

Zmanjšanje stroškov v odpremi z uporabo metodologije šest sigm

Reducing the Costs of Shipping Automotive Products by Implementing a Six Sigma Methodology

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Skupina za izboljšanje kakovosti in produktivnosti v podjetju TPV Johnson Controls, ki izdeluje avtomobilске sedeže za Renault Clio, je izpeljala projekt izboljšanja razmer pri odpremi sedežev. Povod za ta projekt je bila majhna zasedenost delavcev v odpremi, še zlasti voznika tovornjaka. S sistematičnim prijemom in timskim delom smo dosegli ugodne rezultate v obliki ukinitve enega delovnega mesta (enega delavca na izmeno) s prerazporeditvijo del in nalog na druga delovna mesta v odpremi in s tem dviga produktivnosti na zadovoljivo raven.

Tako je uporaba metodologije šest sigm pri izvedbi tega projekta prispevala k precejšnjim prihrankom in izboljšanju uspešnosti poslovanja.

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(Ključne besede: metodologija šest sigm, zmanjševanje stroškov, učinkovitost dela)

The team responsible for improving quality and productivity at TPV Johnson Controls, a company producing car seats for the Renault Clio, carried out a project to improve the efficiency of its shipping procedure. The reason for the project was the low labour efficiency in the shipping area, especially that of the truck driver. A systematic approach and teamwork abilities contributed to favourable results in the form of a lay-off of one workstation (one worker per shift) through a re-distribution of work assignments to other shipping workstations, and to an increase in efficiency to a satisfactory level.

The use of Six Sigma methodology in this project has meant considerable savings for the company and an improvement in its business performance.

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(Keywords: Six Sigma methodology, costs savings, labour efficiency)

0 UOVOD

Postopek, ki se imenuje Šest sigm, je relativno nov in se uporablja pri zagotavljanju kakovosti in vodenju kakovosti s poudarkom na stalnem izboljšanju kakovosti. Postopek izboljšav se uvaja skozi sistematično projektno usmerjeno metodologijo "definiraj, izmeri, analiziraj, izboljšaj in nadziraj" (DIAIN - DMAIC). Raven sigm pokaže možnosti za neakovosten izdelek. V primeru ravni šest sigm so možnosti za neustrezen izdelek enake 3,4 kosov na milijon. Doseganje ravni kakovosti šest sigm vključuje vodstvo, infrastrukturo, ustrezna orodja in metode, pri čemer kakovost postaja del skupnega načrta poslovanja organizacije ([1] do [5]).

1 PROJEKT ŠEST SIGM

1.1 Faza - Definiraj

- Opredelitev problema

0 INTRODUCTION

Six Sigma is a new, emerging approach to quality assurance and quality management with the emphasis on continuous quality improvement. Process improvements are implemented in a systematic manner through DMAIC methodology: Define, Measure, Analyse, Improve, and Control. The Sigma level indicates the possibility of a defective product. In the case of a Six Sigma level, the chance of a defective product is equal to 3.4 ppm. Achieving a Six Sigma quality level involves leadership, infrastructure, appropriate tools and methods, and in addition, quality has to become a part of corporate business plan ([1] to [5]).

1 SIX SIGMA PROJECT

1.1 Define Phase

- Problem Statement & Quantification



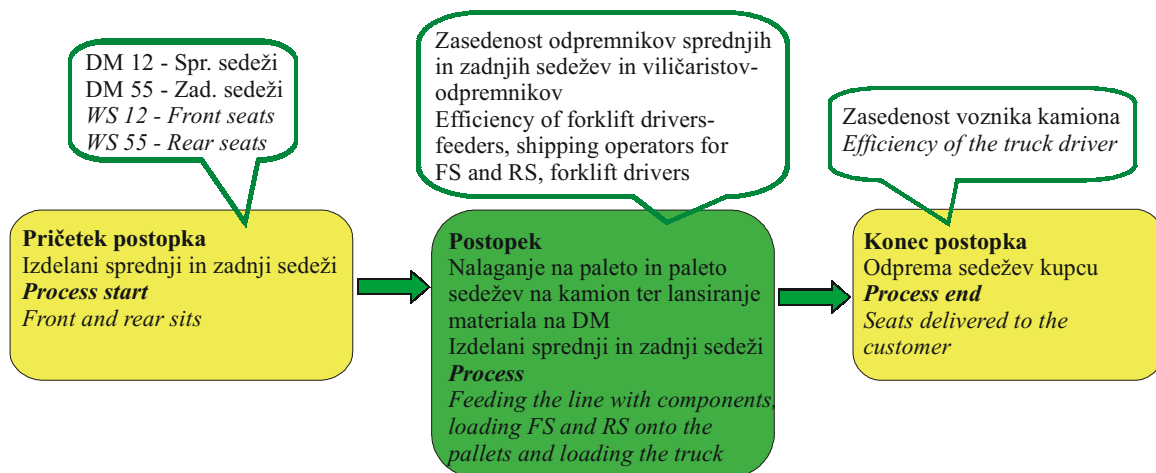
Sl. 1. Opredelitev problema v oddelku odpreme [6]
 Fig. 1. Problem statement in the shipping area [6]

V oddelku odpreme je 10 delavcev (pet v vsaki izmeni): voznik viličarja – lanser sestavnih delov, odprenik SS (sprednjih sedežev), odprenik ZS (zadnjih sedežev), voznik viličarja – odprenik sedežnih garnitur in voznik tovornjaka. Odprenika sedežev nalagata sedeže na palete za odpremo (najprej sprednje in nato še zadnje sedeže). Voznik viličarja – odprenik odvažja palete s sedežnimi garniturami v začasno skladišče in jih potem po potrebi natovarja na tovornjak. Voznik tovornjaka dostavlja sedežne garniture odjemalcu (sl. 1). Zasedenost delavcev na odpremi je nezadovoljiva (manjša od 61 %).

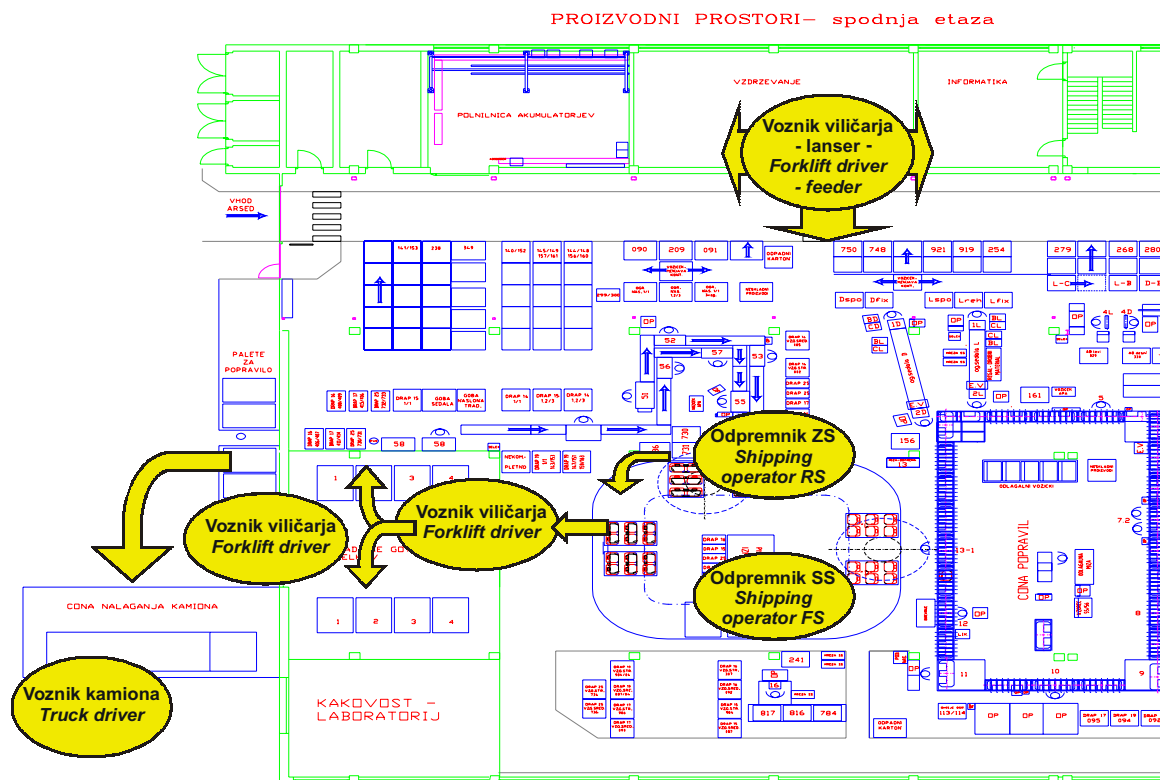
- **Cilj projekta**
 Analizirati zasedenost delavcev v oddelku odpreme ter ukinitvev enega voznika viličarja na izmeno.
- **Upoštevani prihranki projekta**
 Ukinitvev voznika viličarja – odprenika na izmeno/na leto: \$ 18 000
 Skupni letni prihranek (dve izmeni): \$ 36 000

There are 10 workers in the shipping area (five per shift): forklift driver-feeder, shipping operator FS (front seats), shipping operator RS (rear seats), forklift driver and truck driver. The shipping operators load the seats onto the pallets for shipping (first FS, then RS), the forklift driver moves the pallets with seat sets in the area between the shipping line and the temporary warehouse, and then loads them onto the truck. The truck driver delivers the seat sets to the customer, Figure 1. The labour efficiency is unsatisfactory (less than 61 %).

- **Project Objective**
 Analyse the labour efficiency in the shipping area and consequently lay-off one forklift driver per shift.
- **Project Saving Forecast**
 One forklift driver lay-off per shift/per year: \$ 18 000
 Saving per year (two shifts): \$ 36 000



Sl. 2. Začetek in konec (meji) postopka [6]
 Fig. 2. Process Start & End Points [6]



Sl. 3. Slika poteka postopka ([6] in [7])
Fig. 3. Process Map ([6] and [7])

- Težišče projekta in Meje poteka postopka
Kaj naj bi merili: **Zasedenost delavcev v oddelku odpreme**. Začetek in konec (meji) postopka sta podani na sliki 2.
- Slika poteka postopka
Slika 3 prikazuje “Sliko poteka postopka” za dejavnosti v oddelku odpreme.

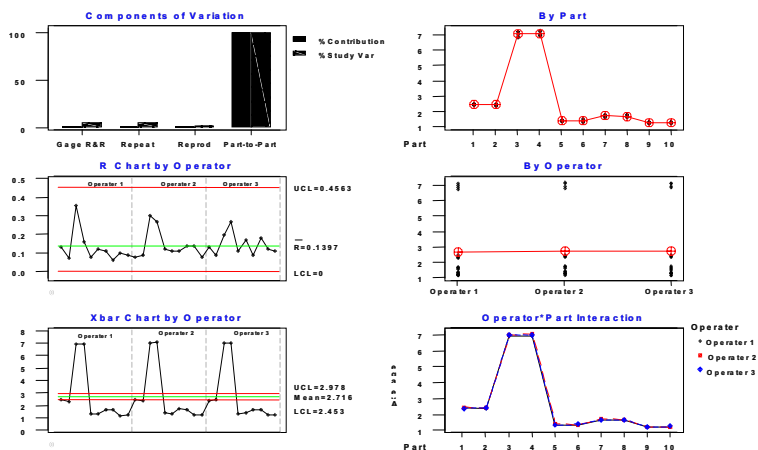
1.2 Faza - Izmeri

- Diagram ponovljivosti meritev
Merjeno je bilo: nalaganje palet z garniturami sedežev ene na drugo, prevoz z odpreme proge v vmesno skladišče in prevoz prazne palete iz vmesnega skladišča na odpremo progo. Analiza ponovljivosti (sl. 4) kaže, da je izbran način merjenja ustrezen. Variiranje med večkratnimi ponovitvami meritev za posamezne dejavnosti je majhno.
- Test normalnosti
Test normalnosti podaja ugotovitev, ali lahko sklop podatkov obravnavamo kot normalno porazdeljene podatke. Vrednost P je namreč verjetnost, da dobimo natančen vzorec, če so podatki normalno porazdeljeni. Sledili smo pravilu:
 - a) Vrednost $P < \alpha$: podatki niso normalno porazdeljeni.
 - b) Vrednost $P > \alpha$: podatki so normalno porazdeljeni.

- Project Focus & Process Boundary Map
What was measured: **Labour efficiency in the shipping area**. The process start and end points are shown in Figure 2.
- Process Map
Figure 3 shows the “Process Map” for the activities in the shipping area.

1.2 Measure Phase

- “Total Gage R&R” – graph
The measured operations were as follows: stacking of full pallets, delivery from the shipping line into the temporary warehouse, and delivery of empty pallets from the temporary warehouse onto the shipping line. The Gage R&R analyses (Fig. 4) show that three operators were measuring consistently. The variation between multiple measurements for each individual part is small.
- Normality Test
The normality test shows whether a collection of data can be treated as normally distributed data. The P-value is the probability of getting an accurate pattern if the data are normally distributed. We follow the principle:
 - a) $P\text{-Value} < \alpha$: The data are not normally distributed.
 - b) $P\text{-Value} > \alpha$: The data are normally distributed.

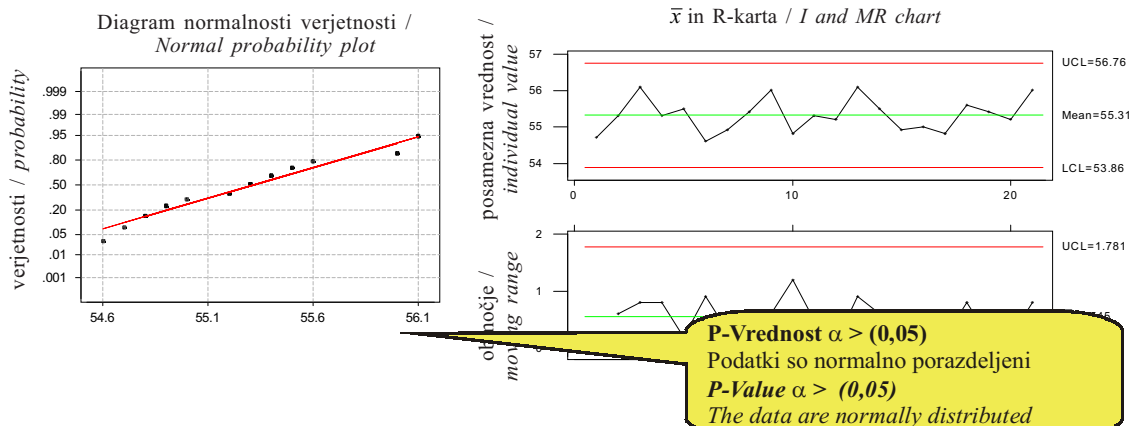


Izbran način merjenja je ustrezen, kar dokazuje izračun ponovljivosti meritev (rezultat znotraj mej 0 in 10 %).
 The selected measurement system is suitable, which is proved by the calculation of Total Gage R&R (the result is within the limits 0 and 10 %)

St. dev / StdDev Vir / Source	Študij var. / Study Var (SD)	%Študij var. / %Study Var (5.15*SD)	(%S)
Celotna ponov. meritve Total Gage R&R	0,09272	0,4775	4,03
Ponovljivost Repeatability	0,09143	0,4709	3,97
Reproduktivnost Reproducibility	0,01541	0,0794	0,67
Delavec Operator	0,01541	0,0794	0,67
Kos proto kosu Part-To-Part	2,30162	11,8533	99,92
Celotna variacija Total Variation	2,30349	11,8630	100,00

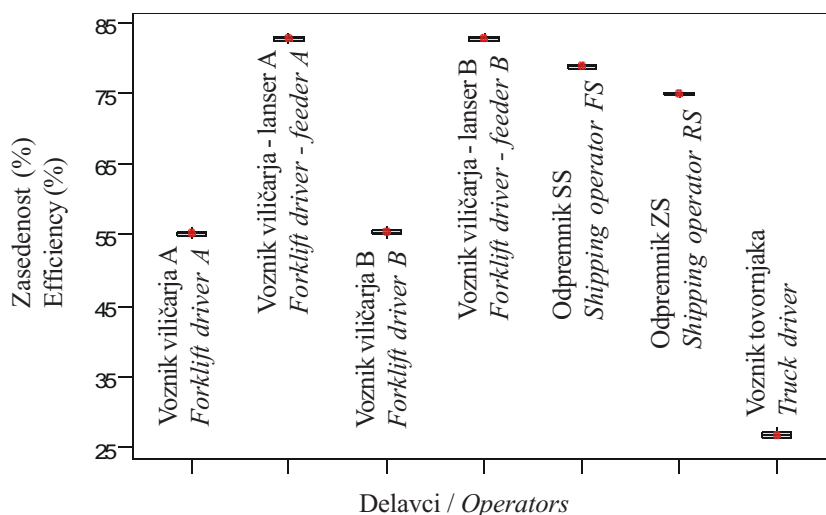
Sl. 4. Analiza ponovljivosti
 Fig. 4. The Gage R&R analyses

- "Diagram normalnosti verjetnosti in \bar{x} , R-karta". Oba testa za vseh 10 delavcev v oddelku odpreme kaže, da sklop podatkov lahko obravnavamo kot normalno porazdeljenega in da so merjeni procesi stabilni, vendar neučinkoviti. Primer "testa normalnosti" za voznika viličarja – odpremnika v izmeni A je prikazan na sliki 5.
- Diagram zasedenosti delavcev v oddelku odpreme
 Diagram zasedenosti na sliki 6 kaže, da sta voznika viličarja – odpremnika učinkovita le 55 %, voznik
- "Normality Probability Plots" & "I and MR Chart", for all 10 workers in the shipping area show that a collection of data can be treated as normally distributed data and that the measured processes are stable, but of low efficiency. An example of the "Normality Test" for the forklift driver in the A shift is shown in Figure 5.
- "Box plots graph" - Labour efficiency in the shipping area
 The Box plots graph (Fig. 6) shows that the two forklift drivers are only 55 % efficient and the truck



P-Vrednost $\alpha > (0,05)$
 Podatki so normalno porazdeljeni
 P-Value $\alpha > (0,05)$
 The data are normally distributed

Sl. 5. "Test normalnosti" za voznika viličarja – odpremnika v izmeni A
 Fig. 5. "Normality Test" for the forklift driver in the A shifts



Sl. 6. Diagram zasedenosti delavcev

Fig. 6. Box plots graph of the efficiency of operators

tovornjaka pa samo 27 %. Torej, je bil cilj tima poiskati poti za bistveno povečanje učinkovitosti dela ter uporabo notranjih rezerv v oddelku odpreme in nazadnje ukiniti delovno mesto dveh voznikov viličarja (v vsaki izmeni enega).

driver's efficiency is only 27 %. Thus, the target of the team is to find ways to substantially increase the efficiency and make use of internal reserves in the shipping area and consequently lay-off two forklift drivers.

1.3 Faza - Analiziraj

- "Testiranje domneve" učinkovitosti za posamezna delovna mesta v izmenah A in B

V podporo doseganju ciljev smo izvedli "testiranje domneve" učinkovitosti dela za vsa delovna mesta v odpremi, v izmenah A in B.

Testi kažejo, da ni bilo razlike pri učinkovitosti enakih delovnih mest v obeh izmenah.

- "testiranje domneve" učinkovitosti za A in B voznika viličarja – odpremnika

1.3 Analyze Phase

- "Hypothesis tests" of the efficiency in A and B shifts on all workstations

To support the setting of targets we made "Hypothesis tests" of the labour efficiency in the A and B shifts on all workstations in the shipping area. The tests showed that there was no difference in the efficiency of the same workstations in the two shifts.

- "hypothesis test" of the efficiency for A and B forklift drivers (FLDs)

Ničelna domneva <i>Null Hypothesis</i>	- Ho: μ A izmena = μ B izmena
Nasprotna domneva <i>Alternative Hypothesis</i>	- H1: μ A izmena \neq μ B izmena

Dvo-vzorčni T-test in CI: A-% voznik viličarja in B-% voznik viličarja
Two-Sample T-Test and CI: A-% FLD in B-% FLD

	N	Sr. vr. Mean	dt.driv. StDev	SE sr.vr. SE Mean
A - % voznik viličarja A - % forklift driver	21	55,314	0,460	0,10
B - % voznik viličarja B - % forklift driver	21	55,419	0,446	0,097

Razlika / Difference = μ A-% voznik vil. / FLD - μ B-% voznik vil. / FLD

Ocena za razliko / Estimate for difference: -0.105 (razlika od srednje vrednosti / difference of mean value)

95% CI za razliko / for difference: (-0.387; 0.178)

T-test razlike / T-Test of diff. = 0 (vs not =): T-vrednost / value = -0.75 P-vrednost / value = 0,458 DF = 39

P-Vrednost $\alpha > 0,05$

Sprejmemo "ničelno domnevo" ni razlike med zasedenostjo voznika viličarja A in B.

P-Value $\alpha > 0.05$

"Null Hypothesis" accepted no difference between the efficiency of A and B forklift drivers.

Ničelna domneva <i>Null Hypothesis</i>	- Ho: μ A voznik viličarja = μ B voznik viličarja = μ voznik tovornjaka - Ho: μ A forklift driver = μ B forklift driver = μ truck driver				
Nasprotna domneva <i>Alternative Hypothesis</i>	- H1: μ A voznik viličarja \neq μ B voznik viličarja \neq μ voznik tovornjaka - H1: μ A forklift driver \neq μ B forklift driver \neq μ truck driver				
»Analiza variance« za vse podatke (za potrditev razlike) / »Analysis of Variance« for all data (to confirm the difference)					
Vir / Source	DF	SS	MS	F	P
Subs	2	11428,69	5714,34	3,0	0,000
Napaka / Error	60	11,33	0,19		
Celotno / Total	62	11440,01			
	N	Sr.vr. / Mean	StDev		
A - % Voznik viličarja	21	55,314	0,460		
A - % Forklift driver					
B - % Voznik viličarja	21	55,419	0,446		
B - % Forklift driver					
Voznik tovornjaka	21	26,795	0,396		
Truck driver					

P < 0.05; Zavrtnemo "ničelno domnevo"
P < 0.05; Null hypothesis rejected

- "Testiranje domneve - ANOVA": Učinkovitost voznikov viličarja – odpremnikov A in B ter voznika tovornjaka

Iz opravljenega izračuna je razvidno, da ni nobene razlike v zasedenosti med voznikoma viličarja – odpremnikoma izmene A in B, kar pa ne velja za razmerje med voznikom tovornjaka in voznikom viličarja – odpremnikom izmene A in tudi ne za razmerje med voznikom tovornjaka in viličaristom-odpremnikom izmene B (obe vrednosti sta pozitivni razliki).

Vse opravljene raziskave (Testiranje domneve, Testiranje domneve-ANOVA, Diagram zasedenosti, Analize izvora in vpliva napak (AIVP)) so dokazale, da so na odpremi delovna mesta, ki lahko prevzamejo določena dela in naloge od voznika viličarja – odpremnika (v obeh izmenah).

1.4 Faza - Izboljšaj

- Akcija za doseganje cilja

Skupina je razporedila dela in naloge voznika viličarja – odpremnika izmen A in B na druga delovna mesta glede na rezultate analize njihove zasedenosti (sl. 7).

- "Testiranje domneve" za voznika viličarja / voznika tovornjaka (novo stanje)

Glede na rezultate simulacije se je skupina odločila, da voznik tovornjaka prevzame dodatna dela (zamenjavo palet, nalaganje tovornjaka in zamenjavo akumulatorja na viličarju). Za statistično

- "Hypothesis test - ANOVA": Efficiency of A and B forklift drivers and the truck driver

The calculation shows that there is no difference between the efficiencies of the A and B forklift drivers, but this does not hold true for the ratio between the truck driver's efficiency and that of the A forklift driver, in the same way as it is not true for the ratio between the truck driver and the B forklift driver (both values are positive – difference).

All our researches (Hypothesis test, Hypothesis test - ANOVA, Box Plots graphs, Failure mode and effect analysis (FMEA)) so far prove that there are workstations in the shipping area that could take over some tasks from the forklift drivers (both shifts).

1.4 Improve Phase

- Action to achieve the target

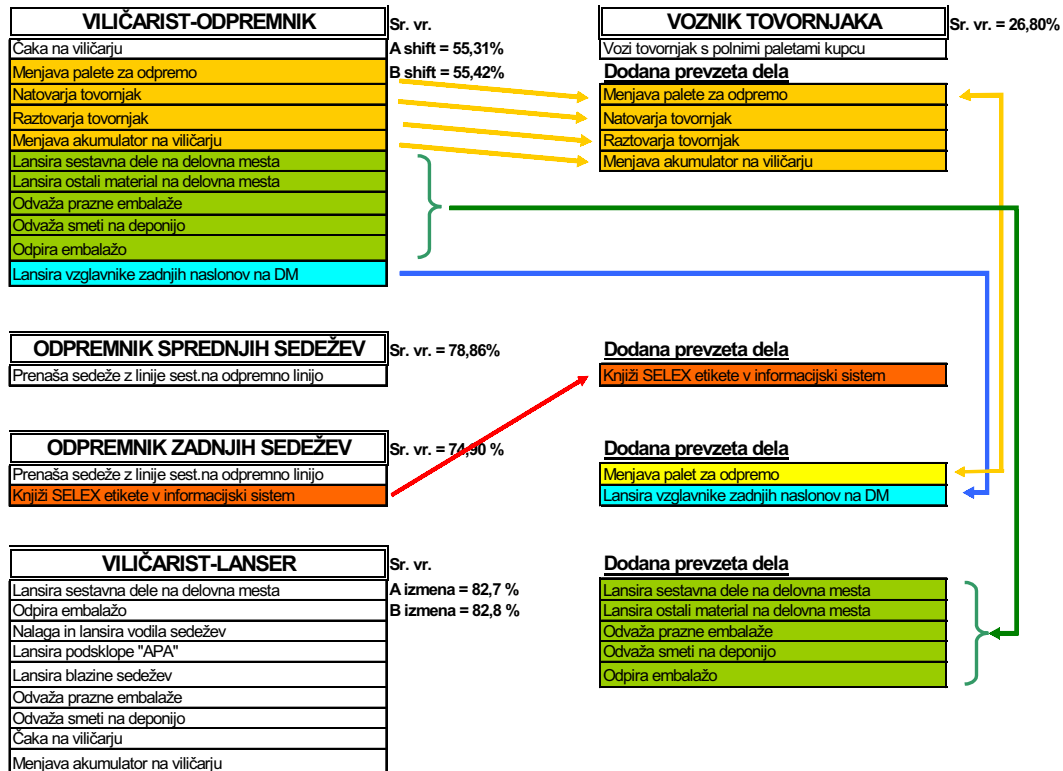
With the help of the team we succeeded in distributing the work assignments of the A and B forklift drivers to other workstations on the basis of their efficiency analysis (Fig. 7).

- "Hypothesis test" for forklift driver - FLD / truck driver - TD (new situation)

Based on the simulations the team decided that the truck driver should take on additional tasks (changing of pallets, loading the truck and changing the battery on the forklift). To

Ničelna domneva <i>Null Hypothesis</i>	- Ho: μ voznik viličarja = μ voznik tovornjaka - Ho: μ forklift driver = μ truck driver			
Nasprotna domneva <i>Alternative Hypothesis</i>	- H ₁ : μ voznik viličarja \neq μ B voznik tovornjaka - H ₁ : μ forklift driver \neq μ B truck driver			
Dvo-vzorčni T-test za voznika viličarja proti vozniku tovornjaka / Two-sample T for FLD CH.				
	M	sr.vr. / Mean	StDev	SE sr.vr. / Mean
voznik viličarja	30	6,7870	0,0223	0,0041
FLD CH. PALLET				
voznik tovornjaka	30	6,8003	0,0243	0,0044
TD CH. PALLET				
Razlika / Difference = μ voznik viličarja / FLD CH. PALLET - μ voznik tovornjaka / TD CH. PALLET				
Ocena za razliko / Estimate for difference: -0,01333				
95% CI za razliko / for difference: (-0,02539; -0,00128)				
T-Test razlike / of difference = 0 (vs not =): T-vrednost / Value = -2.21 P-vrednost / Value = 0,031 DF = 57				

P < 0,05; Sprejmemo "Ničelno hipotezo"
P < 0.05; Fail to reject the Null Hypothesis



Sl. 7. Porazdelitev delovnih nalog voznikov viličarjev – odpremnikov A in B

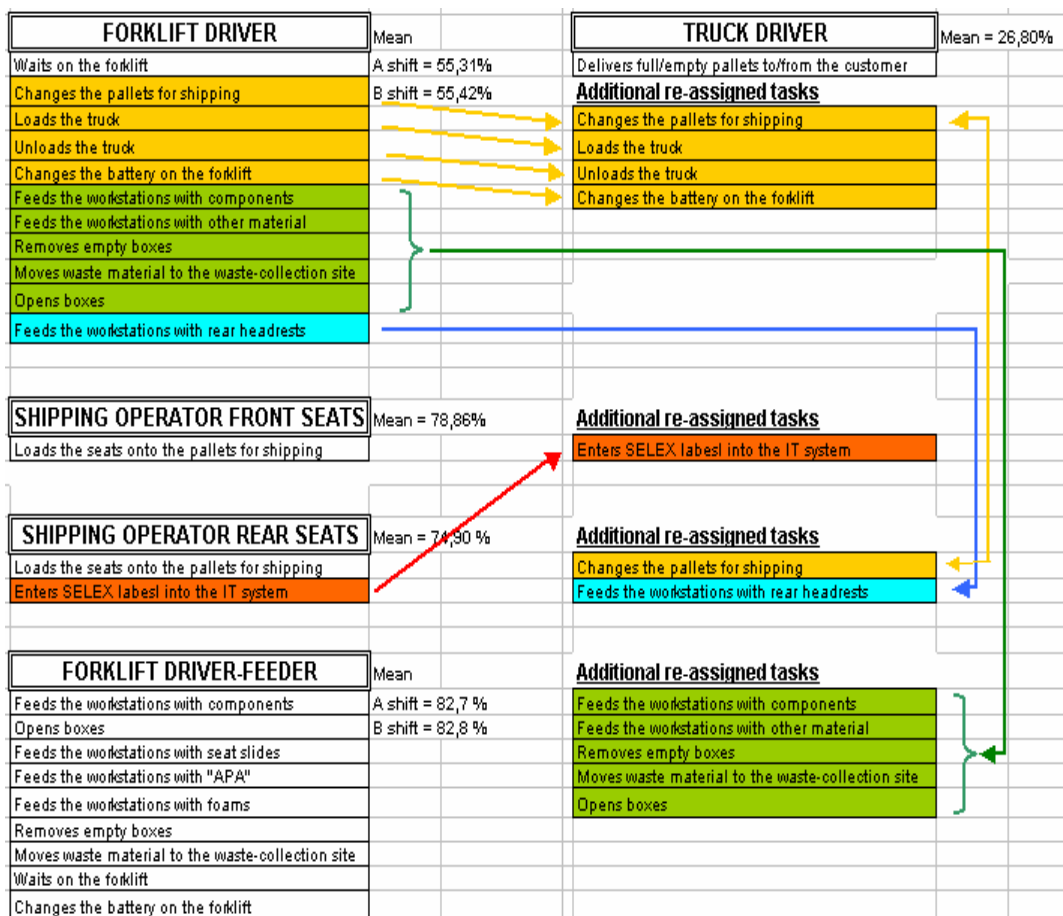
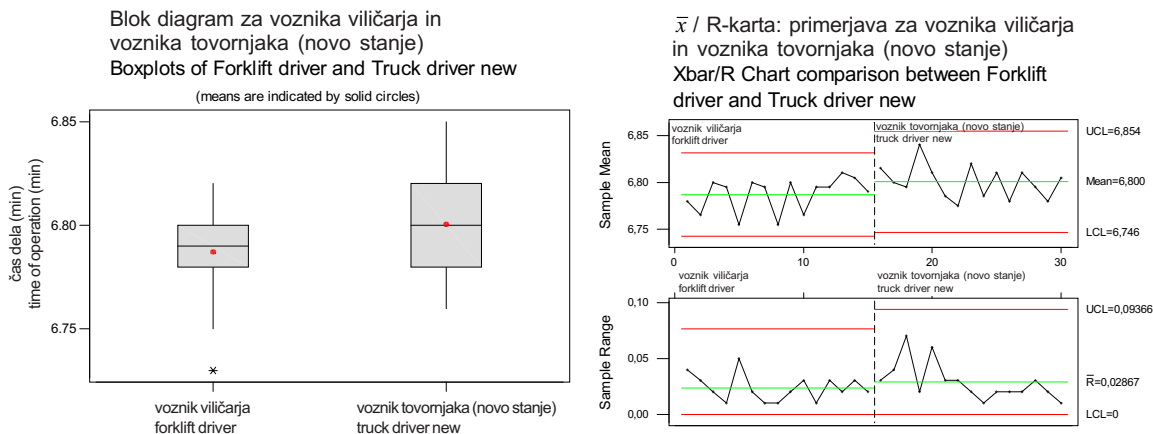


Fig. 7. Distribution of the work assignments of the A and B forklift drivers



Sl. 8. Blok diagram in \bar{x} / R-karta
 Fig. 8. Box Plots and Xbar/R Char

potrditev upravičenosti naše odločitve smo naredili nove meritve in izračune.

Blok diagram in \bar{x} / R-karta (sl. 8) kažeta, da voznik tovornjaka lahko prevzame nalogo zamenjave palet od voznika viličarja – odpremnika.

- Diagram zasedenosti delavcev v oddelku odpreme – novo stanje

Diagram na sliki 9 prikazuje povečanje zasedenosti delavcev v oddelku odpreme, ki je posledica prerazporeditve delovnih nalog zaradi ukinitve delovnega mesta enega voznika viličarja na izmeno.

statistically confirm the justification of our decision we made new measurements and calculations.

The box plots and the Xbar/R Chart (Fig. 8) show that the truck driver is able to take over the task of changing the pallets from the forklift driver.

- “Box Plots graph” for labour efficiency in the shipping area – new situation

The graph (Fig. 9) shows the increase in labour efficiency in the shipping area, which results from the re-distribution of work assignments due to the lay-off of one forklift driver per shift.

1.5 Faza - Nadziraj

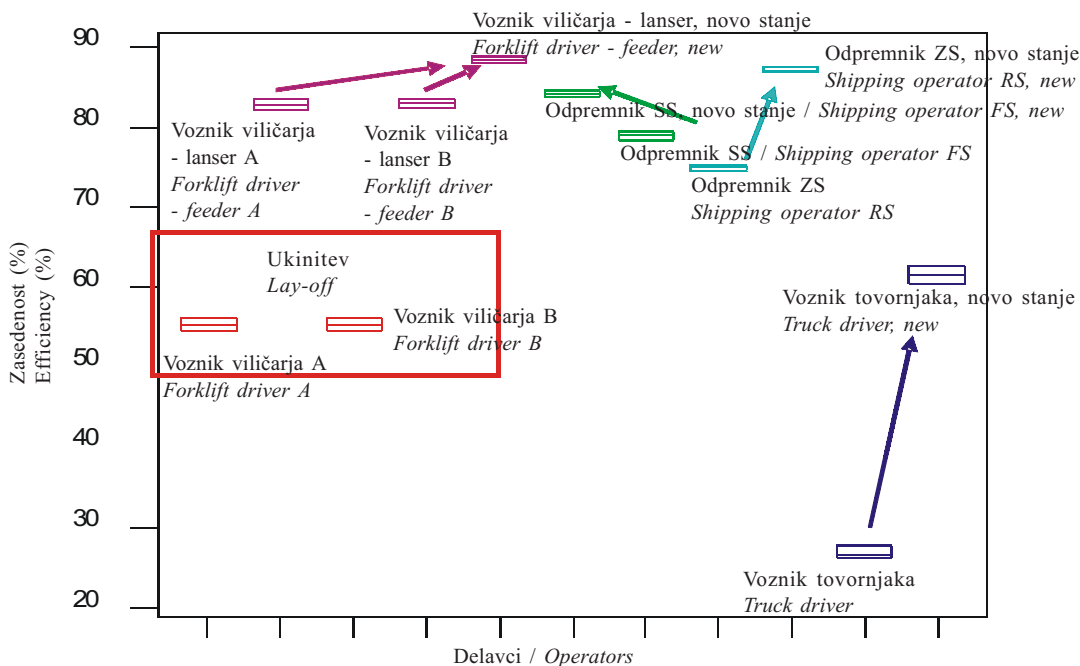
- “ \bar{x} / R-karta” za delavce v odpremi

V tej fazi smo preverili stabilnost novih postopkov in povečanje učinkovitosti, kar ponazarja uspeh projekta (sl. 10).

1.5 Control Phase

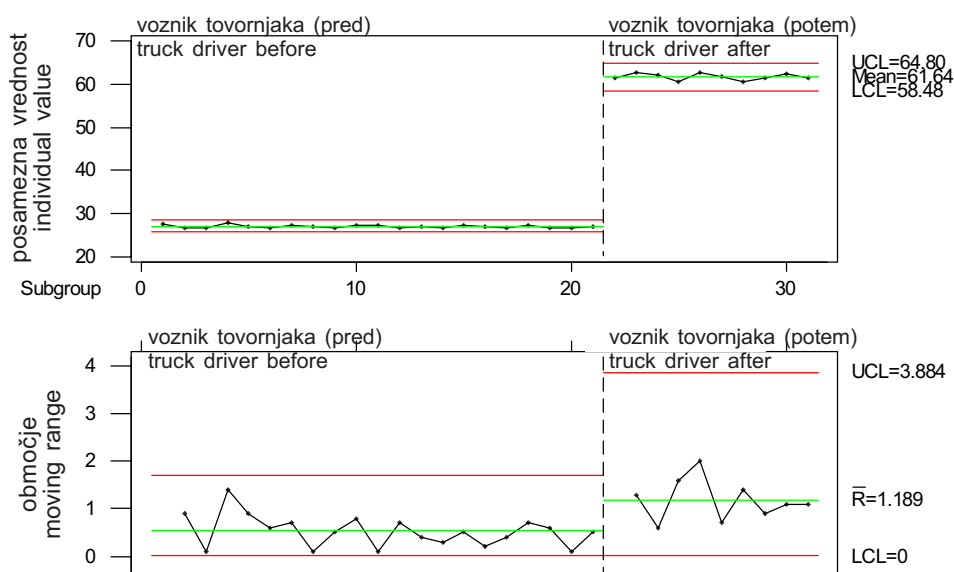
- “I and MR Charts” for shipping workers

These charts prove the stability of the new processes and the rise in efficiency, which demonstrates the success of the project (Fig. 10).



Sl. 9. Diagram zasedenosti za novo stanje v odpremi
 Fig. 9. Box plots graph for the new situation

\bar{x} in R-karta za voznika tovornjaka pred in po spremembi I and MR Chart for Truck driver before and after



Sl. 10. \bar{x} / R-karta voznika tovornjaka pred prerazporeditvijo nalog in po njej
Fig. 10. I and MR Chart for shipping workers

- Spremenjeni načrt nadzora

V tej sklepnih fazi metodologije DAIIN je bil razvit načrt nadzora, da bi zagotovili konsistentnost procesov in izpolnitev zahtev odjemalcev.

- Modified Control Plan

In this final phase of the DMAIC methodology, a control plan was developed to ensure that the processes consistently meet our and the customer's requirements.

2 SKLEP

Postopek Šest sigm zahteva sistematičnost in konstruktivno delo celotne skupine. Cilj šest sigm je izboljšati organizacijsko učinkovitost kakor tudi uspešnost pri zadovoljevanju odjemalčevih potreb ter resnično oblikovanje ekonomskega blagostanja tako za odjemalca kakor dobavitelja. V analiziranem primeru je podjetje doseglo prihranke v znesku 36.000 \$ na leto.

2 CONCLUSION

Six Sigma requires a systematic approach and the constructive work of the whole team. The objective of Six Sigma is to improve an organisation's efficiency as well as its effectiveness in meeting the customer's needs, ultimately creating economic wealth for the customer and the provider. In the analysed case the company achieved savings of \$ 36,000 per year.

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