Degradations and Consequences of ICT in Occupational Prevention Terms as Illustrated by the Transport and Logistics Sector

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Abstract. Information and Communications Technologies (ICT) are designed to fluidify and secure information flows and to strengthen workforces. They have permeated companies irrespective of their business sector and the jobs performed by their workers. They evolve rapidly and are composed of hardware, applications and services. Various research studies agree on the fact that these technologies are creating changes in the world of work. INRS has conducted research on these transformations, which may affect both working conditions and operator health. Our inquiry addresses two issues: Are these changes specific to certain ICTs? Does abolition of work boundaries result in propagation of effects to other work situations? Our aim is to provide elements of an answer to these two questions and to identify therefrom possible prevention approaches.

Keywords: ICT · Occupational prevention · Propagation

1 Introduction

Companies implement Information and Communications Technologies (ICTs) to fluidify information flows, to secure these flows and their related transactions, to strengthen workforces and to increase productivity, to promote process standardisation and to ensure traceability among other functions. They permeate companies irrespective of their business sector and the jobs performed by their workers. They evolve rapidly and assume various forms in that they may be composed of hardware (e-phone, tablet, computers, connected glasses, etc.), applications (messaging software, geo-tracking systems, ERP, etc.) and/or services (e-application, social networks, etc.).

Scientific communities focusing on these "objects" are diverse in view of the plurality and ubiquitous nature of ICT. While their mission may be human, social or technical, they have often opted for a "benevolent" or progressive attitude to these technologies, which offer user mobility, socialisation through development of multiple networks, elimination of certain repetitive tasks or enhancement of human (mainly physical) capacities. Yet, for several years, an ever greater number of research studies have addressed the user-related cost and paradoxes of at least the ICTs that are implemented in a work framework, although these studies have never called into question the capacities permitted by these technologies. The studies conducted also agree on the fact

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that these technologies are creating a change in the world of work; they abolish conventional work boundaries (man-machine combination, work teams, company) and they accelerate time by dictating a work tempo of immediacy [1]. From the literature, we can generally identify five factors governing degradation of working conditions: work intensification, weakening of relations between workers/workforces, blurring of boundaries, information overload and greater activity control [2]. Frequently however, identification focuses primarily on the use of communication tools (email/messaging software, collaborating space, etc.) [3, 4]. Moreover, it often targets a single work situation, while abolition of conventional boundaries is a basic characteristic of ICTs.

Against this background, INRS has conducted research on ICT-induced work transformations, which may affect both working conditions and operator health. Our present inquiry addresses the following two issues: Are the five factors identified from the literature specific to certain ICTs? Does abolition of conventional frontiers result in propagation of degraded conditions to other work situations? Our aim is to provide elements of an answer to these two questions and to identify therefrom possible prevention approaches.

The transport and logistics sector is well suited to investigating various ICT usages (communication, management and production tools). This sector is structured by a complex network of companies, into which different ICTs have been integrated to reduce not only goods reception and market demand processing times, but also work cycle times through task optimisation and rationalisation and generalisation of simultaneous performance of necessary operations independently of space or company area. This is a sector in which goods transit from the producer to the final customer, flowing from one department to another and from one company to another (production site, transporter, storage platform, distribution hub, etc.). This flow of goods is accompanied by a continuous flow of data supported by ICTs.

2 Method

Six transport or logistics companies took part in this study, in which we adopted an ergonomic approach. Each company taking part was followed for three weeks based on the same observation and interview protocol covering all departments within these companies (production and operations).

2.1 Observations

Observations were collected in the form of video and audio recordings. Video recordings were made cameras, which monitored employees performing a usual operation during their work shift. Observations were recorded from the start to the end of the work shift during full days. They were formalised based on a code denoting not only the activity (enabling us to quantify the time and frequency of the operations performed), but also use of various tools, the communications implemented, the purpose of these communications, the speakers, etc. Depending on the principal activity of the company involved, the observed situations concerned:

- Transport operations department personnel and goods transport drivers
- Order preparers, forklift drivers, reception and shipping supervisors, loading bay operatives, procurement and customer managers at logistics platforms.

2.2 Interviews

At all sites, INRS representatives conducted interviews of at least one person from each company work team: senior management, human resources, accounting, operations, drivers, managers… an interview assessment grid was developed and systematically implemented. This comprised topics relating to the interviewed employee, description of the activity performed, changes in the employee's activity in the last 5 and 10 years, changes in the tools used and their usages, operators external to the site or company and activity volume.

3 Results

The ICTs used at the six companies studied included:

- Communication tools: email/messaging software, Electronic Data Interchanges (EDI), smartphones and/or cell phones, Internet
- Production tools: Voice Picking, radio frequency terminal or Radio Frequency Identification (RFID) reader, geo-tracking system, on-board computer system
- Management tools: Enterprise Resource Planning (ERP), round management software, Transport Management System (TMS), Warehouse Management System (WMS), transport software, Office pack, movement monitoring software

The inventory of ICTs used at these transport companies revealed the diversity of systems in place and the fact that several such systems were simultaneously operated at each company. Irrespective of their companies and jobs, all employees used a combination of ICTs, when performing their activity. During our observations, we chose to record the type of ICT used rather than its version, developer or supplier. Hence, only one EDI was counted when several different ones are used in a department. The average number of ICTs used by an employee was approximately four; this average generally comprised two communication tools and two management tools. Production tools were more specific to a job and their usage was therefore less general across the company.

The following observation was based on the fact that companies opt for certain ICTs, while others were imposed on them by their business contacts (customers, suppliers). There were many such business contacts. This resulted in multiple ICT combinations, which depended more on the business contacts than on the operation to be performed:

- Use of several "customer" EDIs to perform an operation (customer order validation), which then complement the company's in-house EDI (customer EDI and in-house company EDI both requiring data entry)
- Use of "parallel systems" depending on business contacts. Parallel systems included email, fax, conventional spreadsheet software, etc. for suppliers with no ERP or EDI

- Multiple procedures for the same external business contact; for example, order intake and validation using an EDI generating an email, which validates an order after customer EDI usage… and entry in the company in-house EDI.

All employees of the companies taking part were affected by these initial observations: superposition of different ICTs and plurality of ICTs for performing the same task. However, personnel performing some jobs were less affected: order preparers, forklift drivers and truck drivers. Their jobs usually involved the use of one or two production tools (RFID, on-board system, Voice Picking) and, to a lesser extent, one communication tool (usually a Smartphone). These workers appeared to be only indirectly affected by usage of ICTs imposed by company external contacts.

These general observations led to us refocus our initial question. The companies taking part in the study did not use a unique ICT category. We therefore retained the option of identifying work situation degradation factors based on the ICT category mainly implemented (communication, management or production tools). We compared the results for order preparers and forklift drivers and for other jobs in order to provide elements for understanding the relationship between degradation factors and usage diversity and intensity for the ICT types.

3.1 Work Intensification

The dimensions involved in work intensification are increase in interruptions, requests and acceleration in the pace or tempo of work [5]. The average time for most of the work operations was less than one minute in all the quantitative analyses. Operations by workers were performed at comparable and sustained rates at the companies taking part, despite their different nature (delivery round building, customer relations, data entry, handling, etc.). These operating rates were observed for both managers and first level operators. Two jobs represented exceptions to this: truck drivers and loading bay supervisors, whose average operation times were at least four to five times longer than those of other company workers. These two jobs are inconsistent in terms of ICT usage; the truck drivers used ICTs very little, while the loading bay supervisors used a combination of communication tools, WMS, traceability systems, etc. Moreover, the order preparers and forklift drivers, who had been previously identified as having ICT user profiles similar to those of truck drivers, performed operations lasting approximately one minute.

Beyond the sustained work rates observed, we need to show whether these increase when ICTs are implemented.

Frequent Interruptions Frequency of communications governs work tempo because it represents interruptions in the operations in progress. Communications were numerous (direct, telephone, email/messaging or on-board system) and 61 % of them were conducted through ICTs. The employee received them in 2/3^{rds} of cases. The split between received and emitted communications was similar in all the activities involved. Interruptions were noted in relation to the loading bay supervisors, the platform managers and the reception operators… these workers were interrupted via communication, management or production tools. Order preparers, forklift drivers and truck drivers were little affected by interruptions, but they could cause them to change an

itinerary, add or remove a collection or a delivery, or perform a priority picking operation. These interruptions were therefore different to those observed to affect other workers. In these situations, the interruptions were mediated by communication or production tools.

Acceleration Mediated by ICTs Acceleration of the pace of work of order preparers was observed with a "prescriptive" ICT such as Voice Picking. It is not the Voice Picking system that directly imposes the order preparer's work rate; it is also its mode of operation: delivery of data such as the address or quantities of goods to be picked is broken down into elementary units, which are given to the preparer step by step. Each preparer reply triggers the subsequent Voice Picking data…. leading to a new reply from the preparer, who effectively self-accelerates. Comparison of the order preparation activity with and without Voice Picking revealed work rate acceleration and increased productivity of 15 % and 20 % respectively, when Voice Picking was implemented [6]. This increase in productivity and thus in the overall load handled led to an increase in the physical stresses to which these employees were subjected.

Increased Mental and Psychological Stresses Some companies transferred certain operations considered "outside their core business" to other company departments in order to optimise operation of departments subject to high demand (heavy workload, numerous communications, frequent interruptions, etc.). However, transferring operations "outside core business" leads to a paradox, namely an increase in work rate in both the departments taking on these additional operations and the department to be relieved of them. To illustrate this paradox, we offer the example of an operations department at a transport company taking part in the study. The operations department was a vital department that managed customer relations, located the goods, scheduled and monitored driver activity in real time, managed physical resources, etc. The company had transferred operations involving claims processing, physical accident management, vehicle pool control, driver work contract management, etc. to its accounting department. Processing these operations required information on the activities performed and traceability of work situation status, decisions taken, changes in schedule, etc. It was the operations department that provided these data. The accounting department therefore requested access to this information from the operations department and these new demands from the accounting department represented a 36 % increase in requests for transport operations department personnel.

Summary of Work Intensification Our results confirm work intensification. This affects all the jobs monitored, even those implementing a small number and variety of ICTs. Communication, production and management tools all contribute to work intensification.

The work intensification noted above for different jobs has consequences for other company workers; for example, acceleration in order preparers' work leads to higher procurement and shipping work rates. This acceleration has, at the very least, a "mechanical" effect on workers in upstream and downstream departments: forklift drivers, procurement and shipping personnel, drivers, etc.

3.2 Information Overload

Information overload comprises three dimensions [7]: (1) the excessive information volume, (2) the limit of individuals' cognitive capacities in processing information and (3) the communication component through dialogue multiplication mediated by ICTs.

During our interviews, the notion of information overload was not referred to directly and irrespective of the interview's job. Nevertheless, all those interviewed mentioned their need to concentrate, their recourse to information management strategies (Post-It stickers, intermediate monitoring chart, etc.), risks of errors and oversight in the event of interruptions and fatigue.

Our quantitative results show that, in 70 h of observation, the volume of information to be processing during communications (1956 oral or telephone communications) was accompanied by an even larger volume of information (3201), i.e. 46 data media/hour on average. These data were extracted from hardcopy or digital purchase orders, emails, job-related software, etc. These usages could take a few seconds or several minutes. They were often fragmented and could represent information acquisition, searching or building. They were performed under in contexts involving time-related pressure and as double tasks in some situations. Moreover, several different data could be "activated" in parallel for certain tasks such as building a delivery round, for example. Finally, there were many information media with different purposes. This multitude of media denoted multiple methods of structuring the information to be used, processed and also supplied. Furthermore, they were scattered about in different forms within the various ICT tools. The volume of information was therefore large. Conditions under which this information was used, such a double tasking, time-related pressure and interruptions in processing, are consumers of cognitive capacities and are all the more so when the information is scattered and mediated by a multitude of ICTs [8]. All three dimensions of information overload were therefore present.

For example, every type of tool was used by transport operations department personnel; their usage could be broken down into 39 % communication tools, 30 % production tools and 31 % management tools. Similar results were obtained for every job except for order preparers, forklift drivers and truck drivers. The latter employees in fact used fewer ICT tools, which were also used separately or independently of each other. Data were thus concentrated within just one operation-dedicated tool. In these three cases, the information volume was nevertheless large but it directly prescribed or dictated the activity, while such information tended to form a basis for interpretation in other jobs. Finally, communication tools were little used; truck drivers used such tools for an average of 3.5 h (14 h for transport operations department personnel) out of the 70 h monitored.

As before, the information overload was neither local nor dependent on just one work situation. It was produced and promoted by various workers both within and outside the company and it propagated.

3.3 Greater Activity Control

Greater activity control was referred to by all the interviewed workers. There were two types of control [9, 10]: direct control by a technology or "machine", control using traces provided by the "machine".

"Machine"Control This type of work control is implemented by production and management tools, which prescribe or dictate performance of an operation or activity. Hence, when an operation is not performed in the expected order or when the reply provided by the employee is not the reply expected by the control system, the latter stops the process until the "right" answer has been given. In the case of the order preparers, forklift drivers, loading bay and reception personnel, the tool imposed a sequence of operations or actions. For example, at a transport platform, ERP required that the goods received at the platform pass through 6 stages or "statuses" before being released for delivery preparation. Situations involving breaks in workflow were observed. In such situations, the relevant goods were at the platform, but they could not be delivered despite the urgency of the situation: The platform was temporarily saturated and the system could not allocate the goods to storage and picking location. Picking was rendered impossible by the system without this location. An impression of being subjected to the system, its pace and its constraints was widely felt and expressed. This machine-based control was also encountered in jobs involving customer relations and procurement management. In these jobs, we observed a forceful prescriptive process dictating activity performance, accompanied by frequently curtailed opportunities for action; for example, a customer manager could not delay a delivery date or modify a product reference, when an order error had been detected, even with the customer's agreement or at the customer's request. It was up to the customer to cancel a request through its EDI or ERP before editing a new order form. These restrictions led to not only customer dissatisfaction and sometimes tense relationships with the transport company's customer manager, but also to statements such as "the ERP controls everything! We're just pawns…. What about customer relations? Quality of work?"

"Trace" Control This type of control was referred to by all interviewees from the companies taking part in relation to communication, production and management tools. Such tools enable one to trace who has done what, at which moment and for how long. The first element quoted by all workers involved real-time identification of the user and, hence, of his/her responsibility for the actions taken. Identification was considered spying or mistrust by order preparers, forklift drivers and truck drivers. This control was implemented in relation to truck drivers, for example, when their delivery route did not correspond to the optimum itinerary in terms of kilometres travelled. It was also embodied by establishing a driver rating based on diesel consumption. Some workers were more guarded in their statements. They stressed the advantages of this control in dispute situations; it effectively provided an objective element, which often ensured healthier relations between workers in relation to disputes with customers. Workers also emphasised the benefit of this control when ensuring equity of treatment among employees; the tracing process was aimed at detecting "abnormal" events rather than strictly controlling a prescribed procedure. Finally, in view of the time-consuming aspect

of trace usage, these workers insisted on the limits of its application under the conditions of time-related pressure prevailing at these companies.

Summary Introduction of ICTs has led to an evolution in work activity control, which applies to all employees independent of their level of responsibility at companies. All ICT tools are involved in work control except for communication tools, which appear to be unaffected by the "machine" control dimension. The feeling of the different workers taking part was lukewarm in relation to any type of tool or any specific job within their companies: for some, such controls caused deterioration in quality of work, time-related pressure and mistrust; while for others, they prompted healthier relations between personnel. Control had an effect on the areas of action of the various departments: it allowed identification of "who has to do what", albeit without guaranteeing the quality of action performed by a department or for a department intervening later in the processing system.

3.4 Weakening of Inter-personnel and Work Group Relationships

Under certain conditions, non-uniformity of ICT-paced or traced personal performance leads a work group to implement a mechanism that exerts pressure between co-workers, to strengthening the control exercised by the work group on individuals and to increasing competition between individuals or teams.

Co-worker Support No pressure between co-workers was observed or reported. On the other hand, co-worker support has disappeared. Assistance among order preparers had indeed been a common phenomenon, taking the form of help in handling heavy loads, when preparing an order on which the preparer had fallen behind or was suffering from tiredness, etc. This support decreased, when production tools (RFID or Voice Picking) were implemented. The same phenomenon was also observed for customer managers, when management tools were implemented. Co-worker support is prevented by the tool because customers are allocated by name to a manager, who becomes the only person permitted to take action on his/her portfolio of customers, unless his/her management intervenes.

Increasing Competition Between Individuals or Teams In some jobs, such as order preparation, the "values" of the preparer workforce had evolved from job recognition based on pallet quality criteria to prepared quantity criteria. A good preparer was not the one who had made up a "good" pallet, but the one who had made it up quickly. Furthermore, communications between co-workers had deteriorated: 84 % of preparers (120 preparers consulted) reported a decrease and deterioration in these communications.

With implementation of a management tool, creation of competition between truck drivers became established based on their performance ratings achieved in terms of diesel consumption. Competitive situations were also noted among the platform manager and the loading bay supervisor: under these conditions, each of them had to achieve targets "traced" by the tool by overriding consequences for the other team.

Summary Management and production tools were referred to as being causes of a weakening of relationships and work groups. Situations associated with this weakening and communication tools were not observed or mentioned. Here again, the phenomenon is independent of the jobs and tasks observed. Repercussions internal to a work situation were linked to repercussions in adjacent work situations.

3.5 Blurring of Boundaries Between Private and Work Spheres

All workers taking part in the study were unanimous, when confronted by the issue of blurring of private-work sphere boundaries: "There's no blurring… except in unusual situations, which would only involve managers". Nevertheless, interviews can be quoted as tempering this assertion. For example, order preparers using Voice Picking stated that they were subject to a number of language-related reflexes after leaving their shift: preparers used the word "OK" 400 to 500 times an hour in mass-market retailing activities. They reckoned it took approximately one hour after the end of their shift for this reflex to fade away. With regard to the transport operations department, its personnel contacted their colleagues to obtain a report on the situation a few hours before starting their shift. The platform manager took his work laptop computer home to monitor activity progress on days and nights with a heavy workload. Moreover, he would return to complement shift teams in the event of difficulties. The company manager took home files requiring time to avoid interruptions…These few interviews therefore indicated that the boundaries between private and work spheres were not as clear as those initially portrayed: So-called "unusual" situations occurred regularly and the populations involved were not limited only to managers, even though the nature of boundary blurring for the order preparers was different to that observed for other workers. Production, management and communication tools were implemented in the observed situations.

4 Health and Safety Consequences of Five Degradation Factors

The five degradation factors were frequently combined and interlinked. Several points were regularly repeated in relation to these degradation factors: reduction in physical and psychological recovery time, fatigue, stress, weakening in capacity for action, time-related pressure. Available knowledge of the health consequences of ICT usage are indirect; it requires assessment of degradation factors associated with health [3, 4, 10] and safety effects, such as increased risks of occupational accident, MSD and RPS. Acceleration of the pace of work and repetitive movements [11], efforts made to keep up the work rate are all embodied by a stiffening of movement, which raises the probability of injuring oneself or contracting a musculoskeletal disorder (MSD). Fatigue is nevertheless associated with increases in accident risks. With regard to time-related pressure, studies [12] have shown that employees protect themselves less and are exposed to an increase in accident risks when subject to such pressure.

5 Discussion – Conclusion

Information and communications technologies are widely used at transport and logistics companies. All jobs are affected by these tools even through the functions fulfilled are different. Most jobs use "packages" of ICTs rather than a single software programme, service or tool.

There are differences in some degradation factor dimensions for two ICT types, namely communication and production tools. In communication tools, the "activity control by machine" and "weakening of relations between personnel" dimensions were not observed or reported by the employees interviewed. This observation concerning "weakening of relations between personnel" was unexpected; multiple studies [2–4] insist on an explanation relationship between communication tools (forums, emails, social networks) and this factor. What hypotheses can be advanced for investigating this difference? Communication tools could represent a means for workers to deal with weakening of relations between themselves and between work groups rather than being the cause of such weakening. Investigation of this communication–weakening of relations relationship remains necessary.

With regard to production tools, the "interruption" dimension in relation to work intensification does not appear to be essential. This may be explained by the purpose of production tools, which effectively model tasks, rationalise them to accelerate the production process, to fluidify it. Interruption would therefore be an epiphenomenon to be avoided on a productive level.

Thus, considering all the conclusions of the present study, it is difficult to attribute specific degradation factors to types of tools or to attribute one factor to one tool independently of the other tools used in the work situation concerned.

Another contribution of this work is that it shows that the job-based transversality of these tools is accompanied by propagation of degradations to other work situations. Work intensification for order preparers guided by Voice Picking is effectively embodied by quicker movements, greater repetitiveness, higher loads handles, probably shorter recovery time, etc. The consequences for these employees are greater risk of MSD and stress [13, 14]. Occupational stress is linked to the pace of work imposed by the "machine" and results from high time-related pressure combined with little decision-making freedom. Work intensification propagated to procurement managers corresponded to more demands and thus frequent interruptions that curtailed their concentration capacity and gradually led to the feeling of not being capable of performed quality work or of even performing the job [3, 4]. This causes fatigue, irritation and more stress, when a high workload is combined with heavy time-related pressure [12]. Increased activity for procurement managers will itself induce greater activity for the reception department in terms of both the volume of information to be processed by this department and the volume of goods to be moved through the platform. This will also have a resounding effect and consequences on these employees' health and safety due to work intensification in their department. This example of propagation of a degradation factor from one work situation to another is only partial for it continues outside corporate boundaries to different departments at transport companies, suppliers, customers and

every intermediary. Moreover, this propagation involves all the five degradation factors previously considered and accompanies both information and material flows.

What prevention approaches can be prompted to emerge from these conclusions? Two families of consequences can be distinguished: the first applies to analysis of a work situation involving the use of ICTs. In view of the variety and plurality of the ICTs present, consideration of a single user-ICT combination is increasingly inappropriate in an approach to understanding a work situation. The temptation is nevertheless strong since the user himself or herself often ascribes most of his or her ills to a specific ICT. Hence, an emailing or messaging system is frequently blamed for the increase in interruptions, time-related pressure, blurring of boundaries, depersonalisation, loss of meaning, etc. Our conclusions would tend towards envisaging more analysis of the combination of ICTs used in a work situation rather than just one isolated ICT.

The second consequence applies to the phenomenon of propagation of degradation factors from one work situation to another. Detection of a problematic work situation usually prompts analysis of the situation followed by proposal of prevention solutions appropriate to the situation. With integration of the propagation phenomenon into the approach, we consider that analysis of the problematic situation could incorporate factors relating to several work situations and could therefore enhance the efficiency of proposed solutions; the information and material flows convey degradation factors to work situations that act on one of these flows. Implementation of a suitable but targeted solution for a work situation does not prevent continued propagation of propagation factors. Consideration of the propagation phenomenon is therefore equivalent to consideration of the information flow and hence of its path between the various contact persons extending beyond a specific work situation. This leads us to envisage more global prevention solutions for workers acting on the flow.

In conclusion, this research should be pursued to test various hypotheses involving the relationships between these degradation factors and ICT types. This type of study should also be extended to other business sectors in order to verify whether the conclusions are specific to just one sector structured into networks of companies implementing information and material flows.

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