

# **Time analysis in international logistics systems with the 6-Sigma approach towards an international JIT-System**

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**Abstract:** Time-based supply chain management is already realized to a certain extent – especially on a regional or national level. But in an international context the time focus is only visible in particular supply chain segments as for example the just-in-time delivery. Other areas of the global supply chain are only allowing a continuous parts flow with the help of stocks. For reducing these stock levels a consequent time measurement and structured 6sigma approach are implemented – particularly in the automotive sector due to the competitive cost pressure. Some chain elements like the customs process can only be leveled to a certain sigma degree and therefore bear some risk when calculating the supply lead time. Hence a stock free international supply chain is a vision but in practice a controlled stock level guarantees a smooth local production. The logistical chain is therefore consisting of a pull and push fragment with stocks to be pushed and the local parts supply to be pulled from the foreign plant via a JIT system.

**Keywords:** Globalization, 6-Sigma, JIT, Lead time

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## **1. Introduction**

“Time is of the Essence” is one of the common terms used in legal contracts (Beatson 2002, pp. 142-144). It emphasizes the meeting of deadlines and possible actions if these time limits are not fulfilled. A similar constellation is given with the just-in-time (=JIT) approach: only deliveries in a certain time window are processed further to the next stage in the logistics pipeline (Monden 1993, pp. 59-62). Particularly in short or medium distances the JIT system is widely found but also larger distances are considered as JIT capable (Liker 2004,

pp. 203-208). By looking at international logistics networks the question arises to what extent a JIT application is possible. Based on empirical results and benchmark studies being both in the automotive industry, the paper focus on logistics lead time monitoring with a deviation analysis by 6Sigma tools (Eckes 2001 and Rehbehn/Yurdakul 2005). Based on these statistical findings the possibility to implement JIT in a global context will be investigated. Further research fields and the implication for the automotive industry are mentioned in the conclusion of the article.

## **2. Time Measurement in International Logistics Pipelines**

### **2.1. Time as the Common Measureable**

Anywhere in the world time is measured in the same way. With this great advantage a time related key performance indicator (=KPI) bears the opportunity to be an easy understandable and commonly acknowledged performance metric (Kuhn 1998, p. 138). Compared to cost and quality this global understanding makes time unique: cost is a matter of allocation and calculation methods as well as differentiation between long- and short-term perspectives. Quality depends on the consumer's perception of the various quality facets like performance, durability, aesthetics or features. Hence both cost and quality is an object of interpretation whereas time is given an absolute character with a fixed 24 hour day on the earth and the time being controlled by atomic clocks like in Braunschweig (Germany).

To plan and measure the different processes along the logistics pipeline the time factor already exists like e.g. the cycle time, lead time or just-in-time delivery (Christopher 2005, pp. 143-174). For differentiating the time needed for a specific process a hierarchy of logistics viewpoints is detailed as shown in figure 1.

### **2.2. Time Focus in International Logistics**

Focusing on international logistics there are several main elements forming such a logistics chain (similar to Christopher 2005, p.217):

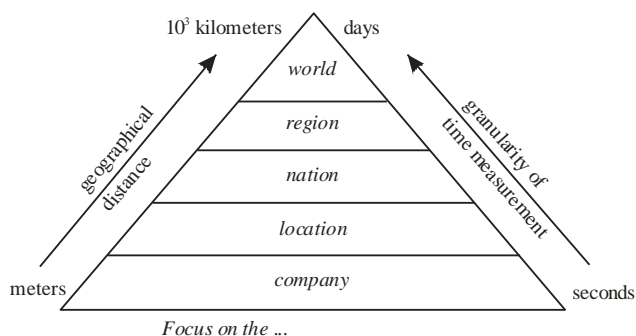


Figure 1: Hierarchy and time relevance of logistical processes

1. National/Regional freight transportation outbound
2. Sea-/Airport operation (incl. customs)
3. Sea-/Airfreight
4. Sea-/Airport operation (incl. customs)
5. National/Regional freight transportation inbound

Zooming into the international supply chain in the automotive sector a kit supply from Germany to Thailand is detailed in figure 2.

As given in figure 2 this kit supply chain consists of a total of 33 points whereas only one point is directly linked to the production process. Hence the overall performance is very low regarding the resulting in app. 99.99% non-value adding time.

$$\text{production value adding} = \frac{0,04 \text{ days}(= 20 \text{ minutes})}{95 \text{ days}}$$

Referring to logistics as a function to deliver the right material in the right quantity and the right time in the right quality with a continuous material/information flow the logistics value adding is shifting the viewpoint away from production: It is the continuous flow within the logistics pipeline characterizing valuable logistics (Pfohl H.Chr. 2004, pp. 12-13). Therefore the calculation as above is given a new direction with the resulting in 60.5% non-value adding logistics time.

$$\text{logistics value adding} = \frac{37,5 \text{ days}}{95 \text{ days}}$$

The common goal for international supply chains is to achieve a smooth and continuous flow. Empirical analysis in the automotive sector verified that

certain points along the logistical pipeline bear more risk stopping this flow than other ones. The top three points for such a risk are

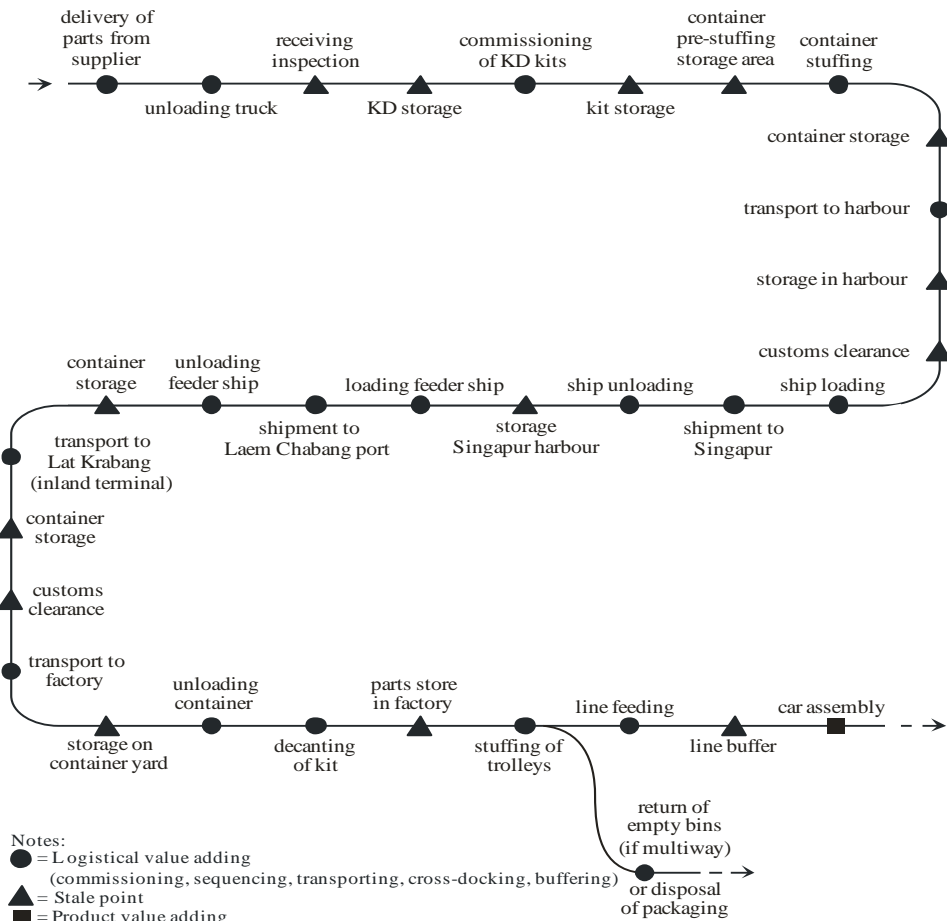


Figure 2: Kit supply from Germany to Thailand

1. Customs inbound,
2. Material delivery for kit packaging and
3. Inbound transport to the production plant.

For improving the flow several country and regional related projects were launched during the last years. Guided by a 6Sigma quality approach the logistics pipeline was investigated regarding this continuous flow. As for example the lead time for a country related customs process is given in figure 3.

The data analysis was based on a ½ year compilation of actual customs processing time and represented by a total of 100 cases. Each data set was

analyzed regarding its values being a normal distribution curve by a hypothesis test: with a p-value of 0,017 (before improvement) and 0,015 (after improvement) both sets fulfilled the test.

The customs process itself is defined from arrival of the material at the port until final release of it. The customs process needs some preparation by the importer before the official approach can be made to the customs body. These preparations are not calculated into the customs processing time.

The distribution of the customs cycle time (figure 3) gives evidence that a solid prediction for this process is not possible. As the next major step the conceivable influences on these process times were elaborated and the dominant influence factor X (the main X) was worked out. By improving the variation of customs the processing time was successfully reduced. Figure 4 shows this effect with its consequence for an improved planning preciseness for this particular cycle time. The time optimization also helped to gain a better understanding and interface between the importer and the customs office.

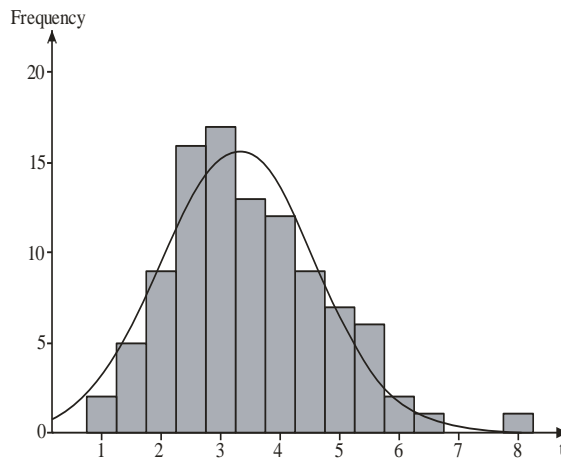


Figure 3: Customs cycle time for a specific country

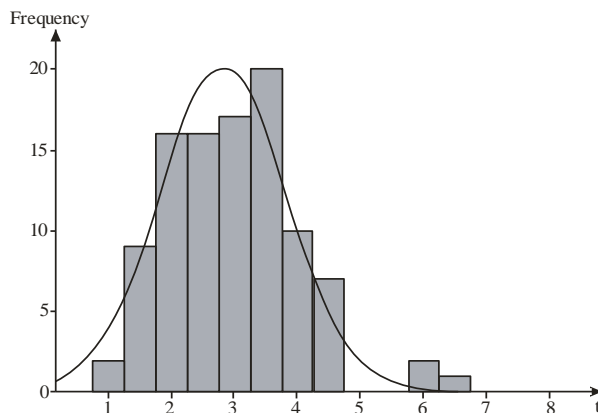


Figure 4: Customs cycle time after improvement

Regarding the material delivery the actual delivery time slot was compared to the requested one as set by the material controller. The statistical analysis focused on the time delta  $z$  between the actual and the requested time value: Actual time is 3.30pm and the requested one is 1pm  $\pm$  30minutes so the  $z$ -value is 2 hours for this example. The  $z$  distribution of the international delivery time as shown in figure 2 is given in figure 5. The actual values in days are transformed due to confidentiality reasons but the characteristics of the distribution are still given.

The target is to get the supplies within their given time frame. One of the major X factors was the controlling of the supply times themselves. Only by a strict and consequent escalation in cases of non-meeting the time frame an improvement could be achieved. The  $z$  distribution is reduced with only some minor deviations due to material shortages or force majeure along the transportation pipeline.

The inbound transport is measured by the transportation time from loading the container at the port until unloading it at the plant. The time calculated began after the customs release until the container was opened at the container docking station in the factory.

The time variations were analyzed and the distribution curve showed a range of 3Sigma only.

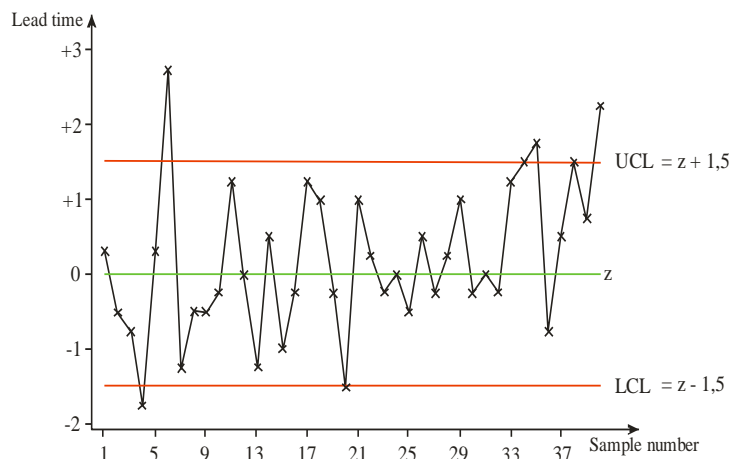


Figure 5: z distribution curve for the material delivery

To improve the situation and get closer to 6Sigma the different transport companies were invited. Some of the findings include road conditions (e.g. diversions), traffic conditions (e.g. traffic congestion) or force majeure (e.g. break down of trucks). Due to the unpredictability of the entire main X the improvement is to still accept this 3Sigma level if the time slot for delivery is met. It will increase the waiting time before delivery but the importance of meeting the delivery time slot is higher than meeting the given transportation time. Therefore no special actions were initiated in this case.

### 2.3. JIT in an International Context

Considering the top three points and all related ones the overall goal of an international JIT supply was also investigated. The conclusion was to split the supply chain into two logistical segments: The one is demand-pull orientated and reaches from the foreign plant until the container call-off from the harbor abroad. Before this process a supply-push principle dominates the supply chain. JIT is therefore only implemented in the local supply chain as shown in figure 6.

The relevant control parameter in this JIT supply chain is the stock level in the container yard. Since this stock ensures a smooth production a trade-off is apparent between line stoppage and stock level. Three main factors drive this level:

1. In case of any part failures or damages a replacement part can be robbed from kits still in the inbound transportation pipeline.

2. Due to local demand changes a kit buffer is supporting to balance the production flow.

3. The reduced but still existing unpredictability of the customs processing time also influences the stock level.

Hence the question in international supply chains is not whether to hold stock but to which level the stock is filled up and how close this level gets controlled and continuously adjusted.

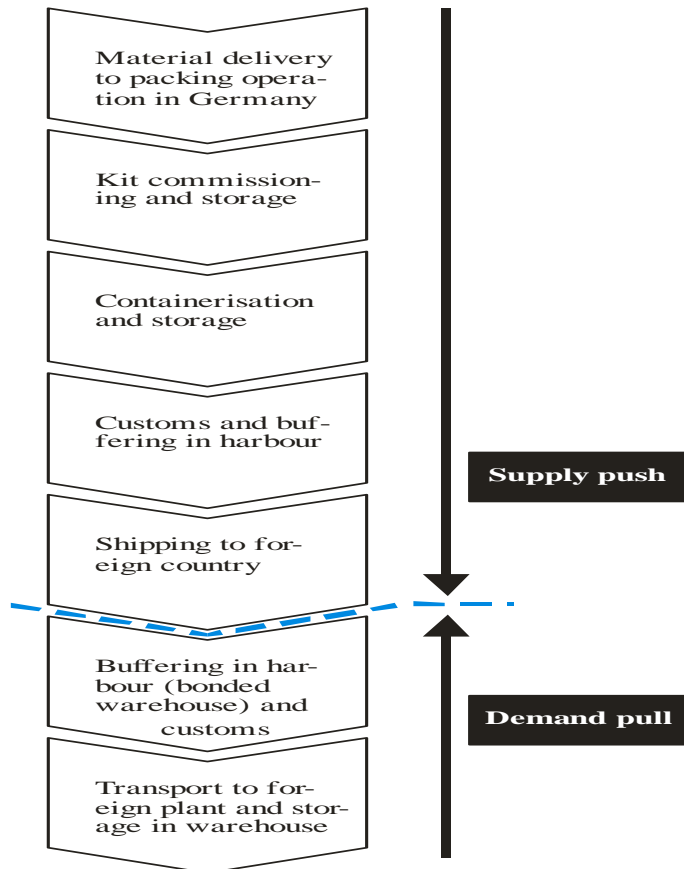


Figure 6: Hybrid supply chain for the kit delivery to foreign plants

### 3. Conclusion

Applying the JIT philosophy on an international scale needs a thorough analysis of the supply chain. Particularly in the automotive sector this analysis is pushed forward with the help of the 6Sigma approach focusing on time values. Further research fields include the 6Sigma application for logistical cost and quality



figures as well. Only by having all three target areas combined a holistic optimization can be achieved but still with the delivery time being the primary target for supply chains. Another research area involves the collaboration of different OEM in supplying jointly parts to foreign plants. Such cooperation can help to avoid misunderstandings with customs and different interpretations about laws or regulations on logistical operations. A further research potential is linked to outsourcing the international supply chain as a whole. Currently the majority of automotive OEM are having an in-house logistics and its controlling with only some specific processes being outsourced. But still the 4PL is not in the picture to operate and orchestrate all the kit supply points to foreign destinations (see figure 2). Especially the legal form and the interfaces need further investigation to give the 4PL its mandate but also the OEM the last call – if the deviation to given targets exceeds a certain limit.

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