you within your boundaries before something happens."

Q8: Can you tell us what you liked and disliked about the Signal Ladder?

- Liked: the wider "comfort steps" (because "they take a lot of stress off your feet") and the ladder's ability to be leaned against a wall or into a corner area while in a locked/closed position. "There are certain areas where you can't extend the ladder fully, so this is great to be able to put it up against the wall."
- Disliked: the weight of the ladder. Also suggested that the top cap could be a little bigger and have "combinations for some extra tools or some materials."

New York City Pilot - Summary of Foreman Feedback

The following is a summary of responses by the electrician's foreman:

- He really likes the ladders. He is looking forward to when ladders will be assigned to specific workers so he can get alerts about any worker who is generating multiple alerts and correct an issue before it becomes really dangerous.
- He was not concerned at all about whether workers might have concerns about the ladder's ability to record their individual data. "Bottom line, if you want to go home to your wife, kids, family, and you want to be safe, then you shouldn't be upset with something that will help make sure you get home safe. I don't really see it as a problem. If you're doing the right thing, it shouldn't be a problem."
- He had not had any feedback from superintendents about the ladders.
- He said it would be helpful to get specific bits of data such as the time of day that a problem occurred. He thought this could help them identify times that they need to focus on.
- In response to a question about the 40% reduction in warnings and alarms in the week after the audible alerts were activated, he said, "I don't think that was just the audibles. I think it was also

the tutorial that you gave me. Cause after you told me, then I knew what to watch for and I explained to the guys what they're doing wrong."

Review of Data compared to Scripted Actions on Ladders

Throughout the New York City pilot project, a weekly test was conducted on a randomly selected ladder. Otto personnel performed a video-recorded "scripted test" of a person interacting with the ladder in a way that was designed to trigger a data response from the ladder. These scripted tests included the following actions: No load, load, exceeding load, back climb, lean right, lean right further, lean left, lean left further, folded-state, walking/hopping, step off second step, tipping over, not level, not upright.

A review was conducted comparing the ladder data for the date and time these actions were tested to the actual video-recorded actions. **In these scripted tests, nearly all the scripted elements appear to have been captured, which validated that the ladders do reliably send data that is then captured in the Otto back-end for analysis.** However, there was also evidence of the potential for some data errors. For example:

- In nearly every test, we did not see data evidence of leaning left or right (either warnings or alarms), but those actions may not have been properly demonstrated on video in a way that would have caused a warning or alarm. This conclusion is likely since warnings and alarms for "leaning" accounted for about 90% of all reported warnings and alarms in the actual data.
- In one scripted test, "missed last rung" was reported in the data five different times even though it was only performed once as part of the script and shown only once in the videos.
- In another test, "walking" and "hopping" were not reported at all even though these actions were performed.
- In one test, the ladder selected had malfunctioned and did not transmit any data for comparative review between July 18-30 (including the date for this specific test).

Overall Conclusion

Experts' Panel Assessment of the SmartLadder™ Pilots

The Experts' Panel Charter tasked Panel members with the responsibility of addressing three key aspects of the Pilot:

1. affirm that the Otto technology operates in accordance with its design, i.e., (based on the data and observations provided to the panel members) that the Otto ladder reliably gathers data on weight distribution on the ladder (implying worker positions while on the ladder as well as some workplace conditions relating to level work surfaces), transmits the data accurately to the cloud, and processes the data correctly in the back-end,
2. analyze data produced during the pilot to assess its potential for improving worker safety, and
3. make suggestions for potential improvements to the Otto system before its commercial launch.

To accomplish this assessment, the Experts' Panel members were provided (throughout the pilot) with updates on the various pilot projects via email, written project updates, six Experts' Panel meetings (via Zoom), and access to a cloud-based file sharing Box folder that contains:

- Pilot reference materials and resources.
- Raw data in .csv file format.
- Photos and videos from the pilot sites.
- Video recordings of Experts' Panel Zoom meetings.
- Summary reports from onsite field visits and worker feedback from Worcester, Springfield, and New York City.
- Video recordings of workers and foremen responding to questions.
- Video recordings of scripted tests performed by Otto staff on randomly selected ladders along with a review of the raw data compared to the scripted actions.
- Copies of written "Distributed Reports" provided weekly to the New York City general contractor.
- An independent data analysis provided by MEM Insurance.

At the conclusion of the New York City pilot, Panel members were asked to provide feedback on the three key aspects of the pilot. Their responses are summarized below along with direct quotes to provide additional clarity:

Aspect #1: affirm that the Otto technology operates in accordance with its design

The consensus opinion of the Experts' Panel is that, overall, the ladder functions as designed by gathering data on weight distribution and transmitting that data accurately. Some specific comments from Panel members include:

- I believe the above portions were met other than the batching-up of data causing some issues, and to overcome these issues, they had to build their own internal coding to glean out information that we (Experts' Panel) didn't have access to. However, I believe they learned and began doing this to be in a place where, toward the end, they were gathering better data than they were in earlier stages.

- It appears that the ladder is still a work in progress. The ladder has been demonstrated to measure many target conditions, but based on the Video review by Chuck Easterly and the Pilot Analysis by MEM, there are still areas of needed improvement to demonstrate data collection reliability and precision.
- While it can be affirmed that data is collected, transmitted, and processed, it's difficult to fully qualify and/or quantify that this data is accurate. Brandon Jones' independent data assessment combined with some of the videos of workers using the ladder indicated notable noise and possible accuracy issues with the data. As a panel member, I am not able to fully affirm that the accuracy of the data is fully validated currently. While there clearly is improvement opportunity in data quality, this is to be expected for a novel technology. Advancement in technology and AI will surely contribute to the rapid advancement and refinement of data quality and actionability. The question for me is, is the data accurate **enough** to produce a positive benefit? I'd say yes.
- It should be noted that the technology vendor should be commended for the thought, attention to detail, transparency, and structure of this pilot.

Aspect #2: analyze data produced during the pilot to assess its potential for improving worker safety

The consensus opinion of the Experts' Panel is that the Otto SmartLadder™ system does have the potential for improving worker safety. These initial results are very promising, but more data is needed before a more definitive assessment can be made. Some specific comments from Panel members include:

- This definitely has the ability to improve worker safety as long as the metrics are reliably met – meaning, if the alarms are too sensitive, as we saw in the data, then employees will ignore the alarms, if they aren't sensitive enough, then they may not pick up on hazardous situations. That's really a balancing act and I would have thought they would have done one more pilot to verify they got this dialed in. Regardless of that, if done right, they should be able to impact worker safety with the alarms, app, and training.
- Falling off a ladder is a major loss source for us and if we can continually engage the worker in what safe behavior is when working from a ladder, which I believe they are on the path for that, we can decrease the number of incidents.
- The MEM Data Analysis included this finding: *"Total number of alarms dropped by approximately 50% (~30,000 vs. ~14,000) when comparing two weeks prior to the alarms being turned on, to the two weeks after the alarms were turned on. However, this could be due to the training of the employees being more aware of what triggers an alarm versus the alarms triggering a behavior response."* My response: This is a great outcome! Training could produce this outcome, but training-triggered behavior wanes over time. The alarms will continue to reinforce the behavior and result in longer term, more effective adoption of safer use practices. I know the pilot didn't run long enough to study this, but behavior science would say it is the most likely outcome. This is a strong finding.
- This is an area of opportunity from an analytics perspective. The data being captured needs to be easily consumed and meaningful to both management and the individual worker receiving the feedback. Specifically looking at the information MEM Insurance went through, there are too many lines to consume. What is the balance or interval for recording events that helps better identify unsafe behaviors while creating a better data source that is easily consumable? I think about my personal ladder use around the house. Does the ladder need to record me

leaning outside the frame while changing a filter 5 times over a 5 second period or 1 time for that duration?

- There is a potential for the SmartLadder™ to produce information that could be used to inform the improvement of worker safety, but again there are further refinements, particularly in the algorithm development that are needed.
- Falls from ladders are among the most common and most severe injuries that I see in the workplace. The technology tested for this pilot most has significant potential to improve worker safety and is a massive leap forward into data-driven decision making using proactive vs. reactive information in the world of safety.
- In aggregate, the data certainly suggests that ladder alerts and informed action post receipt of the information by the employer and employee does have a measurable impact on safe work behaviors and positive modification of behaviors therein. The pilot provided evidence that data gathered prompted action at both the supervisor and employee level. Workers noted having at risk behaviors and movements being 'caught' by the system and adjust behavior. Supervisors used the aggregate data to inform trade-use specific conversations around safe ladder use and modifications in behavior needed.

Aspect #3: make suggestions for potential improvements to the Otto system before its commercial launch

Suggestions were varied, but they fell into the categories below (with specific comments from Panel members to provide context):

Reduce the ladder weight:

- Key will be getting the weight of the ladder down as much as practicable, and they mentioned they're working on this.
- One of the designers mentioned marking the carrying spot to balance the weight. I like this idea. Don't add a handle as it will add weight. But consider curving edges at the best spot for carrying so a handle shape is in the design.

Include additional metrics that demonstrate a "rate" instead of simply raw counts:

- Add in the rate of ladder use versus just a type/count methodology. That way when this much data is coming in, the ability to know some type of warnings/alarms per some "x" timeframe will give the supervisor more indication to know how safe someone is working.
- Include something such as "number of alarms/warnings per ladder hour" as well as another measure for "severity" (for higher-risk events).

Data visualization / Data accuracy

- Create compelling data visualizations that focus on core elements of employee safety and package them in a way that enables both employees and supervisors to act.
- A video overlay with the data would be one of the most helpful aspects because the video would help provide a clear understanding of the validity of the data. Too many false alarms aren't helpful. Having the data in aggregate is really important information to better understand worker behavior in general. The aggregate trends will be helpful for meetings with workers as we are better able to identify specific tasks that tend to generate greater risks.
- Continue to improve upon the quality of the data gathered by the ladder tech.
- Ensure events are recorded with the proper timestamp.

Refine the ladder alarm/warning sensitivity / Additional pilot testing:

- Decrease the sensitivity of the ladders to only alarm or warn when necessary.
- Re-deploy the pilot once sensitivity and timestamp factors are corrected.
- Prior to commercial launch, additional software improvements as noted by the MEM review are needed (decrease the sensitivity of the ladders to only alarm or warn when necessary; ensure events are recorded with the proper timestamp etc.) and additional pilot tests should be conducted.
- While you may pull back slightly on the triggering alarms, don't do too much of that. When a worker's behavior changes and results in fewer alarms, that will provide the reinforcement for ongoing change in that area. Prep adopters to hear a lot of beeps in the early stages of use and that it will go down as behaviors are adjusted.

Keep it simple as possible for the worker:

- In everything, simple is better for me from a consumer/user perspective. From a worker perspective safety tech needs to provide efficient and effective feedback in as close to real time as possible. I feel the biggest opportunity is to find a happy medium from the data capture and feedback loop.

Refine audible alerts the ladders provide to workers:

- There was some desire for haptics/vibration or indicator lights in addition to, or in place of, alert tones. This is also a possible solution to overcome hearing-impaired workers and/or noise on job sites.
- Is it possible to have an audible beep followed by a voice indication of the hazard type so the worker knows why they are getting an alert tone? Another means of communicating this information could be visual cues that indicate the nature of the error (i.e., the side of the ladder flashes for lateral reach or the top of the ladder flashes when stepping on the top rung). I think that beeps without a clear indication of the nature of the error might be frustrating for some users and could eventually lead some users to ignore the feedback.

Other feedback/suggestions:

- It appears that the most useful information from this pilot is that the ladder provides immediate, actionable feedback. This is true for the user and for any on-site supervisor/lead/peers. That may mean that the ripest market is for those working in teams or with at least one other person. While it may be helpful for overseeing lone workers, it's probably more helpful with others on site.
- The output data is useful, but more useful is the immediate feedback to the user and their supervisor. Emphasize this as the data collection can feel punitive. In fact, the longer-term data might not prove as useful to companies. I wouldn't change it now, but I wouldn't waste much.
- Before a full commercial rollout, I would recommend a heightened level of attention to any breakage or unexpected behavior from the ladders. This pilot was not a test of durability, but that will be important before a full commercial rollout.
- Consider employing an expert in safety technology to further refine and develop the technology. Cameron Stephens is a world-renowned expert in this realm.
<https://www.linkedin.com/in/cameronmstevens/>

Appendix A: Otto Experts' Panel Members

Name	Title/Organization
Jeff Floyd	Loss Education & Safety Manager, Kentucky Employers Mutual Insurance
Brandon Jones CIH, CSP	Director, Safety & Risk Services, MEM Insurance
Sabrina Freewynn	Health & Safety Manager, CareOregon
Scott Clark	Regional Operations Director, SAIF (State Accident Insurance Fund, Oregon)
Eric Bourquin, OHST	Vice President, Safety Services, Texas Mutual Insurance
Curtis Giles	Sr. Safety Engineer, SCIF (State Compensation Insurance Fund, California)
Seth Randall, CSP, CHSP	Regional Safety Director, Clark Construction Group
Mark Wilke	Head of Specialized Construction, CNA Insurance
Corey Rimmer, ARM, CRIS	Asst. Vice President of Construction Risk Control, CNA Insurance
Steve Pirovolikos	Vice President of Safety, Structure Tone Group
Rich Trewyn	Director of Risk Education & Training, National Roofing Contractors Assn.
Dennis Kiefer	Associated General Contractors of New York
Mark Dumas, CHST	Vice President of Safety, HITT Contracting
Steve Jones, CBO, MCP, MS	Government Relations Regional Director, International Code Council
Raffi Elchemmas	Exec. Director of Safety, Health, Risk Mgmt., Mechanical Contractors of America
Jon Harvey	President, Ohio Association of Professional Firefighters
Peter Simon, CSP	Total Safety Consulting (NYC)
Steve Wurzelbacher, CPE, ARM	Manager, Center for Workers' Compensation Studies at CDC-NIOSH
G. Scott Earnest	Assoc. Director for Construction Safety & Health at CDC-NIOSH
Kurt Beschorner, PhD	Associate Professor, University of Pittsburgh
Victor Duraj, PhD	R&D Engineer, University of California at Davis
Aaron Costin, PhD	Founder of the Smart Construction Informatics Lab, University of Florida
Kelly Ireland	CEO, CB Technologies
Jason Sprinkle, CSP, CIT	Director of Safety, The Arcticom Group
Jason Galoozis, CSP	Health & Safety Director, PremiStar
Wes Wheeler, SMS	Exec. Director of Safety, National Electrical Contractors Association
Zafar Zafari, PhD	Asst. Professor, University of Maryland School of Pharmacy
Chuck Easterly, ARM	Panel Moderator

Appendix B: Otto Tech Systems Response

We are grateful for this panel's participation and dedication to the assessment of the Otto technology and data solution utilizing the Little Giant Signal™ ladder. The potential to gather insights and feedback from a group drawing upon years of experience in their respective fields was anticipated to be invaluable to us, and it has been essential in driving innovation and shaping our product. We will draw upon these findings as we finalize the commercial launch and continue to develop additional generational improvements to the system.

We have begun to incorporate their suggestions into our system and data products, as discussed below.

1. Reduce the ladder weight

There is a re-design underway of the top cap and the feet of the ladder to minimize weight. In addition, we have discussed the addition of a "balance point" sticker to the rail to indicate the most optimal carrying point.

2. Include additional metrics that demonstrate a "rate" instead of simply raw counts

We are creating analytics to provide normalized data or a "count" as is appropriate to the key performance indicator being presented. This is being vetted with test groups drawn from our target customer base.

3. Data visualization / Data accuracy

Refinement of the presentation is a key aspect of the final portal views we are developing for our commercial launch. This is also being discussed and developed by listening closely to our target customers at various levels (superintendents, subcontractors, general contractors). In addition, adjustments have been made to address the timestamp comments noted by the experts' panel.

4. Refine the ladder alarm/warning sensitivity / Additional pilot testing

We will be holding an additional field trial in May-June 2024.