STANDARDIZING LOGISTICS AT THE CORPORATE LEVEL TOWARDS LEAN LOGISTICS IN CONSTRUCTION

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ABSTRACT

The hypothesis of this paper is that one of the reasons why logistics is poorly managed in the Finnish construction industry is that we try to tailor it too much on a project level and to standardize too little on a corporate level. Depending on various studies the logistics cost is between 10-30% of construction cost. There are many reports, which claim that there is significant amount of waste such as excess inventory, movement of material, and damage related to logistics. In addition, there are many success stories how logistics has been improved on a project. However, even though the opportunities are huge and good practices have been identified, the majority of construction projects in Finland manage logistics poorly. The question is why?

The paper is based on empirical studies from the last five years from a single company. Around 180 projects, some more and some less actively, have been involved. With the help of three cases we present three logistics solutions and how their implementation has progressed. The first case is a customized solution for one project, where engineered-to-order supply chains are made transparent with the help of Building Information Modeling and RFID tags in order to increase delivery reliability. The second case is a "corporate" level solution for managing small make-to-stock items with the help of Vendor Managed Inventory. The third case is a "corporate" level solution to manage make-to-order and large make-to-stock items with the help of a terminal (logistics center) in order to increase site productivity.

All three cases were successful pilot projects, but only the last two have we been able to be more widely implemented in the company. The paper discusses why and comes to the conclusion that there are at least two main obstacles that have earlier prevented or slowed down a wider implementation of good practices. One is poor production reliability and the other one is that we have been trying to customize our logistics solution too much on a project level instead of standardizing processes on a corporate level. There is plenty of literature that supports the poor production reliability argument but much less understanding of the latter argument.

KEY WORDS

Logistics, Production management, Processes, Lean

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BACKGROUND

Many reports claim that the construction industry is lagging behind other industries when it comes to improvement of productivity and reduction of waste (Egan 1996, Koskela 2000). In logistics, there is particularly room of improvement (Weglius et al 1996, O'Brien et al. 2009). The literature estimates that poor logistics increases construction cost by 10-20% (Strategic Forum for Construction 2005). Clearly there is a huge potential. At the same time, there are many informative case studies from the construction industry related to logistics and later extended to supply chain management, which present tools and methods how to improve logistics and supply chain management (Toikkanen 1995, Wegelius et al. 1998, Walsh et al 2002, Arbulu et al. 2003, Elfving et al. 2005, Koerckel and Ballard 2005, Talvitie 2006). These studies report delivery reliability improvements (Talvitie 2006), inventory reduction (Walsh et al. 2002, Arbulu et al. 2003), lead time reduction (Toikkanen 1995, Walsh et al. 2002), and productivity improvements (Koerckel and Ballard 2005). These studies all report good results in a particular pilot study, but rarely continuity or permanent change in the involved organizations. It appears that we know how to fix a project but are unable to make it a habit.

Logistics cost differs somewhat in construction as compared to other industries because 2/3 of costs are expended on site material handling as opposed to transport and storage of materials (Figure). As a result most logistics improvement efforts focus on site logistics.

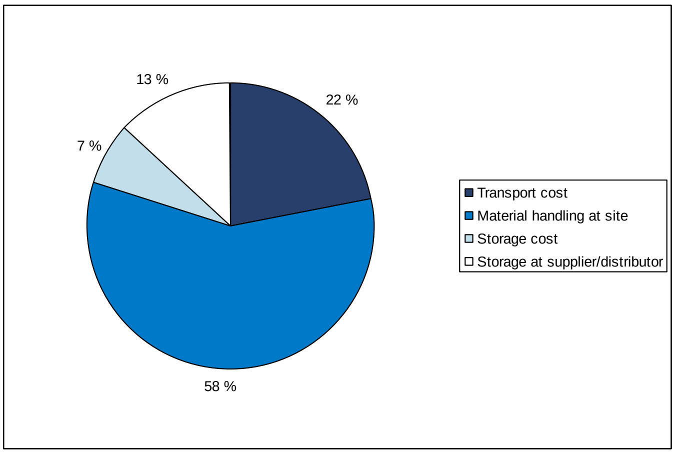

Figure 1. Logistics cost distribution (Source: Skanska internal measurements (1995-2000)

The paradox is that there is poor performance, concepts and tools to fix the problem but why has the industry not fixed the problem? This paper aims to bring more insight how to fix the logistics problem in construction industry with the help of some empirical studies and tests. The studies are from one company but all in all around 180 projects, some more and some less, have been involved during the last five years. In the next chapter we present briefly what and how things have been developed or deployed. Then we present three cases of successful piloting from which only two became successful deployments. The paper ends with a discussion why deployment became successful.

HYPOTHESES

If a) small, high volume made-to-stock materials are maintained in small quantities on site, b) vendors are provided real time information on inventory withdrawals and levels through a web-based software, and c) vendors frequently replenish site inventories, then the net cost of providing, receiving, handling and installing these materials decreases.

If made-to-order materials such as windows and doors, engineered-to-order materials such as precast concrete elements, and the remaining made-to-stock materials are a) kitted into installation packages offsite and b) if deliveries are coordinated with the project production schedule and managed through issuance of offloading time slots, then the net cost of providing, receiving, handling and installing these materials decreases.

If logistics solutions are to be used in more than a test project, they must be planned from a corporate level

THE JOURNEY OF EMPIRICAL STUDIES

We chose an inductive research approach, which relies on the interpretive method and a case study-experiment strategy (Robson 2002).

The logistics research and development effort started in 2005, with a wide range of fact gathering about the current state. We interviewed various stakeholders, measured inventory and batch sizes, lead times, and production and supplier reliability. One of the key findings came when we studied production reliability. This took place on two commercial refurbishment projects. The average reliability of the daily plans was 67% and 68%, respectively; i.e., that percentage of planned tasks were fully completed. Moreover, 80% of the reasons for failure were either unrealistic targets for the amount of work to be completed or the lack of prerequisite work. As a general contractor, we could directly impact these causes of plan failure. Therefore, it was further explored how to improve production reliability.

We also found that supplier reliability was not measured and supply chains were not mapped and transparent to their participants. Later that same year we tried using 4D modeling and RFID tags to make the supply chains for engineered-to-order products transparent (Dagens Industri 2006).

In 2006, the company decided that each of our nearly 200 construction projects was to measure production reliability, but there were minimal instructions given how to measure and no common templates. The purpose was to "wake-up" and get attention. About 60% of projects measured production reliability. In the same year, a large supply chain management initiative was launched in collaboration with the University of California Berkeley. It aimed to develop production and supply chain management concepts and tools.

In 2007, a systematic development of production management started on 3 laboratory sites (commercial, residential, and civil). We adapted the Last Planner system of production control (Ballard 2000) to current project management proceedings and applied a so called infection model to deploy Last Planner. In the infection model, project crews were invited to learn from a site that masters Last Planner. We also started to develop a Vendor Managed Inventory concept (Tanskanen et al. 2009).

In 2008, the tools of production management were clearly defined and development of production management was frozen. A systematic deployment with the help of a support organization began. Also the deployment of the VMI concept started with the help of the support organization. By the end of 2009, 40 projects had applied the concept. We also started to develop and test a logistics solution in which materials were kitted in terminals and delivered to the point of installation in response to pull signals from the production management system.

In 2009, deployment of production management was made an explicit responsibility of line management, in contrast to earlier reliance on staff personnel acting as coaches. Production management consists of five tools. In 2009, 93% of all projects used weekly plans and 26% used 5 whys analysis. On average, 56% of all five tools were used.

Deployment of the terminal concept began in 2010. Today 12 projects are managing materials through a terminal. During the last five years, hundreds of people and 180 projects have been involved, and there have been more than 40 workshops. We have learned a lot and there is plenty of data, so we think it is worthwhile to write down some lessons learned.

THE FIELD STUDIES

CASE 1: MAKING ENGINEERED-TO-ORDER SUPPLY CHAINS TRANSPARENT

In the construction industry, supply chains are fragmented and opaque (non-transparent), which results in constant misunderstanding and sub-optimization. Factories are not producing the products that are needed by construction sites, and even if they did, the third party shipping company delivers in the wrong sequence or at the wrong time. As a result inventory starts to build-up, capacity is wasted at the factory and on the construction site, and soon everyone is just firefighting. In 2005, in order to solve the above problem we decided to make transparent the information flow between the construction site and factories with the help of Building Information Modeling (BIM) and Radio Frequent Identification (RFID) tags (Figure) (Dagens Industri 2006, ENR 2008). We collaborated with two of our best suppliers who are always eager to try new things. We also had an excellent site crew that always volunteers for pilots. There was a lot of new technology involved and a lot of effort went into getting the technology to work. The pilot was a success. The stakeholders could follow the movement of information and materials through the supply chains in real-time and could pro-actively act on potential problems or delays. Products were delivered when needed and in the right sequence, and the project was completed on time and on budget. It was a true success story.

However, after the pilot project, we managed to use the concept only in 3 other projects in Finland and in one project in the US (ENR 2008). It then faded out. The concept was customized for each of these projects. We carefully collected all wishes from the stakeholders, the project crew actively participated in the development work, and we had a strong support organization that was present the entire time either at the factories or at the construction sites, so that the pilot would not fail because the stakeholders did not have time or competence to implement the concept. For the pilot we used the best suppliers and best people because we wanted to do everything that we could so that the pilot would be successful. The pilot was successful but deployment of the innovation failed.

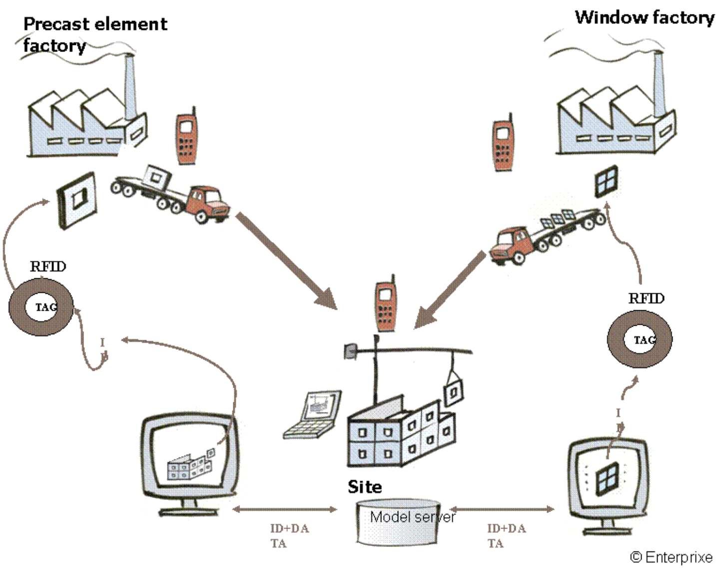

Figure 2. The concept of making the engineered-to-order products transparent

CASE 2: REDUCING INVENTORY AND TIME SPENT ON SMALL MAKE-TO-STOCK PRODUCTS

Small make-to-stock (MTS) products, such as screws, nuts, bolts, and personal protection equipment, are challenging in a construction project. Their value is very small in comparison to the overall construction cost so they tend to get little attention. However, when they are poorly managed it leads to a vicious circle where more and more of the foremen's time goes to making sure that there is enough small MTS products: Less time to plan and order small items in advance, which leads to expensive rushed orders from retailers, or shopping trips by construction site personnel to the hardware store. In addition, the site inventory is poorly managed; it is difficult to find goods which leads to both overstocking and wastage (Figure).

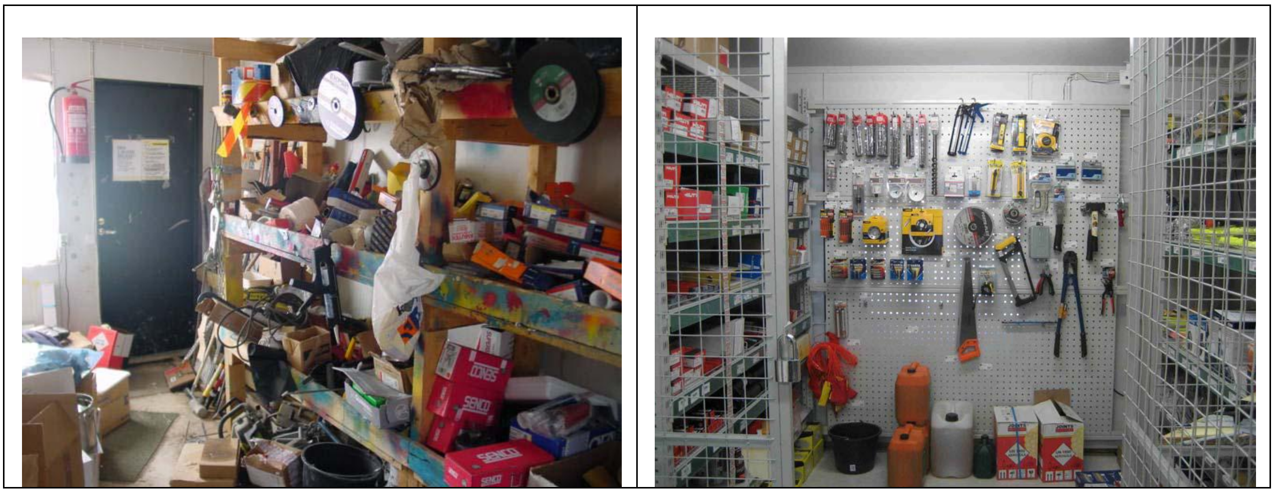

Figure 3: An example of ordinary site store (left) and the VMI store (right)

In order to improve the situation we introduced a Vendor-Managed-Inventory concept (Tanskanen et al. 2009). Many MTS suppliers offer Vendor-Managed-Inventory solutions, however, they have never become industry standard. Instead of using our MTS suppliers' Vendor-Managed-Inventory systems, we decided to design our own to avoid dependence on a single supplier. We collected data from 19 different construction sites and analyzed the material consumption for make-to-stock items suitable for site stores. Based on the analysis we developed our own Vendor-Managed-Inventory system, consisting of the physical small-item store, a VMI-replenishment system, a procedure for the construction company and the supplier(s) to plan the assortment of the store, procedures for the day-to-day operations of the supplier, and procedures for scaling up on the corporate level.

The concept was then tested simultaneously on three construction sites. The pilots were successful. 70% less time was spent looking for the products, there was not a single rush order, invoice handling was reduced by 90%, and inventory was reduced by 70%, etc (Tanskanen et al. 2009).

In spring of 2010, about two years after the pilot, over 50 projects have used or are using the system. Not only the piloting but this time also the deployment has been successful. The concept is not customized to any particular project. It is standardized at the corporate level for all building projects. We defined some prerequisites that have to be fulfilled so that the concept can be applied. These include the length of the project, size of the project and the level of self performance on the project. The support organization consist of 0,5 full-time employee and a network of super users. The full-time employee trains the super users and manages supplier relationships. The super users are at project or district (area) level and actively use the concept and guide other people at the project.

CASE 3: REDUCING MATERIAL HANDLING TIME FOR MAKE-TO-ORDER AND MAKE-TO-STOCK PRODUCTS

It is not too hard to find construction sites filled with unorganized material. The reasons are poor logistics planning, poor supplier reliability, and not properly receiving material at site. In our spot measurements, the supplier reliability has been as low as 10% when the time window has been 1h. As a result, many deliveries arrive at the same time, there are no or wrong offloading resources, loading sequence does not match the offloading sequence, material is moved several times within the site, and material is damaged when moving or in storage.

In 2009, we started to test a system where make-to-order (MTO) and large MTS products were kitted into delivery packages in a terminal, then delivered directly to the point of installation. The concept in itself is nothing new and it is a common logistics solution when there is a limited material laydown area at the site (Talvitie 2006). However, in our case the main driver was to increase site productivity. We also, if successful, wanted to make it a corporate level solution not just customize it for one project. The system consists of the physical terminal, a procedure for linking production management to the terminal activities, processes for suppliers interacting with the terminal, and processes for site preparation and receipt of deliveries (Figure).

The site crew, our subcontractors and our logistics partner actively participated in the testing. We collected lots of data, e.g., measured supplier and production reliability, off-loading times, moving times, installation times, usage of offloading resources, inventories, and damages. During the test period all our senior management, regional managers, and all project managers from that region visited the project.

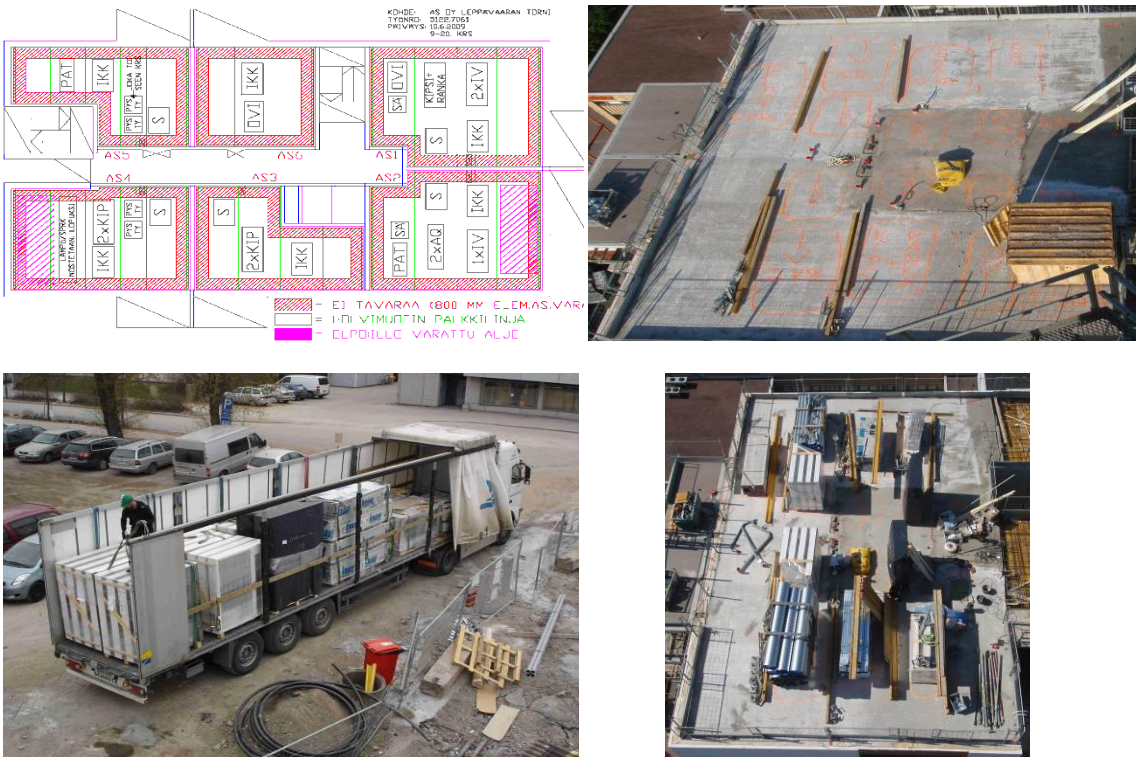

Figure 4. Procedure for preparing and receiving deliveries

The results were very interesting. Traditionally, the terminal is considered an additional cost and is only used when there is limited laydown area. In our test project, the productivity gain was larger than the cost of the terminal. The offloading became more efficient, e.g. we saved around 134 tower crane hours, productive labor time increased; e.g., the productivity gain was 20% for window installers (Figure) and for mechanical, electrical, and plumbing significantly more.

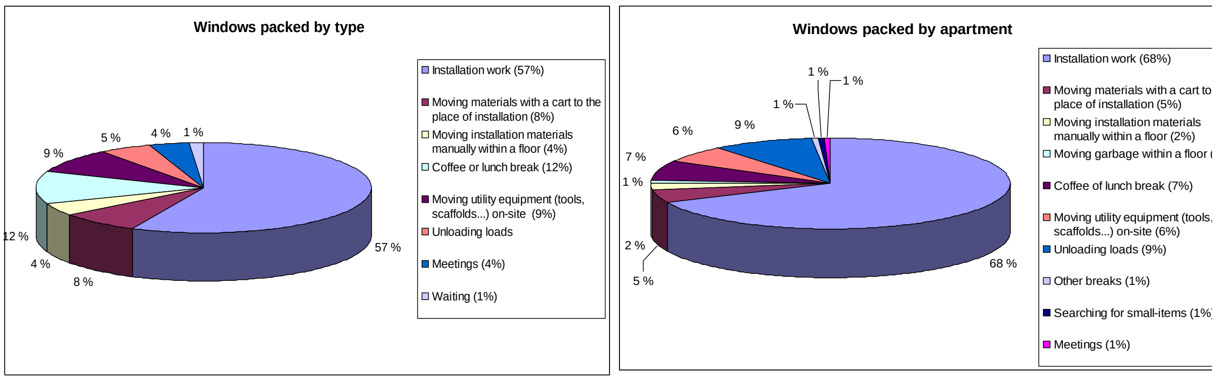

Figure 5. Difference in productivity when windows were delivered directly to the point-of -installation

System deployment began in 2010 and currently there are around 12 projects in the pipeline, prepared to employ this logistics solution. Again, the system is not customized to any particular project. It is standardized on the corporate level for all building projects. Prerequisites for use include the length of the project, size of the project, integrating subcontractors' material flows, and the level of self performance on the project. Deployment is supported by one full-time-employee and a "showroom" site in each region or district. The full-time employee trains the showroom sites including the suppliers, manages the relationship with the terminal, and also makes sure there are no deviations from the standard solution. The showroom sites demonstrate to other projects that have not yet applied the concept how the concept is executed in real projects.

LESSONS LEARNED

During the last five years, we have collected a large amoount of data and there are many interesting findings. We emphasize two in this paper:

Logistics can only be as good as the production management

In a company the logistics should be solved at the level of the corporation, not the project

The first finding is consistent with previous studies (Ballard 2000, Koskela 2000, Hopp & Spearman 2000). If there is poor production reliability, there is a penalty paid in lost capacity, longer lead times, and/or increased inventory. Therefore, if production reliability is low, there is limited performance improvement, no matter how sophisticated the logistics solutions may be.

The second finding has been less discussed in the literature. One reason why the Finnish construction industry may not be able to spread good logistics pilots may be that it tries to customize them too much for a particular project. When customizing solutions to a certain project they tend to become too sophisticated and require specially skilled people and tools. Also, since the development and testing of the logistics solutions require substantial resources, customizing the logistics solutions for every project becomes very expensive, and probably impossible even for the largest companies. The company one of the authors represent has in Finland around 200 building projects and in the Nordic countries more than 1000 projects. Most of the projects in Finland have between 2 and 5 people in the site management, adding one or two more people to develop the logistics would be very challenging from a cost point of view. Therefore, another and most likely affordable way of improving logistics would be to standardize key processes and solutions, deploy the standard processes and solutions, and improve the standards rather than the customized solutions. In fact, it seems that there is a need to standardize much fewer processes than there are supply chains to the construction site. We have identified three main processes that need to be standardized and can be copied to all building projects (residential, commercials, schools, healthcare, etc). These are Engineered-to-order/make-to-order products that are delivered directly from factories to construction sites, make-to-order and make-to-stock products that are kitted to assembly packages in a terminal prior to the delivery to the site, and small make-to-stock items that are stored at the site.

The Hypotheses

1. All three hypotheses are supported by case study findings; i.e.:

Production reliability is prerequisite to good logistics

Site stores are a cost-effective means for managing small, high volume made-to-stock materials

Offsite kitting and managed deliveries reduce costs both to suppliers, especially of engineered-to-order products, and users.

2. Logistics solutions must be planned from a corporate level if the solutions are to be used in more than the test project. The strategy of managing logistics centrally rather than from the project appears to be sound, and supports further extension:

   to manage more projects from a shared logistics center.

   to extend the strategy upstream into sourcing and management of shared inventories.

   to make rather than buy strategic engineered-to-order materials.

Findings consistent with hypotheses do not establish the hypotheses, as there could be other causes than those hypothesized. In socio-technical systems, it is generally not possible to completely isolate possible causes, so knowledge development is messy as compared to the natural sciences. Nonetheless, the findings were sufficiently encouraging to support deployment and further development.

FUTURE RESEARCH

Additional testing of the hypotheses is needed to assess their extension to various types and sizes of projects. The authors intend to explore creation of critical experiments and testing in least likely cases. The authors are further developing the supply chain management initiative within the Finnish national contractor, and also supporting deployment in other national companies of the same contractor. Future development will be focused on integrating within projects; specifically embracing the entire project, including design and construction, both in a design-construct role and in the role of developer. Development will also focus on integrating across projects through the formation of alliances and preferred suppliers, as well as the centralized sourcing, inventory management, and delivery of materials to projects.

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