Ethical Internal Logistics 4.0: Observations and Suggestions from a Working Internal Logistics Case

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Abstract. In this paper we present our experiences and insights from a Use Case in heavy industry, where OCR text recognition is combined with algorithms to correctly identify labels for additives to be introduced into a production process. Ethical issues are presented relative to the effects of the Use Case upon the shop floor operators using the new technology. We then discuss recommendations given and our success in getting them implemented. An argument follows, regarding what we view as the source of many of the ethical issues: the unreflective acceptance of Industry 4.0 and Internal Logistics 4.0 as a generalized and idealized 'plan' which technological development and the human operator have to adapt to. We contrast this to an approach where the needs of the human in the work context would drive and limit internal logistics 4.0 development as a set of gradual improvements tailored to the worker's situation.

Keywords: ethics; internal logistics 4.0; industry 4.0; artificial intelligence; human-centered manufacturing; material identification; supporting technologies

1 Introduction

Internal logistics will be a very important element of Industry 4.0, and the more so since many of the interactions of humans with the autonomous systems being developed for Industry 4.0 are located precisely in the realm of logistics. Logistics involves the movement of materials or – in the Industry 4.0 context – information, between otherwise distinct parts of a process. Logistics creates linkages in areas where the regularity suitable to mere machine linkages is absent so that human participation will be needed for a long time to come.

In this article, we examine some particular issues surrounding a working case in internal logistics, a Use Case in an ongoing project in which we are involved as ethical advisors. Following a brief overview of ethical research related to Internal Logistics 4.0, we proceed in four sections. In Section 3 we describe the Use Case generally, in

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Section 4 we describe the various ethical issues and challenges encountered in the Use Case, in Section 5 we describe recommendations that we have made relative to those issues, and in Section 6 we generalize our insights from our efforts, to provide future research pathways for those engaged in the ethics of Internal Logistics 4.0.

2 Overview of Ethics of Internal Logistics 4.0

The ethics of Internal Logistics 4.0 specifically, is a relatively unresearched area. It overlaps with ethical research into Industry 4.0, the latter of which is itself not well developed. Trentesaux along with Caillaud and others have made various opening moves in the area of Industry 4.0 ethics, looking particular at the issue from the perspective of the engineer. But as they admit, there are "a critical lack of contributions in that field" (Trentesaux and Caillaud 2020). There is an even greater void in the area of ethics of internal logistics, and to our knowledge, there is no research which specifically focuses on the latter. (Cimini et al. 2020) outline a number of issues that are definitely ethics related, e.g. human supervisory roles, privacy rights, psychological effects on operators and job loss. But their list is only a subset of issues which require ethical engagement, and they go no further than an outline with no explicit reference to ethics. Another technical outline, that of (Schmidtke et al. 2022), notes the problem of job losses and the relieving of employees as benefits, but goes no further and makes no link to ethics. The best consideration we have found of the issues involved – although it addresses Industry 4.0 generally rather than Internal Logistics 4.0 specifically – is in (Berrah et al. 2021), who definitely take a worker centred view which agrees in part with the view we argue for below. (Anderson and Fort 2022)[a] address internal logistics indirectly in the context of practical suggestions toward ethical Industry 4.0.

3 An Internal Logistics Use Case

Our project, a partnership between research and industry, develops various types of AI systems to be used in heavy industry factory settings. The Use Case described is one of many initially selected for development. The specific logistics area involved in this Use Case would be categorized under the dimension of Material Identification and subdivision Method of Identification (Zoubek and Simon 2021)[a] or under Picking/Supporting Technologies/Information Flows Management (Cimini et al. 2020).

Within a factory setting, bags of additives are combined with several main materials to create a final product. The additives change regularly depending upon production needs. The bags, each weighing on the order of a ton, are retrieved from a stockroom by mechanical means. They are selected by an operator and brought to a hopper zone, where they are placed upon lifts to be hoisted over specific hoppers through which the additives are released into the production process. Bag labels describing the additives are sometimes unclear and labelling is often inconsistent between suppliers. Currently, the operator carries the bag label to a control room several floors down to be verified by a control room operator before the bag contents begin to enter the process. The factory is a busy place and sometimes the operator is delayed. Occasionally this coincides with the wrong bag being selected, which leads to trouble in the production process.

Shortening the time for verification of the bag label and eliminating any potential error and delay in this part of the process is the goal, through combining OCR (Optical Character Recognition) with an algorithm that can decipher unclear labels. The text recognition is to be carried out first by means of a hand-held tablet of a type already used, and then more experimentally, by a voice activated assisted reality helmet mounted wearable. The OCRed text is sent to one of the tech development partners, processed by the algorithm, and results sent back to the tablet or helmet to be confirmed by the operator and forwarded to a central computer handling the production process.

The human operator's original role in this logistics process combines manipulation with material identification. The operator is part of an operator team whose central 'gathering place' is the control room, in a nearby building, several floors below. Normally the operator walks down to the control room, interacting with colleagues. The environment is noisy, requiring special ear protection, and dangerous. Quick evacuation may be required under certain conditions of which the operator must remain aware. Different operators fill the role at different times. The new technology will change the operator's role and they will longer have to walk down to the control room with the labels. They will also have to deal with any mistakes made by the algorithm, either correcting manually through the tablet or helmet HMIs (Human-Machine Interfaces), or rejecting the algorithm's suggestions.

4 Ethical Issues and Challenges Encountered

What counts as an ethical issue? In our experience related to this Use Case, the role of ethics shifts from one of normative theorizing to practical contextualization and application. Historical developments in mass manufacturing have inexorably removed the human from the mass aspect of production processes (Smil 2020). But since the automated aspects of production processes are imperfect, the human is still needed. Ethical efforts are thus best directed at the humans remaining in the production processes, whether shop floor operators, maintenance workers, or machine specialists. Therefore, our concern is with the initial context and role of the operator, as compared with the changes planned by the tech developer and the factory management for the context and role of that operator. We constantly ask: 'what is planned, what harm might it do to the operator, and how can we alleviate that harm?'

4.1 AI for Public Relations

One of the issues we have uncovered is the tendency toward incorporating AI and other technologies merely for public relations reasons. The project is a research project, but expected to produce at least some results which are marketable. As observers from various fields have noted, e.g. (Rossi and Zhang 2022) and (Jakobsson et al. 2021), AI is a much-hyped technology. Its inclusion is thus arguably an obvious choice to improve marketability for eventually marketable results. Given that the project is research based, there is an impetus to 'experiment' with new techniques and technologies. Yet since those techniques and technologies are open to being adopted and marketed, the call to research could serve as an excuse for taking ethical liberties with regard to marketing. In our Use Case there are several levels of devices proposed for HMIs. The first level devices are selected to solve the problem at hand and probably be actually used. The next level is selected so as to experiment with more complex technologies. An AI integrated application on a tablet-based HMI was developed for the first level, tested in working conditions, and expected to be adopted. Once this was well underway, the HMI focus shifted to potential wearable helmet devices, virtual or assisted reality. *The operator is thus expected to adapt to a new technology, and then potentially adapt once again to a still more complex technology, which is stressful*. It also *puts the focus on developing and displaying new technologies primarily, regardless of potential operator inconvenience*. It leads naturally to asking: "what is the primary purpose of adding the technology?" If it is marketing the abilities of the tech developer, there is an ethical danger of related human effects being rendered secondary.

4.2 Overlooking or Misusing Technical Specifications and Product Warnings

Product specifications raise other issues. Off the shelf technology products such as the HMIs mentioned, have technical specifications and product warnings, which get bound up in ethical issues in at least two ways. Firstly, *they contain information and warnings that may be overlooked, regarding potential inconvenience and harm which the product can cause the user*, and secondly, *they can serve as an objective impediment to adapting to the context of the user*. We encountered both. We took time to read the product warnings for the proposed HMIs, which showed us that the virtual reality wearable in particular might cause a wide range of physical or psychological problems. On the other hand, we have seen the technology developers sometimes fall back upon technical specifications – and the inbuilt architecture of the device – to argue that certain changes cannot be made. The language of the operators became an issue here, because the software base upon which the OCR/AI application was developed was only devised for a set number of languages, and not the primary language of the operators. The solution was using the device in English. The operators can speak English, but their accent creates difficulties. (Radzikowski et al, 2021) have discussed both the problem and advanced potential solutions to it. As in many devices, English serves as one of the default languages for use, but here this fact comes to serve as an objective impediment for not being able/willing to adapt the device to operator's native language.

4.3 Deferring to the Technology Developer

Whether the OCR/AI application will actually be used on the factory floor has been difficult to clarify explicitly. The managers seem to adopt a 'wait and see' approach, i.e. *if* they can get it to work sufficiently and *if* the operators accept it, then it will be used. This alternates with a 'we need this at any cost' approach. Thus, the industrial partner tends to defer to the technology developer in terms of particulars: 'if you can get it working right we need it,' which implies: 'how you get it done is more or less up to you.' These attitudes *put the operator's role at the mercy of the technological development plan and the specific technology*. They also raise *the danger of the redundancy of technologies*, i.e. the operator may have to use both the new and old systems at once, since 'we can't afford to make mistakes.' This doubles the operator's work, increasing the chances of confusion between the different systems.

4.4 Lowering the Reliability Bar

A further issue is the tendency to lower the bar regarding reliability. KPIs (Key Performance Indicators) are determined and prioritized in the project first in the initial project proposal (generally) and then more specifically through a dedicated project task. Performance of AI solutions is the first priority – assessed in KPIs related to production efficiency, product quality and resource consumption, among others – but impact upon workers in terms of user acceptance of AI solutions is also considered. Going beyond the latter, we attempted to get *worker side* KPIs instituted. Questioning how often the application would correctly read the bag labels, we asked early in the Use Case for a first reliability estimate, which was about 80%. As months passed however, and we requested updates and discussed potential errors, the estimated reliability became successively 85%, 90-95%, 98%, and finally 99.5%. Meanwhile, the issue of setting a reliability KPI, i.e. 'what is the minimum error rate for the application to be considered reliable enough to use?' tended to be pushed further away. To admit that the technology will make errors at all seems difficult for the developers to do. Thus, questioning reliability seems to invite lowering the bar, until the working assumption becomes: 'the technology will nearly always be right.' Later we learned that the industrial partner had provided very little data yet to make a reasonable reliability assessment. There are thus three interwoven issues here: *failure to adopt strong KPIs related to human operator inconvenience* (the default assumption is that the human will 'take up the slack' when the system makes an error); *a lack of enthusiasm on the industrial side in providing data to support setting and assessing such KPIs*; and finally, *a gradual lowering of the bar for reliability, abetted by the first two issues*.

4.5 Lack of Access to Operators and Workers

A number of ethical issues arise from not having free access to the operators. From a human centered approach, not being able to speak to the workers or observe their testing of the application on the HMIs, means *not being able to assess directly their comfort with those technologies, either explicitly with regard to KPIs or implicitly through more subjective observations about worker satisfaction*. It also means *not being able to verify whether the operators are consulted about the developments* by the industrial partner or tech developers, before, during, or after. The delineation between business as a private concern, with workers subject to contractual obligations and management orders, as long as the obligations are legal, is a *de facto* state of affairs inimical to ethical assessment. Bluntly: we often cannot easily find out what we need to know in order to make ethical assessments. This issue is not particular to ethical assessment. (Ferretti

2021) has noted that government often lacks information about both business and technology with which to make regulation effective. But ethics does not even have the types of leverage which government wields, which is worse.

4.6 Responsibility for Errors

Responsibility for errors remains an ongoing worry also. In case KPIs are adopted and faithfully measured, neither of which is certain, still *the ultimate responsibility and the question of what to do when an eventual inevitable error occurs*, are important. Our experience in discussing this with the technology developers and company management is that the question is left in a grey zone. We understand their reticence, admitting to inevitable errors is admitting to an imperfect product. Yet we want to know how the operator should deal with an error when it does happen. Not preparing for such situations in advance is another – unethical – way of developing Internal Logistics 4.0 by putting the plan and ideal of the technology first, and leaving the uncertainties to be absorbed by human operators who have little or no control over the implementation of the technology. It amounts to: 'here you go, make the best of it.'

4.7 Physiological and Psychological Issues

Finally, physiological and psychological issues round out the issues encountered. We observed the work environment of the Use Case in the control room and the factory to be collegial and smooth running. Introducing the new technology will certainly change operator team interactions. Even assuming the technology eventually works very well, the trip to verify the bag label will be eliminated. This is a loss of opportunities for physical movement, and a loss of human contact with co-workers. The change is only a small one, but many such small changes – making up part of the larger vision of Internal Logistics 4.0 – will tend to deaden collegiality and make human interaction less smooth. If the technology works intermittently or poorly, the situation could be much worse, with the frustrations of correcting for the errors of the application, and the stresses of clarifying the situation and delays to a distant work colleague. Plant noises may also cause difficulties in using the voice activated assisted reality helmet. The latter may also add to visual or balance issues, typical of such products and typically included in product specifications, and here aggravated by the fact that the work environment is both dangerous and more expressly 'three dimensional.'

5 Our Ethical Recommendations and Responses to Them

5.1 Clarifying and Questioning

The ethical issue of adopting new technologies for public relations purposes is built into such projects, thus difficult to address. Our approach was to continually try to clarify what was being developed, how long different stages would take, and whether the device was actually in use. We only achieved partial success. It was difficult to get clear and timely information from the developers and industrial partner. We recommended considering whether the AI service should be used at all, reasoning that the ultimate goal was to reduce the occasional time delay of operator verification of bag labels which sometimes resulted in missing the fact that a wrong bag had been selected. Estimating time delay due to AI error and comparing this to original time delay occurrences which caused the problem, was suggested. If the former were just as great, then the installation of the AI service *at all* should be reconsidered. This conflicts with one of the project goals however – to test and research new AI technologies for industry – and also with a goal of the lead developers: showcasing new technology developments. The recommendation has not been taken up so far.

5.2 Reviewing Product Specifications Thoroughly

Overlooking product specifications was addressed by our reviewing the product documentation of proposed off the shelf devices. We noted product warnings and potential issues and raised them in meetings. On this basis one planned off the shelf fully virtual reality wearable was removed from consideration, and replaced by an assisted reality helmet wearable. Hence this approach achieved some success. The tendency of the developer to fall back upon product specifications as reasons for not adapting the device in certain ways is more difficult to address. We did not succeed in convincing the lead developers to change off the shelf products that they had already committed to. This highlights one of the weaknesses of internal logistics 4.0: that – as in the notion of industry 4.0 – it assumes fixed components linked by various processes. If components such as off the shelf products, have ethically problematic aspects built into them already from their design phase, e.g. default language assumptions, then these problems bleed into other areas of the internal logistics process. The assumption is that the human user will adapt to the problems already built into the system, accordingly, those built in problems are simply accepted rather than addressed.

5.3 Direct and Early Contact with Operators

The issue of actual use on the factory floor was engaged variously. We kept asking this question explicitly at different stages, but answers remain vague. We specifically recommended that the lead developer to work directly with the operators from an early stage. It would have the benefit of making the service and app better and testing HMI appropriateness in real conditions, so that if actual factory floor use occurred, the groundwork would already be done. A related recommendation was to gather feedback from the operators early. A further recommendation was to retain the role of colleagues in the control room in verifying the bag labels, but in a modified way, so as to avoid redundantly retaining old tasks and technologies together. The first recommendation has been only partially taken up and the second and third not at all so far.

5.4 Preparing for Inevitable Errors

We addressed the lowering of the bar with regard to reliability in a roundabout way. Since we only had estimates of the reliability/error rate of the OCR/AI services at the beginning, and also later, we made a number of recommendations based on the assuming that that at some point the operator would have to deal with an error, no matter if the likelihood was only 0.5%. These recommendations included: adopting a formal protocol of the steps the operator would take in case of error, undertaking a logical conceptual analysis of the points at which error might occur, and early recommendations for the lead developer to work directly with the operators in designing the HMI. These recommendations have not yet been adopted. As noted earlier, the tendency has been to avoid the issue, by saying that the technology "will almost always work."

5.5 Pushing for Open Operator Developer Interaction

The difficulty of not having regular access to the operators is partly a result of the necessities of work conditions. Introducing outside observers into an ongoing production process is also tricky. We visited the factory and observed the workers in their day to day activity, but the ideal of observing the workers *using* the new AI services and discussing their satisfaction has not yet been possible. We receive second hand affirmations from company managers that the workers have tested the new technology, but we have no simple means of verifying this. We remain unsure how to address this issue better. A recommendation that the ethics team have regular access to speak with operators, and participate in deliberately scheduled meetings between operators and developers would seem an obvious path. This would depend upon operator willingness.

5.6 Clarifying *Who* is Responsible and AI as a Tool

The issue of responsibility for error was especially important and resulted in a number of recommendations. We advised formal clarifications regarding *who* was to be responsible for checking the accuracy rate of the OCR/AI service and what type of operator feedback the AI training would require and for how long. We recommended not taking the control room operator out of the label verifying process. Trial stages were recommended, in cooperation with the operators. Finally, we presented reasoning and a recommendation to urge viewing the AI services as a *tool* to augment operator capabilities rather than viewing the operator as a safeguard, or 'AI supervisor.' Regarding the first recommendation, partial clarifications were made. On the other hand, the recommendation regarding retaining the control room operator's role was not adopted, and we remain unsure of trial stages implementation.

5.7 Testing Under Real Conditions and Monitoring Effects

Physiological and psychological issues were engaged in various practical recommendations. We recommended providing a holster to the operator to offset the weight of the OCR scanning tablet. Testing the HMIs in actual conditions with work gloves on was also recommended. To address the changes in role and human interaction, we recommended directly asking the operator team about their satisfaction, and regular monitoring of the cohesion of the larger operator team in trials or after actual introduction of the new technology. Commitments to adopt the first two recommendations were made in deliverables. The other recommendations have not yet been adopted.

6 General Discussion of Insights Gained and Pathways Forward

The causes of the ethical issues encountered are interwoven in a larger theme, which is: the very notion of Industry 4.0 itself. The idea of Industry 4.0, and Internal Logistics 4.0, depends upon accepting *a conceptual level social engineering of the workplace*. Instead of a process of industry slowly acting from the actual situation in the workplace to improve the human work experience, Industry 4.0 is laid out as a conceptual vision of a future workplace. The technology is supposed to develop to fill out the vision. (Zoubek and Simon 2021)[b] for example, speak of implementation strategies where the point of reference is Industry 4.0; a company's internal logistics must be ready *for* the latter. To some extent the technology can fill out the vision. Engineering the human to fill it is more difficult. At best, this approach is unethical, in not addressing humans needs. Instead, the approach *creates* those needs. It syncs very well with a public relation driven development of technology however. This is so much the case now that simply coining buzzwords generates hype. The iterative buzzword, e.g. Industry 5.0, and now Industry 6.0, (Kuosmanen et al. 2021) can be advanced as a goal, before Industry 4.0 is even close to a 'first draft' in terms of actual implementation. (Berrah et al. 2021) note the technology focus of Industry 4.0, and advocate moving on to Industry 5.0, in which humans are presumed to be present. But this does not prevent the ideal of Industry 5.0, from shifting the emphasis of development away from where it arguably ought to be. It is still development *toward*/*for* Industry 5.0, rather than development *from* the human worker.

Our own project uses the Industry 4.0 notion thus helping normalize this vague 'technology first' approach, which creeps into the development process in various ways, e.g. in accepting the limitations of off the shelf technologies – the latter allow the development to proceed at the speed which is sought. The rush to get things done in technology development is hype and public relations driven to a large degree, and inherently contrary to ethics. Again, the 'technology first' approach facilitates an 'if you can make it work we'll take it' attitude to technology development, which is the driver of change, on the part of manufacturing management. It also gives power to technology developers to do whatever it takes to get the technology working.

Recognizing this emphasis, it becomes easier to see why KPIs related to human worker satisfaction are not typically considered. Human participation is messy and not easily compartmentalized under generalized goals. Avoiding such KPIs, or gradually watering down the more quantitative measurements that could be attached to them, guarantees tidy results. The open and continual access to workers that such human sided measurements would take, does not fit within what (Green 2021) has called "corporate logics and incentives," so it is easy to brush aside. Difficulties in admitting errors also arise here. Since Industry 4.0 or Internal Logistics 4.0 masterplans are laid out in advance in a generalized way, proceeding by trial and error runs counter to them. The latter approach would require that technology developers admit in advance and by default that products are often unreliable, which damages the marketability of the product. In particular, this creates an incentive to overlook types of error which only inconvenience the worker.

The notion of human centeredness is sometimes raised as a sort of 'proto-ethical foundation.' (Cimini et al. 2020) mention human-centeredness, but not ethics. But without sustained reflection this concept does not advance us toward an ethical outcome. (Lagorio et al. 2021), for example, in a three-dimensional taxonomy scheme for Internal Logistics, develop a third axis representing the Human-Technology Relation. Ostensibly this is a good conceptual base to develop human-centeredness upon. The delineations of the axis however – automation and support – show that the human technology relation is viewed from the technology side. The technology automates some human tasks and supports others. The direction is: *what can the technology do for the human*? This is precisely not a human-centered approach, i.e. one proceeding from the human to the technology. This approach proceeds from the technology. An ethically amenable approach would reverse it: *what does the human seek, need, or desire, in the technology* and, taking a step further: *what can the human contribute to the community developing the technology* (Anderson and Fort 2022)[b]. The current 'for the human' emphasis leads easily to declarations and assumptions about the necessity of the technology: 'we will build it and we will find someone to use it.' What if the human doesn't want the technology on offer?

It is not enough that the human be statically somewhere within – ostensibly at the center of – the development process. There has to be a process 'to or from,' with, we suggest, a 'from the human,' approach, being the most promising. Viewed as a component, even though 'centered' within the great plan, the human becomes secondary, being molded to the plan, rather than the plan being adapted to the needs issuing out of the human. Aspects of (Zoubek and Simon 2021)[a] illustrate the problem. In their framework for a logistics maturity model, they outline five main dimensions: *manipulation*, *storage*, *supply*, *packaging*, and *material identification*. They then outline the characteristics of the subdimension of *manipulation technology*, by level, through six levels, i.e. from no application of Internal Logistics 4.0 elements, to a full application of such elements. Yet in all of these levels – including the lowest – there is only one explicit mention of human involvement "Human loads and unloads material," repeated at five levels, and verbatim in three of those, while at the sixth and highest level of logistics automation we get suddenly: "One only oversees here." The impression is that the changes in automation occur all around the human operator without affecting the latter's role, until abruptly the operator transforms into a mere supervisor of the system. Not only is this internally inconsistent, since an operator truly disconnected from the development and implementation of internal logistics 4.0 in the production process, is in no position to appreciate the system they must suddenly supervise, but it provides no room for a movement 'from' the operator regarding the changes occurring all around.

Given the above issues, we suggest that Internal Logistics 4.0 should be advanced along the following lines, in order to be ethical.

- Internal logistics 4.0 – and Industry 4.0 – should be re-envisioned as a set of improvements relative to a thorough analysis of a given particular industrial context. Instead of a high-level generalization of where we must get to, we would work from the question: "given this particular human work context, how can we improve it for the worker involved?"
- The first stage of this process toward an ethical internal logistics would be a sustained and patient interaction between workers and developers, where the latter would outline their needs relative to what could improve their work experience.

- That first stage requires the normalization and acceptance of regular access to the workers by developers, ethicists, and related specialists.

- KPIs that measure what is satisfying to the human worker relative to their particular work context would need to be developed and implemented.

- Off the shelf products should be modified to the needs of the humans involved and abandoned if they cannot be, or if they cannot be brought up to a sufficient level of quality, as envisioned for example, by the EU Commission's High-Level Guidelines for Trustworthy AI, or others.

- The need for the technology should only be built upon the needs of efficiency, insofar as those needs can also be integrated with the needs of the humans who will use the technology, i.e. helping the human do a better job should be the first consideration in adding new logistics technologies to the workplace, the push for efficiency should be built upon and serve the former goal.

7 Conclusion

Our goal was to describe the ethical issues in developing internal logistics solutions in an actual working context, discuss what we have encountered, and offer a number of general but practical suggestions toward making internal logistics ethical. We have presented various issues encountered in a heavy industry Use Case where we act as ethical advisors. They include: developing technologies primarily for public relations, overlooking product specifications or leaning upon them to avoid better adaptations to worker needs, ambiguity regarding real world use of the technology and worker responsibility for error, lack of access to workers, and various physiological and psychological issues. We have argued all of these issues arise from an outlook where Internal Logistics 4.0 (as a sub-field of Industry 4.0) is conceptualized as a general goal and then inexorably advanced toward without considering particular industrial contexts more deeply as beginnings. The conditions for that deeper consideration, beginning with the worker's point of view, are the conditions for an ethical Internal Logistics 4.0, and we present some of those conditions.

Future research pathways include: developing methods to facilitate worker and tech developer interaction, showing how strong KPIs proceeding from worker assessments of their own needs can be developed, and exploring ways to change the outlook of industry with regard to beginning from the worker. We think it will require a change in the idea of Industry 4.0, and a rethink of the need to iterate new Industry *X.0* buzzwords ultimately, to develop the former ethically. We are optimistic that it could be done.

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