

Kako zagotoviti konkurenčnost majhnega podjetja

How to Achieve a Competitive Position with a Small Company

Marko Starbek - Jože Duhovnik - Janez Grum - Janez Kušar

Osamosvojitve Slovenije v letu 1991 je za slovenska podjetja pomenila dramatično zmanjšanje domačega tržišča. Velika podjetja, ki se niso prilagodila na nove tržne razmere, so bila obsojena na propad. Ustanovljenih je bilo večje število manjših podjetij, ki so imela večjo možnost za prilagajanje novim tržnim razmeram. Pri vstopu na svetovni trg so se ta podjetja srečevala z različnimi problemi, največji problem pa so bili predolgi časi uvajanja izdelkov.

V prispevku je prikazano načelo istočasne izvedbe postopka uvajanja izdelkov. Ker trg sili majhna podjetja k prehodu iz zaporednega na istočasni inženiring in ker je temelj istočasnega inženiringa skupinsko delo, je posebna pozornost namenjena načrtovanju timov in delovnih skupin v zankah postopka istočasovnega uvajanja izdelkov v majhnih podjetjih.

Pregled objavljenih del s področja načrtovanja timov v velikih podjetjih ([1] in [2]) je pokazal, da se za velika podjetja priporoča tronivojska struktura timov in delovna skupina, sestavljena iz štirih osnovnih timov. Kritična ocena tronivojske strukture nas je pripeljala do sklepa, da predlagamo za majhna podjetja le dvonivojsko strukturo timov in delovno skupino, sestavljeno iz dveh osnovnih timov.

Prikazani so rezultati načrtovanja dvonivojske strukture timov in postopka izvedbe istočasovnega inženiringa v majhnem podjetju, ki izdeluje mini-nakladalnice.

© 2003 Strojniški vestnik. Vse pravice pridržane.

(Ključne besede: inženiring simultani, zanke, delo skupinsko, timi projektni)

In 1991 the independence of Slovenia resulted in an enormous decrease in the domestic market for Slovenian companies. Big companies that did not adapt to the new conditions were destined to collapse. Several smaller companies were established, and they were more easily able to adapt to the new market conditions. When these companies entered the global market they encountered several difficulties, the most important of which was an excessively long time for product development.

This paper presents the principle of the concurrent product development process. The market forces small companies to switch from sequential to concurrent engineering, and as team work is the basic element of concurrent engineering, special attention has to be paid to forming workgroups in the loops of the concurrent product development process in small companies.

A survey of the published works in the field of planning teams in big companies ([1] and [2]) has revealed that in big companies a three-level team structure is recommended, as well as a workgroup consisting of four basic teams. An analysis of the three-level structure has led us to the conclusion that in small companies a two-level team structure and a workgroup consisting of two basic teams is to be preferred.

The results of planning a two-level team structure and the implementation of concurrent engineering in a small company that produces mini-loaders are presented.

© 2003 Journal of Mechanical Engineering. All rights reserved.

(Keywords: concurrent engineering, loops, team work, project teams)

0 UVOD

Če analiziramo svetovni trg, lahko ugotovimo, da zahteve kupcev glede na funkcionalnost in kakovost izdelkov stalno naraščajo, hkrati pa se zmanjšuje pripravljenost kupcev, da bi za boljše izdelke plačali več in da bi

0 INTRODUCTION

An analysis of the global market has shown that customer requirements regarding the functionality and the quality of products are continuously increasing – but the customers are not willing to pay more for better products and neither do they accept

dovolili podaljšanje rokov dobave izdelkov. Kupci postajajo čedalje bolj zahtevni in njihove zahteve se nenehno spreminjajo. Vse bolj se uveljavlja izrek »kupec je kralj« [3].

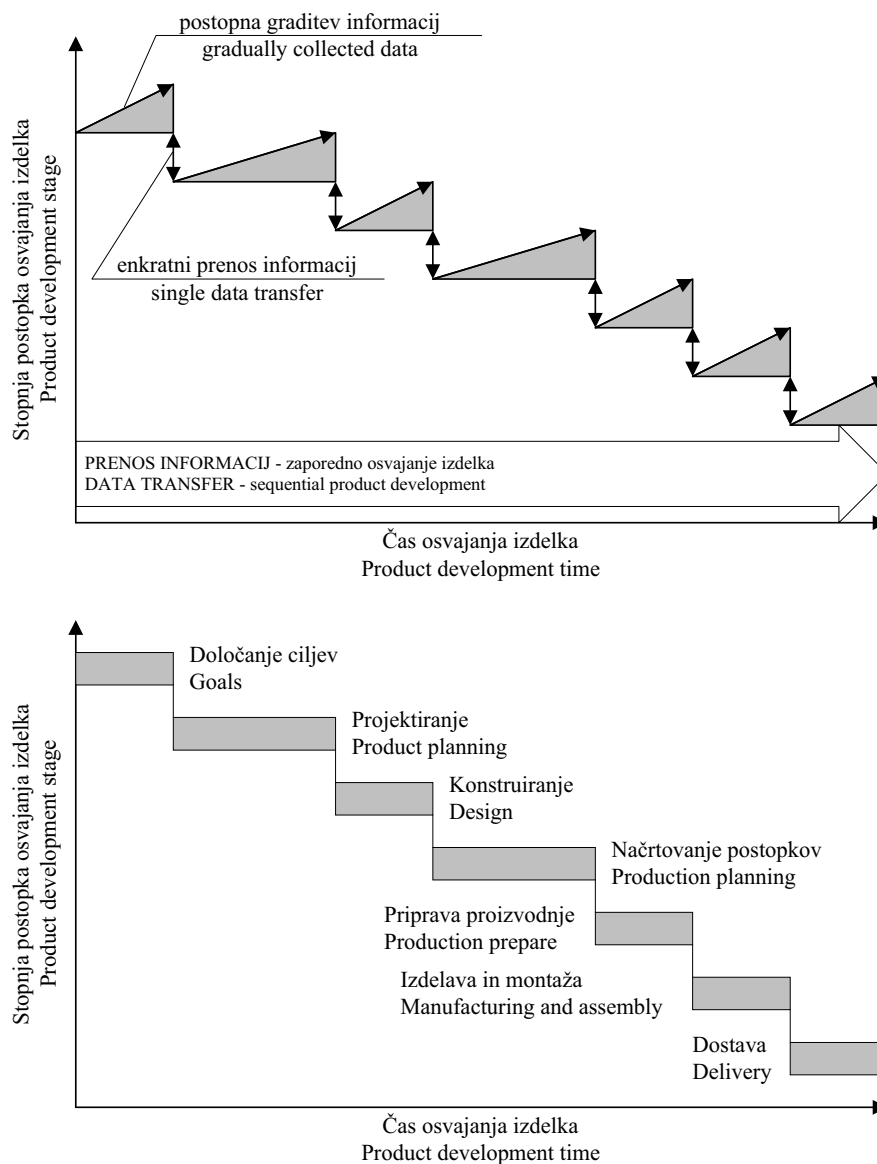
V tem položaju imajo možnost preživetja na trgu le tista podjetja, ki lahko ponudijo kupcem glede na zahtevano funkcionalnost in kakovost prave izdelke, ob pravem času, v pravi kakovosti in po pravi ceni.

Sodelavci *Labortorija za proizvodne sisteme* smo izvedli anketo, ki se je nanašala na problematiko neizpolnjevanja želja kupcev in predolgi časov uvajanja izdelkov, na katero je odgovorilo 23 majhnih podjetij z posamezno in maloserijsko proizvodnjo. Rezultati ankete so pokazali, da je v podjetjih zelo poudarjen problem neizpolnjevanja zahtev kupcev ter problem predolgi časov uvajanja izdelkov.

prolonged delivery terms. Customers are becoming more and more demanding and their requirements are changing all the time. "The customer is king" is becoming the motto of today [3].

In these circumstances only those companies that offer their customers the right products in terms of functionality and quality, and products that are produced at the right time, quality and price, can expect to succeed.

The members of the *Production Systems Laboratory* compiled a questionnaire about the unfulfilled wishes of customers and excessive product-development times. Responses were obtained from 23 small companies with individual and small-series production. The results of the questionnaire showed that these companies had definite problems with the unfulfilled requirements of customers and excessive product-development times.



Sl. 1. Zaporedno uvajanje izdelka
Fig. 1. Sequential product development

Izkazalo se je, da imajo v vseh podjetjih organizirano zaporedno uvajanje izdelkov, kar je vzrok dolgih, za trg nesprejemljivih časov uvajanja izdelkov.

Z rezultati ankete smo seznanili vsa v anketi sodelujoča podjetja in jih skušali zainteresirati za sodelovanje pri projektu postopnega prehoda iz zaporednega na istočasovno uvajanje izdelkov.

Od anketiranih podjetij se je za takojšnje sodelovanje pri projektu odločilo podjetje, ki je izdelovalec majhnih serij mini nakladalnikov, s katerimi se pojavlja na domačem in tujem trgu.

1 ZAPOREDNI IN ISTOČASOVNI INŽENIRING

Zaporedni inženiring karakterizira zaporedno izvajanje stopenj postopka uvajanja izdelka. Opazovana stopnja postopka se lahko prične, ko je

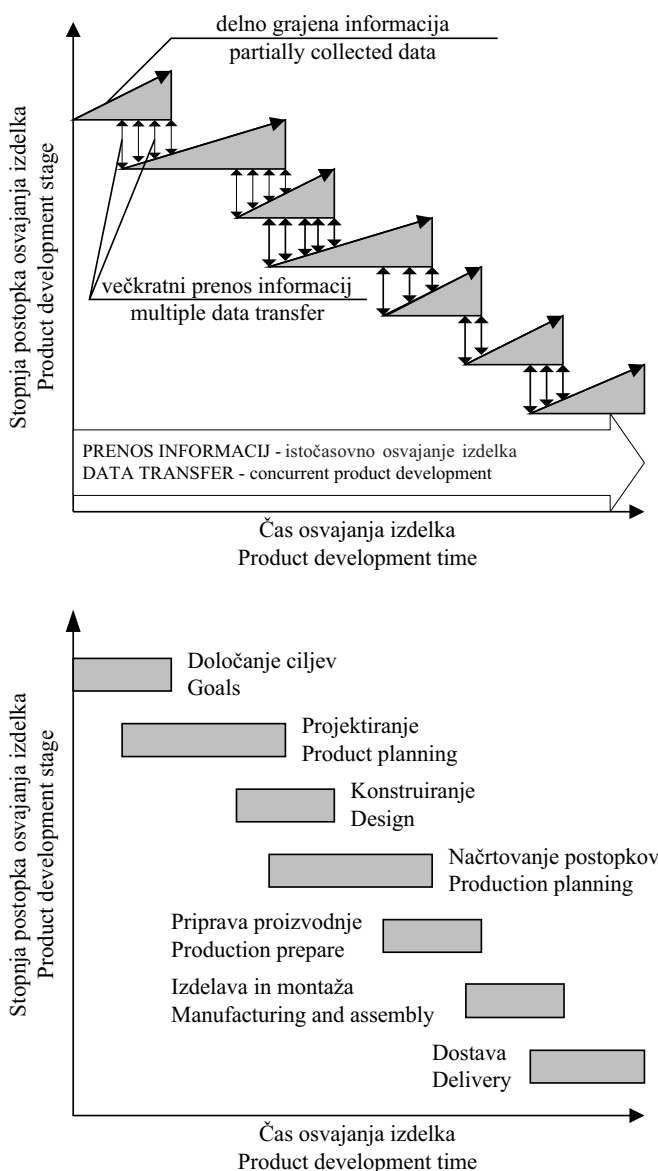
It became evident that all the companies were using a sequential product development process, which caused excessive and unacceptable times for product development.

The results of the questionnaire analysis were sent to all the participating companies and we tried to arouse their interest in cooperating in a project involving the gradual transition from the sequential to the concurrent development of products.

Of all the companies, a company that produces mini-loaders in small series for domestic and international markets immediately decided to participate in the project.

1 SEQUENTIAL AND CONCURRENT ENGINEERING

The main feature of sequential engineering is the sequential implementation of stages in the product development process. The treated process stage can



Sl. 2. Istočasovno uvajanje izdelka
Fig. 2. Concurrent product development

predhodna stopnja v celoti končana. Informacije o opazovani stopnji postopka se postopno gradijo in so ob koncu stopnje popolnoma zgrajene ter posredovane naslednji stopnji.

Slika 1 prikazuje načelo zaporednega uvajanja izdelka [1].

V nasprotju z zaporednim inženiringom pa istočasovni inženiring karakterizira vzporedno izvajanje stopenj postopka uvajanja izdelka. Tu se opazovana stopnja postopka lahko prične že pred končanem njej predhodne stopnje.

Informacije o opazovani stopnji postopka se postopno gradijo in se že med gradnjo posredujejo naslednji stopnji. Serija medsebojnih prenosov informacij med opazovano in naslednjo stopnjo postopka se konča v trenutku, ko je graditev informacij opazovane stopnje končana.

Slika 2 prikazuje načelo istočasovnega uvajanja izdelka [1].

Pri istočasnem uvajanju izdelka obstajajo interakcije med posameznimi stopnjami postopka uvajanja izdelka in za izvedbo vplivov je bila razvita stezno zankasta tehnologija [1]. S tipom zanke je popisan tip sodelovanja med prekrivajočimi se stopnjami postopkov. Winner [4] predlaga uporabo 3-T zank, kjer obstaja medsebojni vpliv med tremi stopnjami postopka uvajanja izdelka.

V primeru uporabe 3-T zank (slika 3) se postopek uvajanja izdelka sestoji iz pet 3-T zank.

V vsaki zanki se na podlagi zahtev in omejitev izvede sprememba vstopkov v iztopke [2], kar prikazuje diagram toka informacij v stezno-zankastem postopku uvajanja izdelka (sl. 4).

Analiza na sliki 3 in 4 prikazanega stezno-zankastega postopka uvajanja izdelkov kaže, da istočasovnega inženiringa ni brez dobro organiziranega timskega dela.

begin after the preceding stage has been completed. Data on the treated process stage are collected gradually and they are completed when the stage is finished. After which the data are forwarded to the next stage.

Figure 1 presents the principle of sequential product development [1].

The main feature of concurrent engineering is the concurrent implementation of stages in the product development process. In this case the treated stage can begin before its preceding stage has been completed.

Data on the treated process stage are collected gradually and forwarded continuously to the next stage. The series of data exchange between the treated process stage and the next process stage ends when the data on the treated stage has been completed.

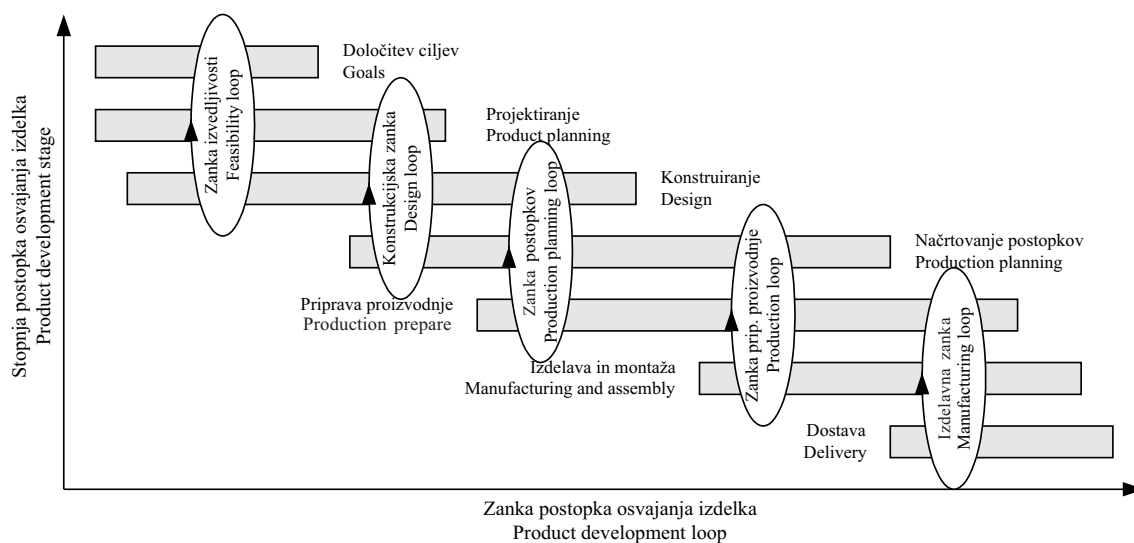
Figure 2 presents the principle of concurrent product development [1].

In concurrent product development there are interactions between the individual steps of the product-development process. Track-and-loop technology was developed for the implementation of interactions [1]. The type of loop defines the type of cooperation between overlapping process steps. Winner [4] proposes the use of 3-T loops, where interactions exist between three levels of the product-development process.

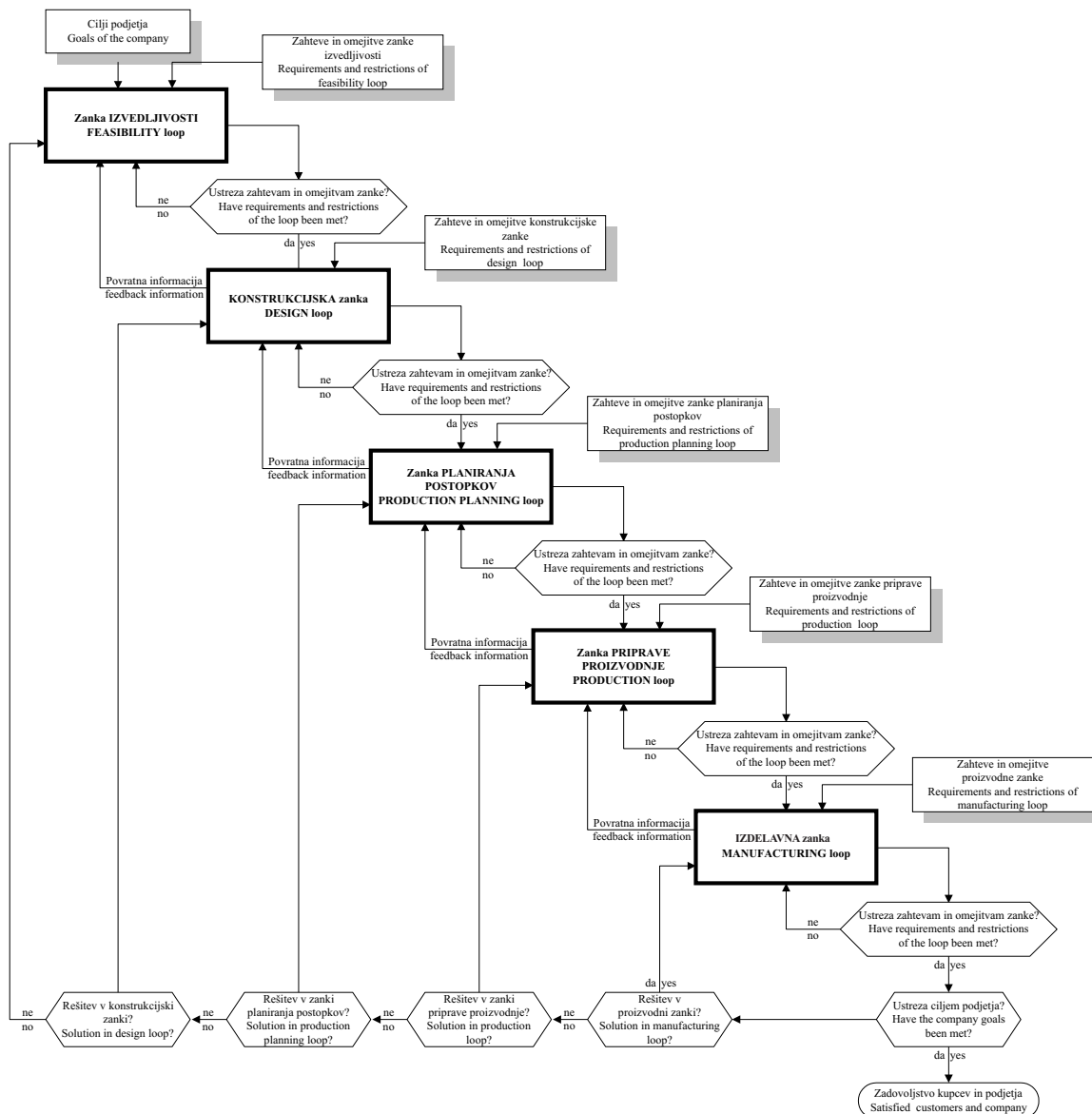
When 3-T loops are used (Figure 3) the product-development process consists of five 3-T loops.

On the basis of the requirements and the restrictions, the input is transformed into the output [2] in each loop, as shown in the diagram of information flow in the track-and-loop process of the product development (Fig. 4).

Analysis of the track-and-loop process of product development, as shown in Figures 3 and 4, reveals that concurrent engineering is not possible without well-organised team work.



Sl. 3. Stezno-zankasti postopek uvajanja izdelka
Fig. 3. Track-and-loop process in product development



Sl. 4. Diagram toka informacij v stezno zankastem postopku uvajanja izdelka
 Fig. 4. Diagram of information flow in the track-and-loop process of product development

2 ISTOČASOVNI INŽENIRING IN
 TIMSKO DELO

2 CONCURRENT ENGINEERING AND TEAM
 WORK

O timskem delu oziroma timu govorimo takrat, ko je skupina ciljno usmerjena za reševanje skupne naloge [5].

Za timsko delo je potrebno [1]:

- sodelovanje, ki mora biti prilagodljivo, nenačrtovano in stalno,
- občutek obveze za doseg ciljev,
- komuniciranje, ki pomeni izmenjavo informacij,
- sposobnost sklepanja kompromisov,
- soglasnost kljub nestrinjanju,
- usklajevanje pri izvajanju medsebojno odvisnih dejavnosti,
- stalno izboljševanje z namenom večje produktivnosti in krajših časov.

Team work refers to a situation when a team is oriented towards the solution of a joint task [5].

The requirements for team work are [1]:

- a flexible, unplanned and continuous cooperation,
- a feeling of obligation regarding the achievement of goals,
- communication in the form of exchange of information,
- an ability to make compromises,
- a consensus in spite of disagreement,
- reconciliation when carrying out interdependent activities,
- continuous improvements in order to increase productivity and reduce process times.

2.1. Oblikovanje sestave timov v velikih podjetjih

Istočasovni inženiring sloni na večdisciplinarnem timu za uvajanje izdelka (TUI - PDT) ([6] in [7]), ki mora vključevati tako strokovnjake različnih služb podjetja, kakor tudi predstavnike strateških dobaviteljev in kupcev.

Člani tima za uvajanje izdelka so komunikacijsko povezani prek osrednjega informacijskega sistema (OIS - CIS), ki jim zagotavlja podatke o postopkih, orodjih, infrastrukturi, tehnologiji in znanih izdelkih podjetja. Predstavniki strateških dobaviteljev in kupcev zaradi oddaljenosti podjetja v timu sodelujejo le navidezno in to s uporabo medmrežne tehnologije (MT - IIS), ki jim omogoča uporabo istih orodij in tehnologij, kakršne uporabljajo člani tima podjetja [7].

Sestava tima za uvajanje izdelka v velikih podjetjih se skozi stopnje postopka uvajanja izdelka spreminja. Tim v določeni fazi uvajanja izdelka sestavljajo vsebinsko zaokrožene delovne skupine, vsaka delovna skupina tima je zgrajena iz štirih osnovnih timov [1], in to:

- logičnega tima, ki poskrbi, da se celotni postopek uvajanja izdelka razbije na logične enote (opravila, naloge) in se določijo vmesni člani in povezave med enotami postopka;
- kadrovskega tima, ki skrbi za potrebne kadre tima uvajanja izdelka, njihovo izobraževanje, motiviranje in nagrajevanje;
- tehnološkega tima, ki je odgovoren za stvaritev strategije in zamisli. Tim mora biti osredotočen na čim nižje stroške in kakovost izdelka,
- navideznega tima, ki deluje v obliki računalniških modulov in oskrbuje preostale člane tima za uvajanje izdelka s potrebnimi informacijami.

Slika 5 prikazuje sestavo delovne skupine v velikem podjetju.

Namen istočasovnega inženiringa je doseči čim boljše sodelovanje med omenjenimi štirimi osnovnimi timi določene delovne skupine.

Splošno velja, da naj bodo večdisciplinarni timi za uvajanje izdelka tako sestavljeni, da se doseže:

2.1. Workgroup structure in big companies

Concurrent engineering is based on a multidisciplinary product-development team (PDT) ([6] and [7]). PDT members are experts from various departments of a company and representatives of strategic suppliers and customers.

Product development team members communicate via a central information system (CIS), which provides them with data about processes, tools, infrastructure, technology, and the existing products of the company. The representatives of strategic suppliers and customers – because they are often remote from the company – participate in the team just virtually, using the internet information system (IIS), which allows them to use the same tools and technologies as the team members in the company [7].

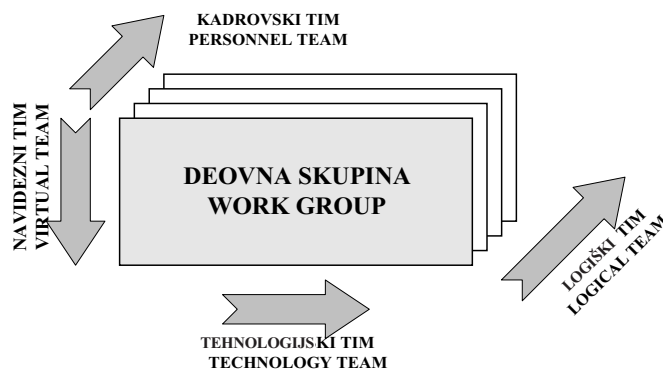
In big companies the composition of the PDT changes during the different phases of product development. The team consists of various workgroups in the various phases of product development, and each workgroup consists of four basic teams [1]:

- the logical team which ensures that the whole product-development process is split into logical units (operations, tasks) and defines the interfaces and connections between the individual process units.
- the personnel team which has to find the required personnel for the PDT, trains and motivates the personnel, and provides proper payment.
- the technology team which is responsible for creating a strategy and a concept. It has to concentrate on producing high-quality products at minimum costs.
- the virtual team which operates in the form of computer software and provides other PDT members with the data they required.

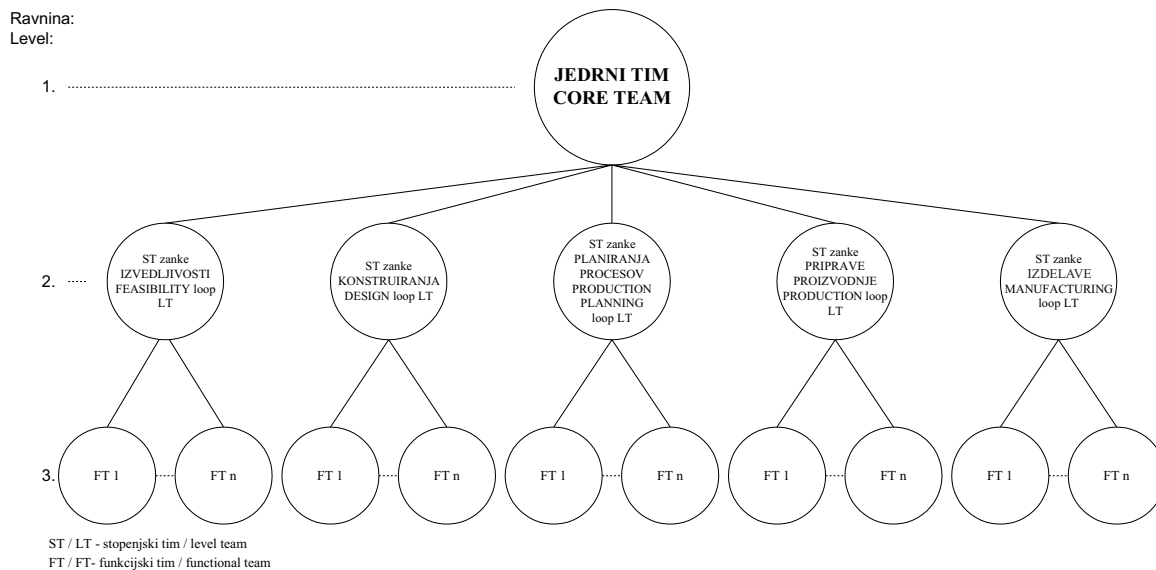
Figure 5 presents the composition of a workgroup in a big company.

The goal of concurrent engineering is to achieve the best possible cooperation among the four basic teams of a particular workgroup.

The multidisciplinary teams should generally have a structure that enables the following goals to be achieved:



Sl. 5. Delovna skupina v velikem podjetju
Fig. 5. Workgroup in a big company



Sl. 6. Triravninska sestava timov v velikem podjetju
Fig. 6. Three-level team structure in a big company

- jasna definiranost pristojnosti in odgovornosti,
- kratke odločitvene poti,
- razpoznavanje članov timov v izdelku, ki ga uvajajo.

Po pregledu objavljenih del s področja načrtovanja sestave timov v velikih podjetjih ([1] in [8]) smo ugotovili, da se za velika podjetja predlaga triravninska sestava timov uvajanja izdelka, kar prikazuje slika 6.

Jedrni tim, ki ga sestavljajo vodilni delavci podjetja in vodja opazovanega stopenjskega tima, ima nalogo, da podpira in nadzoruje projekt uvajanja izdelka.

Stopenjski tim, ki ga sestavljajo vodja stopenjskega tima in vodje v opazovani stopnji oziroma zanki udeleženih funkcijskih timov, ima nalogo, da koordinira in uglašča cilje in dejavnosti funkcijskih timov ter zagotavlja gladek prehod na naslednjo stopnjo osvajanja izdelka.

Funcijski tim, ki ga sestavljajo vodja funkcijskega tima in strokovnjaki različnih področij dela podjetja ter predstavniki dobaviteljev in kupcev, ima nalogo, da izvaja zadane naloge v terminskem, finančnem in kadrovskem oziru.

2.2 Oblikovanje sestave timov v majhnih podjetjih

Analiza rezultatov oblikovanja delovnih skupin in sestave timov v velikih podjetjih je pokazala, da predlagani osnutek načrtovanja delovnih skupin in sestave timov za majhna podjetja ni sprejemljiv (preveliko število timov delovne skupine, preveč timskih ravni).

Pri oblikovanju osnutka delovnih skupin, sestave in organizacije majhnih podjetij bo torej treba paziti na predlaganje:

- čim manjšega števila timov delovne skupine,

- a clear definition of competence and responsibility,
- short decision paths,
- an identification of team members with the product being developed.

A survey of the published works in the field of team-structure planning in big companies ([1] and [8]) has revealed that a three-level PDT structure is recommended in big companies, as presented in Figure 6.

The core team consists of the company management and the manager of the treated stage team; its task is to support and control the product-development project.

The level team consists of the level-team manager and the managers of the participating functional teams in the treated level (loop); its task is to coordinate the goals and tasks of the functional teams and to ensure a smooth transition to the next level of product development.

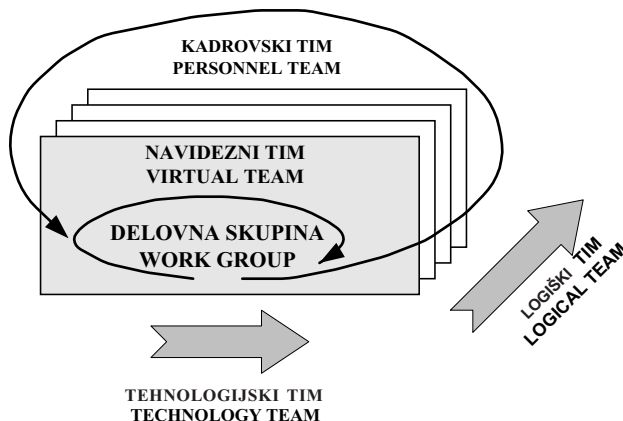
The functional team consists of the functional-team manager, experts from various fields in the company, and representatives of suppliers and customers; its task is to carry out the tasks given, taking into consideration terms, finance and personnel.

2.2. Team structure in small companies

An analysis of the results regarding the setup of workgroups and team structure in big companies has shown that the proposed concept for planning the workgroups and the structure of the teams cannot be used in small companies (there are too many teams in a workgroup and too many team levels).

When developing the workgroup concept, structure and organisation in small companies it will therefore be necessary to propose:

- as few workgroup teams as possible,



Sl. 7. Delovna skupina v majhnem podjetju
Fig. 7. Workgroup in a small company

- čim manjšega števila timskih ravni in
- ustrezne organizacije podjetja.

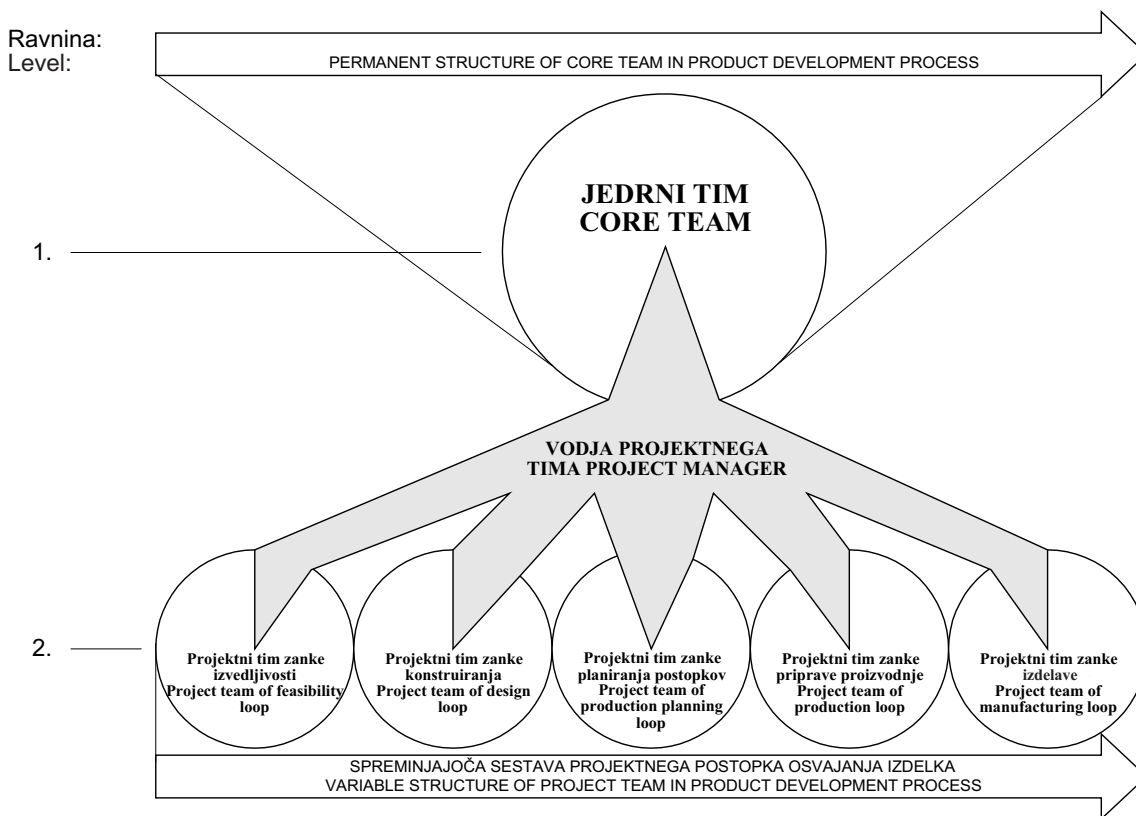
Sodelavci *Laboratorija za proizvodne sisteme* smo izdelali nekaj variant sestave delovnih skupin in sestave timov ter se po vrednotenju predlaganih variant odločili, da za majhna podjetja predlagamo:

- prehod iz štirih timov delovne skupine (kadrovske, logiške, tehnološke, navidezne tim) na dva tima (logiške in tehnološke tim),
- prehod iz triravninske na dvoravninsko sestavo timov.

- as few team levels as possible,
- an appropriate organisation of the company.

The members of the *Production Systems Laboratory* made several versions of the workgroup composition and team structure, and decided, after an evaluation of the proposed versions, that the following was advisable for small companies:

- a switch from four workgroup teams (personnel, logical, technology, and virtual team) to two workgroup teams (logical and technology team);
- a switch from a three-level to a two-level team structure.



Sl. 8. Dvoravninska sestava timov v majhnem podjetju
Fig. 8. Two-level team structure in a small company

V majhnem podjetju bo torej delovna skupina sestavljena le iz dveh osnovnih timov (slika 7) in to:

- logiškega tima, ki naj poskrbi, da se celotni postopek uvajanja izdelka razdeli na logične enote in da se določijo vmesni členi ter povezave med enotami postopka in
- tehnološkega tima, ki naj odgovarja za stvaritev strategije in zamisli.

Naloge navideznega tima bo v majhnem podjetju prevzel osrednji informacijski sistem (OIS) z ustreznimi programskimi orodji, za uporabo katerih morajo biti člani delovne skupine dobro usposobljeni, naloge kadrovskega tima pa bi izvedel vodja projektnega tima.

Za majhno podjetje se načrtuje tudi prehod iz triravninske strukture timov na dvoravninsko strukturo, ki je prikazana na sliki 8.

Jedrni tim, katerega naloga je, da podpira in nadzoruje projekt uvajanja izdelka, naj bi sestavljali:

- vodja jedrnega tima (stalni član),
- vodje strokovnih služb podjetja (stalni člani) in
- vodja projektnega tima (stalni član).

Projektni tim, katerega naloga je izvajanje zastavljenih nalog v terminskem, finančnem in kadrovskega pogledu, naj bi sestavljali:

- vodja projektnega tima (stalni član) in
- strokovnjaki različnih področij dela podjetja ter predstavniki strateških dobaviteljev in kupcev (nestalni člani).

Kot vidimo, naj bi bil projektni tim v majhnem podjetju zasnovan podobno kakor funkcijski tim v velikem podjetju, s to razliko, da je en sam in da skozi stopnje oziroma zanke uvajanja izdelka spreminja svojo sestavo.

V zanki izvedljivosti, v kateri naj bi projektni tim poskrbel za določitev zahtev kupcev, določitev ciljev ter izdelavo različnih variant zamisli izdelka, naj bi projektni tim sestavljali uslužbenci trženja, projektive, konstrukcije ter predstavniki strateških dobaviteljev in kupcev.

V zanki konstruiranja, v kateri naj bi projektni tim poskrbel za idejne rešitve izdelka, projektiranje in konstruiranje izdelka, sklopov in sestavnih delov, razvoj prototipov ter izbira najprimernejših variant z vidika tehnološkega, naj bi projektni tim sestavljali uslužbenci projektive, konstrukcije in tehnologije.

V zanki načrtovanja postopkov, v kateri naj bi projektni tim poskrbel za izbiro najprimernejših tehnoloških postopkov izdelave sestavnih delov in montaže sklopov (določitev zaporedja, opravil, izbira strojev in orodij, normirani časi), naj bi projektni tim sestavljali uslužbenci konstrukcije, tehnologije, priprave proizvodnje in predstavniki strateških dobaviteljev.

V zanki priprave proizvodnje, v kateri naj bi projektni tim poskrbel za določitev poteka dela

In a small company a workgroup therefore consists of just two basic teams (Figure 7):

- the logical team, which should ensure that the whole product-development process is divided into logical units and that the interfaces and junctions between process units are defined;
- the technology team, which should be responsible for providing the strategy and concept.

The CIS performs the role of the virtual team with proper software tools (workgroup members should be well trained to use these tools), and the project-team manager carries out the personnel-team tasks.

For a small company, the transition from a three-level to a two-level team structure is planned too, as presented in Figure 8.

The core team, whose task is to support and control the product-development project, should consist of:

- a core-team manager (permanent member),
- department managers (permanent members),
- a project-team manager (permanent member).

The project team, which carries out the tasks given, taking into consideration terms, finance and personnel, should consist of:

- a project-team manager (permanent member),
- experts from various fields in the company and representatives of strategic suppliers and customers (variable members).

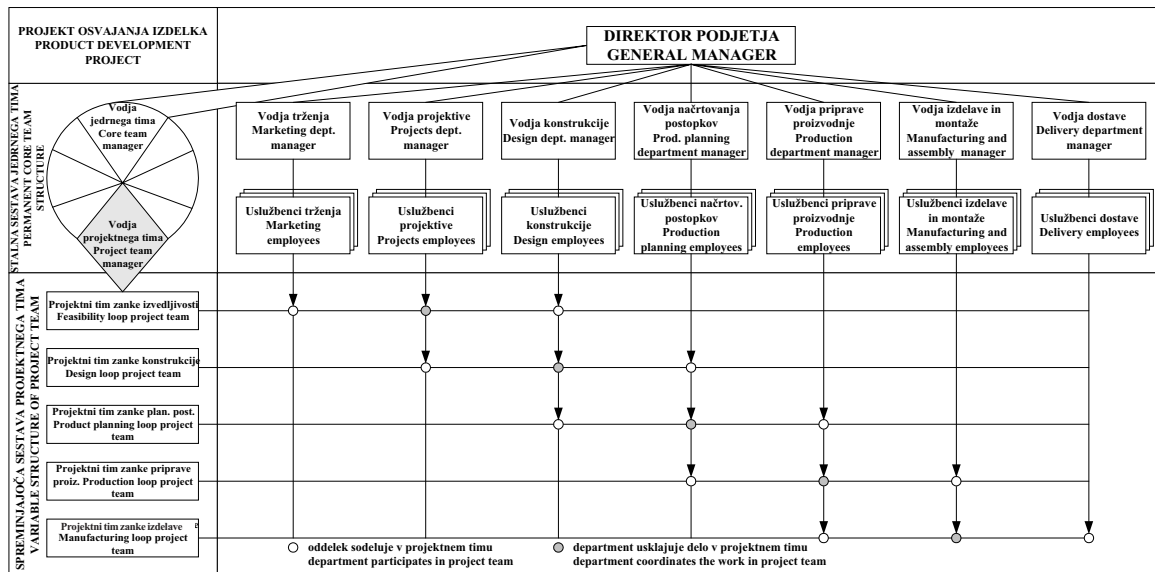
The project team in a small company is therefore designed in a similar way to a functional team in a big company, the difference being that there is just one team and its composition changes in different phases (loops) of the product-development process.

In the feasibility loop, where the project team should define customer requirements and goals, and make several versions of the product design, the project team should consist of employees from the marketing, the product-planning, and the design departments, and the representatives of strategic customers and suppliers.

In the design loop, where the project team should provide general solutions regarding the product, the product planning and the design, its parts and components, the development of prototypes, and the choice of the most suitable versions from the manufacturing point of view, the project team should consist of employees from the product-planning, the design and the production-planning departments.

In the production-planning loop, where the project team should select the best technology operations for the manufacturing of parts and the assembling of components (definition of sequence, operations, selection of machines, tools, and norm times), the project team should consist of employees from the design, the production-planning, and the production departments, and strategic suppliers' representatives.

In the production loop, where the project team should define production type (workshop, cell or



Sl. 9. Vzorna matrična organiziranost timskega dela v majhnih podjetjih
Fig. 9. Ideal matrix organisation in a small company

(delavniški, celični ali izdelčni potek dela) ter za izbiro najboljše razmestitve delovnih sredstev, naj bi projektni tim sestavljali uslužbenci tehnologije, priprave proizvodnje, izdelave in montaže ter logistike in odpreme.

V zanki proizvodnje, v kateri naj bi projektni tim poskrbel za preizkus prototipov, nabavo potrebne opreme, razmestitev delovnih sredstev, izvedbo in preizkus ničte serije, naj bi projektni tim sestavljali uslužbenci priprave proizvodnje, izdelave in montaže, kakovosti ter uslužbenci skladišč in odpreme.

Naloge stopenjskih timov velikega podjetja naj bi v majhnem podjetju prevzel vodja projektnega tima in ta naj bi poskrbel za uskladitev in ugaševanje ciljev in dejavnosti med projektnim in jedrnim timom ter za zagotavljanje nemotenega prehoda iz ene v drugo zanko uvajanja izdelka.

V velikih podjetjih so običajno člani jedrnega tima, stopenjskih in funkcijskih timov projektno organizirani. Takega načina organizacije timov si majhna podjetja ne morejo privoščiti, in to predvsem zaradi premajhnega števila uslužbencev oddelkov podjetja.

Analiza različnih organizacijskih struktur podjetij oziroma timov ([9] in [10]) je pokazala, da bi bila za majhna podjetja najprimernejša matrična organizacija članov jedrnega in projektnega tima (sl. 9).

Posamezni član jedrnega tima, razen vodje projektnega tima, del delovnega časa opravlja naloge v oddelku, kateremu pripada in bi bil za izvedbo teh nalog odgovoren direktorju podjetja, preostali del delovnega časa pa bi posvetil delu pri projektu uvajanja izdelka, za kar bi bil

product-oriented type of production) and select the optimum layout of production means, the project team should consist of employees from the production-planning department, production, manufacturing and assembly, as well as logistics and delivery.

In the manufacturing loop, where the project team should take care of prototype tests, supply of required equipment, layout of production means, manufacturing and test of the null series, the project team should consist of employees from the production department, manufacturing and assembly, quality assurance, warehouse and delivery departments.

The tasks that are performed by the stage teams in big companies should be done by the project-team manager in a small company, and he/she should coordinate and tune the goals and activities between the project team and the core team, and provide a smooth transition from one phase (loop) of the product-development process to another.

In big companies the members of the core, level and functional teams usually use a project type of organisation. This type of organisation cannot be used in small companies, as they have too few employees.

An analysis of the various organisational structures of companies and teams ([9] and [10]) has shown that in small companies a matrix organisation would be the most suitable for the core- and project-team members (Figure 9).

A member of the core team (with the exception of the project-team manager) would carry out tasks in his/her department for part of his/her working time (for this work he/she would be responsible to the general manager of the company), and the rest of his/her working time he/she would work on the product-development project (for this



Sl. 10. Mini nakladalnik »VEPER«

Fig. 10. The "VEPER" mini-loader

odgovoren vodji jedrnega tima. Tudi član projektnega tima, razen vodje projektnega tima, bi prav tako del delovnega časa opravljal naloge v oddelku, kateremu pripada in bi bil za izvedbo teh nalog odgovoren vodji oddelka, preostali del delovnega časa pa bi posvetil delu pri projektu uvajanja izdelka, za kar bi bil odgovoren vodji projektnega tima.

Vodja projektnega tima naj bi bil za čas trajanja projekta uvajanja izdelka izločen iz oddelka in naj bi bil polni delovni čas zaposlen samo pri projektu.

3 PRIMER ISTOČASOVNEGA UVAJANJA IZDELKOV V MAJHNEM PODJETJU

Majhno podjetje, ki je izdelovalec strojev za gradbeništvo, se je odločilo za istočasovno osvajanje mini nakladalnika »VEPER« (slika 10).

Podjetje zaposluje 182 delavcev in ima poleg vodstva (direktor, pomočnik direktorja) oblikovanih devet oddelkov, in to:

- komercialni oddelek, ki skrbi za trženje in prodajo, s 7 delavci,
- razvojno-projektivni oddelek, ki skrbi za razvoj in projektiranje izdelkov, s 5 delavci,
- konstrukcijski oddelek, ki skrbi za konstruiranje izdelkov, s 6 delavci,
- tehnološki oddelek, ki skrbi za načrtovanje proizvodnje in logistiko, z 12 delavci,
- nabavni oddelek, ki skrbi za nabavo in sodelavo, s 5 delavci,
- proizvodnja, ki skrbi za operativno pripravo

work he/she would be responsible to the core-team manager). A member of the project-team (except the project team manager) would carry out the tasks in his/her department for part of his/her working time (for this work he/she would be responsible to the department manager), and the rest of his/her working time he/she would work on the product-development project (for this work he/she would be responsible to the project-team manager).

The project-team manager would be excluded from his/her department throughout the duration of the product-development project and he/she would work full-time on the project.

3 AN EXAMPLE OF THE CONCURRENT DEVELOPMENT OF PRODUCTS IN A SMALL COMPANY

A small company that produces civil engineering equipment decided to concurrently develop a mini-loader called "VEPER" (Figure 10).

There are 182 employees in the company; in addition to the management (the general manager and his assistant) there are nine departments:

- the commercial department is in charge of marketing and sales (7 employees),
- the development and planning department is concerned with development and product planning (5 employees),
- the design department is concerned with product design (6 employees),
- the technology department is concerned with production and logistics (12 employees),
- the supply department is concerned with supply and cooperation (5 employees),
- the production department is concerned with op-

- proizvodnje in samo proizvodnjo, s 136 delavci,
- finančni oddelek s 3 delavci,
- oddelek kakovosti s 3 delavci in
- informacijska enota s 3 delavci.

Da bi podjetje lahko prešlo na istočasovno uvajanje mini nakladalnika, se je bilo treba najprej odločiti za sestavo timov istočasovnega uvajanja načrtovanega izdelka.

Vodstvo podjetja se je odločilo za oblikovanje dvoravninske strukture timov, torej za jedrni in projektni tim.

Da bi prišli do najprimernejše sestave jedrnega in projektnega tima, sta bili organizirani dve delavnici ustvarjalnosti [4], v katero so bili povezani direktor in pomočnik direktorja podjetja ter devet vodij oddelkov.

Rezultati izvedbe prve delavnice ustvarjalnosti so pokazali, naj jedrni tim sestavlja enajst delavcev podjetja, in to:

- direktor podjetja, ki bo vodja jedrnega tima,
- devet vodij oddelkov,
- pomočnik direktorja, ki bo vodja projektnega tima.

Vsi člani jedrnega tima bodo stalni člani, torej se sestava jedrnega tima v času uvajanja mini nakladalnika ne bo spreminjala.

Da bi določili stopnje postopka uvajanja mini nakladalnika, stopnjam pripadajoče dejavnosti ter določili odgovornosti oddelkov za izvedbo dejavnosti, je bila izvedena druga delavnica ustvarjalnosti.

Rezultate izvedbe druge delavnice ustvarjalnosti prikazuje preglednica 1.

V preglednici 1 zbrani rezultati določanja stopenj in dejavnosti ter določanja odgovornosti oddelkov za izvedbo dejavnosti in sprejeta odločitve vodstva podjetja o organizaciji 3-T zank postopka uvajanja mini nakladalnika, je predstavljala temelj za oblikovanje sestave projektnega tima v posamezni zanki uvajanja izdelka. Rezultati oblikovanja spreminjajoče sestave projektnega tima v zankah uvajanja mini nakladalnika so vidni v preglednici 2.

Vodja projektnega tima bo stalni član tima, strokovnjaki devetih oddelkov podjetja ter predstavniki oblikovalcev, dobaviteljev in kupcev pa bodo nestalni člani tima.

Iz rezultatov sestave jedrnega in projektnega tima je bilo mogoče načrtati dvoravninsko strukturo timov osvajanja mini nakladalnika (sl. 11).

V podjetju, ki izdeluje mini-nakladalnike, so dosedaj le-te uvajali na zaporedni način. Analiza rezultatov zaporednega uvajanja različnih tipov mini nakladalnikov je pokazala, da je bil povprečni čas uvajanja izdelkov štiri leta.

Današnji trg terja kratke dobavne roke izdelkov oziroma kratke čase uvajanja izdelkov.

Da bi podjetje skrajšalo čas uvajanja mini nakladalnika in s tem postalo bolj konkurenčno na trgu, se je odločilo za istočasovno uvajanje novega tipa mini nakladalnika.

- erative production preparation and manufacturing (136 employees),
- the financial department (3 employees),
- the quality assurance department (3 employees),
- the IT department (3 employees).

In order that the company could switch to concurrent development of the mini-loader it was first necessary to decide about the structure and the composition of the concurrent product development teams.

The company management decided to form a two-level team structure (core and project teams).

In order to get the best structure of both teams, two creativity workshops were organised [4], with the general manager, his assistant and nine department managers participating.

The results of the first creativity workshop showed that the core team should consist of eleven company employees:

- the general manager, who would manage the core team,
- the nine department managers,
- the assistant general manager, who would manage the project team.

All core-team members will be permanent members; the core-team composition will therefore not change within the mini-loader development time.

A second creativity workshop was organised in order to define the stages of the mini-loader development process, and their corresponding activities, as well as the responsibilities of the departments to carry out these activities.

The results of the second creativity workshop are presented in Table 1.

The results of the second creativity workshop (presented in table 1) and the selection of the project-team manager, made by the company management, allowed for the definition of the project-team structure in the individual loops of the mini-loader development, as shown in Table 2.

The project-team manager will be a permanent team member, while the experts from the nine departments of the company and the representatives of designers, suppliers and customers will be variable team members.

After the structures of the core team and the project team had been defined, it was possible to design the two-level team structure for the mini-loader development (Figure 11).

Up to now the producer of the mini-loaders has developed the products sequentially. An analysis of the results of the sequential development of various types of mini loaders in the past has shown that the average development time for a particular product was four years.

These days the market demands short delivery terms for products and short development times.

In order to reduce the mini-loader development time (and thus get a competitive advantage) the company decided to concurrently develop a new type of mini-loader.

Preglednica 1. Stopnje in dejavnosti postopka uvajanja mini nakladalnika

Table 1. Stages and activities in the mini-loader development process

Št. stopnje: Stage No:	Opis stopnje postopka osvajanja izdelka: Description of product development stage:	Načrtovane dejavnosti stopnje: Planned activities within the stage:	Oddelek: Department:		Uslužbenici: Employees:															
			Razvoj in projektiva Develop. and plan. dept.	Konstrukcija Design dept.	Razvoj Development	Projektiranje Prod. planning	Konstruiranje Design	Načrtov. proiz. Prod. proc. plan	Logistika Logistics	Nabava Supply	Sodelava Cooperation	Proizvodnja Production	Komerciala Marketing and sales dept.	Finance / Financial dept.	Kakovost / Quality dept.	Informacijska enota Informat. unit	Dostava / Delivery	Oblikovanje / Shaping		
1	Definiranje ciljev Definition of goals	Cilji Goals																		
2	Študija izvedljivosti Feasibility study	Terminski plan Term plan																		
		Finančni plan Financial plan																		
		Predkalkulacija Pre-calculation																		
3	Projektiranje Product planning	Cilji trga Goals of market																		
		Idejni osnutek izdelka First draft of the product																		
		Idejni osnutki sklopov First draft of components																		
4	Konstrukcija Design	Projektiranje Planning of the product																		
		Konstruiranje sklopov Design of components																		
		Izdelava delavniških risb Drawings of parts																		
5	Načrtovanje postopkov Process planning	Kosovnice Bills of material																		
		Materialne potrebe Material requirements																		
		Tehnološki postopki Technology routings																		
		Nadzorni postopki Control procedures																		
		Priprave Preparations																		
		Razpisana dokumentacija Documentation of orders																		
		Pregled zalog Overview of stock																		
		Oblikovanje naročil Creation of orders																		
6	Izdelava in montaža Manufacturing and assembly	Naročanje materiala Order of material																		
		Prezem in skladiščenje Acceptance and storing																		
		Proženje proizvodnje Launch of production																		
		Priprava materiala Preparation of material																		
		Izdelava priprav Manufacturing of appliances																		
		Izdelava komponent Manufact. of components																		
		Montaža Assembly																		
7	Trženje in prodaja Marketing and sales	Preizkus Check																		
		Testiranje in nadzor Test and control																		
		Ponujanje in sklenitev pogodbe Offer and contract																		
		Priprava izdelka Preparation of the product																		
		Končni nadzor Final control																		
		Dobava Supply																		

Preglednica 2. Sestava projektnega tima v posamezni zanki uvajanja mini nakladalnika
 Table 2. Project-team structure in the individual loops of the mini-loader development

Št. zanke / Loop No.	OPIS ZANKE: DESCRIPTION OF THE LOOP:	V ZANKO VKLJUČENE STOPNJE: STAGES, INCLUDED IN THE LOOP:	ČLANI PROJEKTNEGA TIMA PROJECT TEAM MEMBERS															SKUPNO ŠT. ČLANOV PROJ. TIMA / TOTAL No OF PROJECT TEAM MEM.			
			VODJA PROJ. TIMA PROJ. TEAM MGR.	RAZVOJ DEVELOPMENT	PROJEKTIRANJE PRODUCT PLAN.	KONSTRUIRANJE DESIGN	NACRT. PROJZ. PROD. PROC. PLAN	LOGISTIKA	NABAVA / SUPPLY LOGISTICS	SODELAVA COOPERATION	OPERATIVNA PRIP. OPERATIVE PREP.	PROIZVODNJA MANUFACTURING	TRZENJE MARKETING	PRODAJA / SALES	FINANCE / FINANCE	KAKOVOST QUALITY	INFORMAC. ENOTA INFORMAT. UNIT		DOSTAVA DELIVERY	OBLIKOVANJE SHAPING	
1.	ZANKA IZVEDLJIVOSTI FEASIBILITY LOOP	<ul style="list-style-type: none"> definiranje ciljev definition of goals študija izvedljivosti feasibility study projektiranje planning 																			12
2.	ZANKA PROJEKTIRANJA PROJECT LOOP	<ul style="list-style-type: none"> študija izvedljivosti feasibility study projektiranje planning konstruiranje design 																			12
3.	ZANKA KONSTRUIRANJA DESIGN LOOP	<ul style="list-style-type: none"> projektiranje planning konstruiranje design načrtovanje postopkov process planning 																			12
4.	ZANKA NAČRTOVANJA POSTOPKOV PROCESS PLANNING LOOP	<ul style="list-style-type: none"> konstruiranje design načrtovanje postopkov process planning izdelava in montaža manufact. and assembly 																			13
5.	ZANKA IZDELAVE IN MONTAŽE MANUFACTURING AND ASSEMBLY LOOP	<ul style="list-style-type: none"> načrtovanje postopkov process planning izdelava in montaža manufact. and assembly trženje in prodaja marketing and sales 																			14

Organizirana je bila delavnica ustvarjalnosti [5], v katero so bili povezani člani jedrnega tima uvajanja mini nakladalnika, in to z nalogo, da ocenijo oziroma določijo:

- čase trajanja posamezne stopnje oziroma dejavnosti postopka istočasovnega uvajanja izdelka,
- možne povezave med stopnjami oziroma dejavnostmi,
- tip in načrtovani čas prekrivanja stopenj oziroma dejavnosti.

Rezultati dela jedrnega tima uvajanja mini nakladalnika so vidni v preglednici 3.

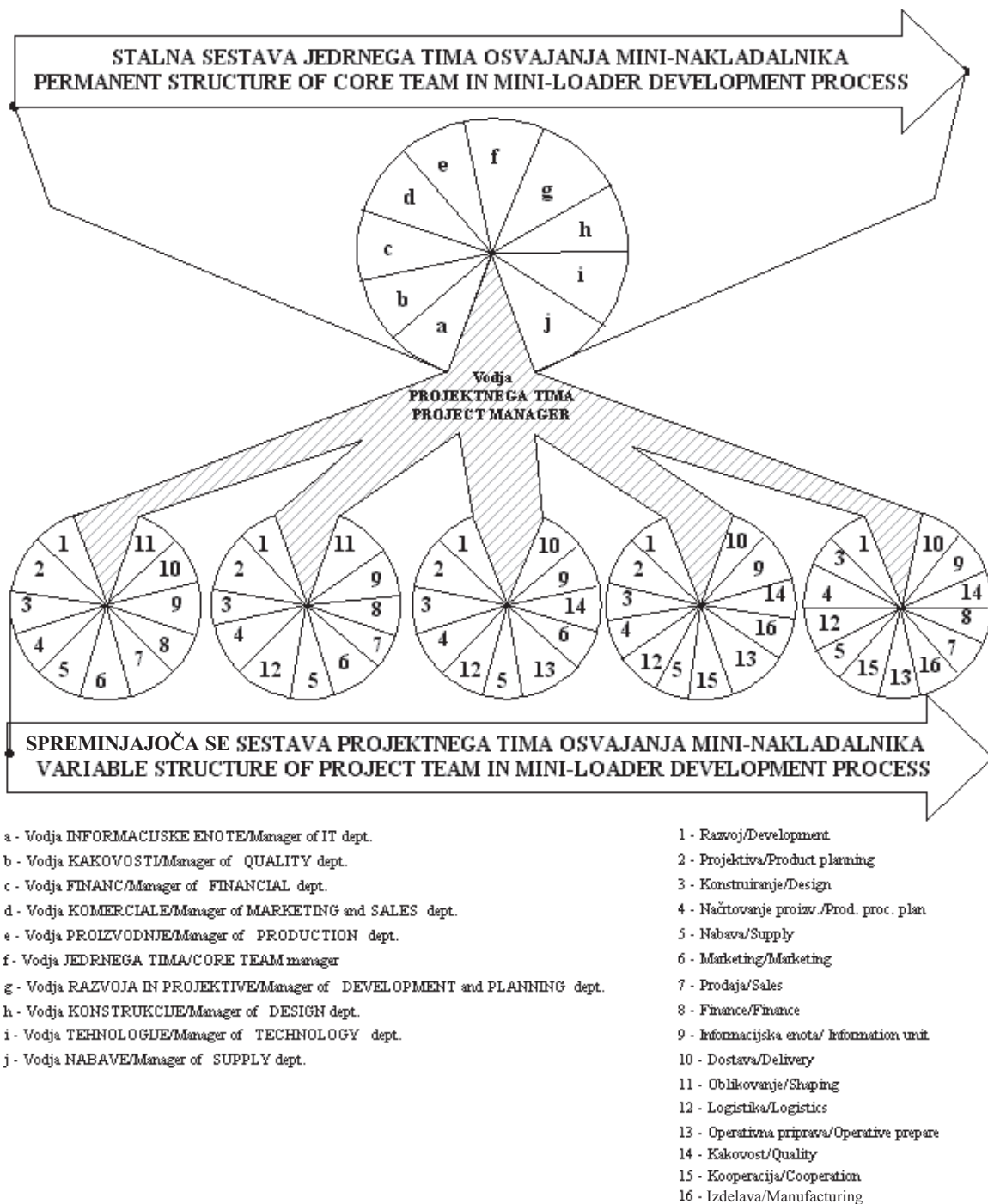
V preglednici 3 zbrani podatki o časih, povezavah in prekrivanjih stopenj oziroma dejavnosti istočasovnega uvajanja mini nakladalnika so predstavljali vhodne podatke za delo s programskim

A creativity workshop was organised [5], with all the members of the core team for the mini-loader development participating. They were asked to estimate or define the following:

- the duration of individual stages (activities) in the concurrent product development process;
- the possible connections between the stages (activities);
- the types and planned times of overlapping stages (activities).

The results of the core-team work during the mini-loader development are presented in table 3.

The data on the times, the connections and the overlapping of levels (activities) in the concurrent mini-loader development (presented in table 3) are the input data for the CA – SPJ software, which



Sl. 11. Dvoravninska sestava timov uvajanja mini nakladalnika
 Fig. 11. Two-level team structure during the mini-loader development

paketom CA – SPJ, s katerim je bil narisana gantogram izvedbe postopka istočasnega uvajanja novega tipa mini nakladalnika (sl. 12).

Analiza gantogramov sedanjega zaporednega in načrtovanega istočasovnega uvajanja novega tipa mini nakladalnika je pokazala, da bo podjetje s prehodom iz zaporednega na istočasni inženiring lahko dalo mini nakladalnik na trg, ne v štirih letih, temveč v petindvajsetih mesecih, kar bo bistveno izboljšalo konkurenčno prednost podjetja.

was used to design the Gantt chart of the development process for the new type of mini-loader (Figure 12).

An analysis of the Gantt charts of the existing sequential and the planned concurrent development of the new mini-loader shows that if the company shifts from sequential to concurrent engineering, it will be able to launch a new mini-loader in 25 months instead of 48 month as before – which would considerably improve the competitiveness of the company.

Preglednica 3. Časi trajanja dejavnosti, tipi in časi prekrivanja dejavnosti istočasovnega uvajanja mini nakladalnika

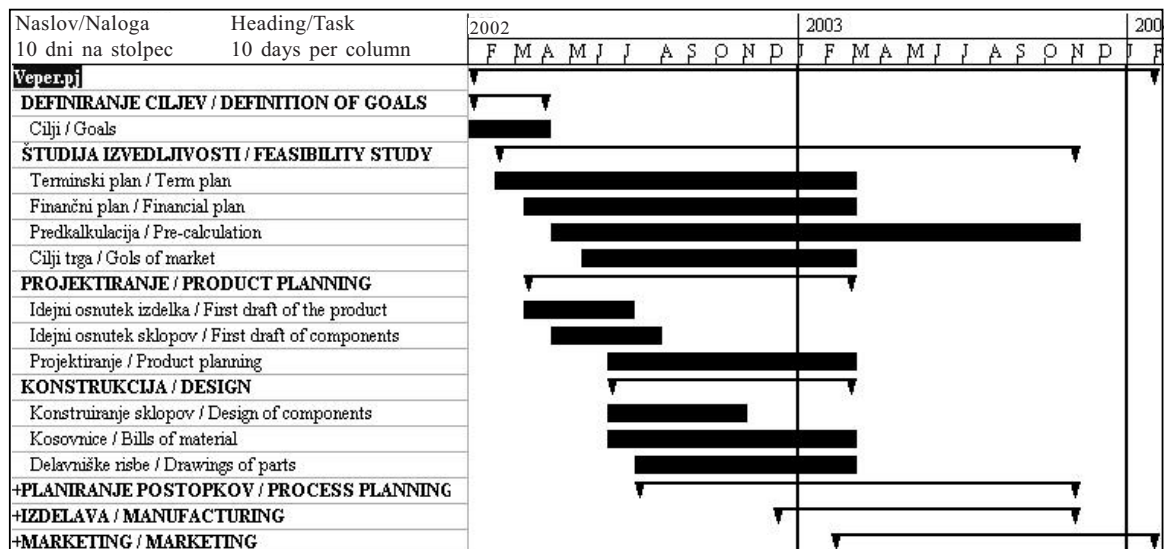
Table 3. Duration of activities, types, and times of overlapping activities the during mini-loader development

Ident stopje Stage id.	OPIS STOPNJE OSVAJANJA IZDELKA DESCRIPTION OF PRODUCT DEVELOPMENT STAGE	Načrtovane dejavnosti stopnje Planned activities within the stage	Ident dejav. Activity id.	Ocena trajanja dejav. [mes] Activity duration estimation [months]	Ugotov. predhodne dejavnosti Preceding activity iden.	Vrsta prekrivanja Type of overlap			Čas prekrivanja [mes] Time of overlap [months]
						FS	SS	FF	
1	Definiranje ciljev Definition of goals	Cilji Goals	2	3	-				
3	Študija izvedljivosti Feasibility study	Terminski plan Term plan	4	13	2		x		1
		Finančni plan Financial plan	5	12	2		x		2
		Predkalkulacija Pre-calculation	6	19	5		x		1
		Cilji trga Goals of market	7	10	4			x	0
8	Projektiranje Product planning	Idejni osnutek izdelka First draft of the product	9	4	2		x		2
		Idejni osnutki sklopov First draft of components	10	4	9		x		1
		Projektiranje Planning of the product	11	9	9		x		3
12	Konstrukcija Design	Konstruiranje sklopov Design of components	13	5	9		x		3
		Izdelava delavniških risb Drawings of parts	14	8	10		x		3
		Kosovnice Bills of material	15	9	9		x		3
16	Načrtovanje postopkov Process planning	Materialne potrebe Material requirements	17	8	9	x			0
					10		x		3
					14		x		0
					15			x	0
		Tehnološki postopki Technology routings	18	11	13		x		3
		Nadzorni postopki Control procedures	19	13	18		x		1
		Priprave Preparations	20	5	19		x		1
		Razpisana dokumentacija Documentation of orders	21	14	18		x		0
		Pregled zalog Overview of stock	22	3	19		x		0
					21		x		1
26	Izdelava in montaža Manufacturing and assembly	Proženje proizvodnje Launch of production	27	11	19			x	0
					21			x	0
					24		x		0
		Priprava materiala Preparation of material	28	6	25		x		1
					27		x		2
		Izdelava priprav Manufacturing of appliances	29	8	7		x		0
					14		x		0
					20		x		4
		Izdelava komponent Manufact. of components	30	4	24			x	3
		Montaža / Assembly	31	5	30			x	2
34	Trženje Marketing	Preizkus Check	32	4	29			x	0
					31			x	1
		Testiranje in nadzor Test and control	33	4	32			x	0
		Ponužanje in sklenitev pogodb Offer and contract	35	11	28		x		0
		Priprava izdelka Preparation of the product	36	4	32		x		0
			33		x		0		
Končni nadzor Final control	37	2	6			x	0		
			33			x	0		
Dobava Supply	38	3	35			x	1		
			37			x	2		

FS: Konec-Začetek/Finish-to-Start

SS: Začetek - Začetek/Start-to-Start

FF: Konec-Konec/Finish-to-Finish



Sl. 12. Gantogram istočasnega uvajanja novega tipa mini nakladalnika
Fig. 12. Gantt chart for the concurrent development of a new type of mini-loader

Ker je uspešnost realizacije načrtovane postopka istočasovnega uvajanja mini nakladalnika v veliki meri odvisna od uspešnosti dela spreminjajoče se sestave projektnega tima v zankah uvajanja izdelka, bo nadaljnje delo usmerjeno v podrobno organiziranje in uskladitev članov projektnega tima posamezne zanke uvajanja izdelka.

4 SKLEPI

Svetovni trg zahteva kratke roke za uvajanje izdelkov in to dejstvo sili tudi majhna slovenska podjetja k prehodu od zaporednega na istočasovno uvajanje izdelkov.

Ker je temelj istočasovnega uvajanja izdelkov timsko delo, smo v prispevku posvetili posebno pozornost oblikovanju in sestavi timov v majhnem podjetju. Raziskave so nas pripeljale do sklepa, da naj bo v majhnih podjetjih delovna skupina sestavljena, ne iz štirih, temveč le iz dveh timov (logični in tehnološki podtim), ter da je za majhna podjetja primerna dvoravninska sestava timov (stalni jedrni tim in spreminjajoči se projektni tim).

Predlagano zamisel oblikovanja timov v majhnem podjetju smo preizkusili na primeru določanja sestave timov v podjetju, ki izdeluje mini nakladalnike. Oblikovana je bila tako stalna sestava jedrnega tima kakor tudi spreminjajoča se sestava projektnega tima.

Člani jedrnega tima so določili čase trajanja načrtovanih dejavnosti, možne povezave dejavnosti ter čase prekrivanja dejavnosti. Zbrani podatki o dejavnostih postopka so omogočili delo s programskim

The success of the concurrent mini-loader development process largely depends on the effectiveness of the work on changing the composition of the project team in the product development loops, and therefore future activities will be directed towards a detailed organisation and coordination of the project-team members during individual loops of the product development.

4 CONCLUSIONS

The global market requires short product-development times, and therefore small Slovenian companies are being forced to switch from sequential to concurrent product development.

As the basic element of concurrent product development is team work, this paper pays special attention to the formation and structure of teams in a small company. Research has led us to the conclusion that a workgroup in a small company should consist of just two teams (logical and technology teams) instead of four teams, and that a two-level team structure (a permanent core team and a variable project team) is more suitable for small companies.

The proposed concept of team formation in a small company has been tested in a sample case of team composition in a company producing mini-loaders. First, the permanent core-team structure and then the variable project-team structure have been defined.

The core team members defined the duration of the planned activities, the possible interconnections of activities and the times of overlapping activities. The data obtained on the process activities allowed the use of the CA – SPJ software to make a

paketom CA – SPJ, s katerim je bila izvedena časovna analiza dejavnosti in izrisan gantogram istočasnega uvajanja novega tipa mini nakladalnika.

time analysis of the activities and to draw the Gantt chart of concurrent development of a new type of mini-loader.

ZAHVALA

Avtorji se zahvaljujejo podjetju SCT Strojegradnja, Ljubljana in g. Jožetu Kastelicu za pomoč in sodelovanje pri tem raziskovalnem projektu.

ACKNOWLEDGEMENTS

The authors wish to thank the SCT Strojegradnja Ljubljana company and Mr. Jože Kastelic for their help and cooperation during this research project.

5 LITERATURA

5 REFERENCES

- [1] Prasad, B. (1996) Concurrent engineering fundamentals, Volume I. Integrated Product and Process Organization, New Jersey. *Prentice Hall PTR*, 216-276.
- [2] Duhovnik, J., M. Starbek, S.N. Dwivedi, B. Prasad (2001) Development of new products in small companies, Concurrent Engineering: Research and Applications, Volume 9, *Sage Publications*, 191-210.
- [3] Ehrlenspiel, K. (1995) Integrierte Produktentwicklung, *Carl Hanser Verlag*, München Wien, 144-180.
- [4] Winner, R. I. (1988) The Role of concurrent engineering in weapons system acquisition, *IDA Report R-338*, Alexandrija, VA: Institut for Defence Analysis
- [5] Schlicksupp, H. (1977) Kreative Ideenfindung in der Unternehmung, *Watter de Gruyter*, Berlin New York, 152-165.
- [6] Starbek, M., J. Kušar, P. Jenko (1988) The influence of concurrent engineering on launch-to-finish time, *The 31th CIRP International Seminar on Manufacturing System*, Berkeley, USA.
- [7] Starbek, M., J. Kušar, P. Jenko (1999) Building a concurrent engineering suport information system, The 32nd CIRP International Seminar on Manufacturing System, *Division PMA*, Katholieke Universitet Leuven, Belgium.
- [8] Bullinger, H.J., F. Wagner, J. Warschat (1994) Ein Ansatz zur Zulieferer-Integration in der Produktentwicklung, Datenverarbeitung in der Konstruktion 1994, *VDI-Verlag*, Düsseldorf.
- [9] Bullinger, H.J., H.J. Warnecke (1996) Neue Organisationsformen in Unternehmen, *Springer-Verlag*, Berlin, Heidelberg, New York.
- [10] Draft, R.L. (1998) Organizational theory and design, *Cincinnati South Western College Publ.*

Naslov avtorjev: prof.dr. Marko Starbek
 prof.dr. Janez Grum
 prof.dr. Jože Duhovnik
 dr. Janez Kušar
 Univerza v Ljubljani
 Fakulteta za strojništvo
 Aškerčeva 6
 1000 Ljubljana
 marko.starbek@fs.uni-lj.si
 janez.grum@fs.uni-lj.si
 joze.duhovnik@fs.uni-lj.si
 janez.kusar@fs.uni-lj.si

Authors' Address: Prof.Dr. Marko Starbek
 Prof.Dr. Janez Grum
 Prof.Dr. Jože Duhovnik
 Dr. Janez Kušar
 University of Ljubljana
 Faculty of Mechanical Eng.
 Aškerčeva 6
 1000 Ljubljana, Slovenia
 marko.starbek@fs.uni-lj.si
 janez.grum@fs.uni-lj.si
 joze.duhovnik@fs.uni-lj.si
 janez.kusar@fs.uni-lj.si

Prejeto:
 Received: 24.6.2002

Sprejeto:
 Accepted: 29.5.2003

Odprt za diskusijo: 1 leto
 Open for discussion: 1 year