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Izkušnje pri uvajanju računalniško podprtega konstruiranja in smeri razvoja v ADRIA Mobil d.o.o.

Experiences of CAD Implementation and Trends in Development at ADRIA Mobil Ltd.

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Adria-Mobil d.o.o. je znano slovensko podjetje počitniških prikolic in avtodomov, ki se je za uvajanje dvodimenzionalnega sistema računalniško podprtega konstruiranja (RPK - CAD) odločilo že pred leti. V članku je opisan način uvajanja, pa tudi izkušnje, pridobljene ob uvajanju in uporabi sistema RPK. Danes je podjetje prisiljeno v menjavo sistema RPK in se srečuje z nekaterimi dilemami, ki so posledica hitrega razvoja sistemov informacijske tehnologije (IT) pa tudi pridobljenih spoznanj. Pred nadaljnjimi investicijami v napredne tehnologije mora biti določena strategija podjetja na tem področju.

(Ključne besede: uvajanje CAD, resničnost navidezna, prototipi navidezni, razvoj)

Adria-Mobil Ltd. is a well-known Slovenian caravan and motorhomes producer, which introduced a 2D CAD system some years ago. In the article, the implementation, development and experiences since are system's introduction are described. The company is about to change its CAD system and is faced with certain dilemmas due to rapid IT-systems development. A company strategy is required before making any major advanced-technology-related investment decisions.

(Keywords: CAD implementation, virtual reality, virtual prototyping, development)

0 UVOD

ADRIA Mobil d.o.o. je znan kot eden vodilnih evropskih izdelovalcev počitniških prikolic in avtodomov in ta položaj ima podjetje namen obdržati tudi v prihodnosti. Že od samih začetkov, ki segajo v leto 1965, sodi Adria med tradicionalno zanesljive izdelovalce prikolic. Velik tržni delež na najzahtevnejših in najbogatejših evropskih trgih je posledica zelo kakovostnih proizvodov ter široko razvejane prodajne mreže po vsej Evropi.

Podjetje izdeluje tri osnovne serije prikolic, ki se razlikujejo predvsem po dolžini in seveda opremljenosti, približno štirideset tlorisnih razporeditev ter tri izvedbe avtodomov. Podjetje je usmerjeno večinoma v izvoz v zahodnoevropske države, pojavlja pa se tudi na tržiščih srednje Evrope in Japonske. Vsak trg ima svoje specifične zahteve, tako glede tehničnih predpisov kakor okusa in potreb kupcev, kar seveda še povečuje število izvedb. Glede na velikost proizvodnje (pribl. 6000 enot) in števila zaposlenih (342) spada med srednje velika podjetja v svoji veji.

0 INTRODUCTION

ADRIA Mobil Ltd. is well known as one of the leading European producers of caravans and motorhomes, and the company's intention is to preserve this status. Since the beginning of caravan production in 1965, Adria has been one of the most important traditional producers of caravans. A large market share in the most lucrative and demanding of European markets is the result of high-quality products and a European-wide sales network.

The company produces the three basic types of caravan, which differ mainly in terms of length, equipment and layout, as well as three varieties of motorhome. The company is mainly focused on exporting to Western European countries but is also present in the markets of Central Europe and Japan. Every market has its own technical regulations, different customer preferences and needs; and this increases the number of different models which are produced. Considering the level of production (ca. 6000 units) and the number of employees (342), the company is classed as a medium-sized enterprise in this area.

Sl. 1. *Počitniška prikolica Adrie nekoč in danes*
Fig. 1. *Adria caravans from yesterday and today*

Konkurenca na tržišču je izredno huda, zato je nujno potrebno sprotno izboljševanje kakovosti in osveževanje proizvodov, tako zunanjosti kakor notranjosti, ter zmanjševanje časa proizvodnega kroga. Precej značilen je tudi proizvodni krog, saj se dokumentacija in prototipi izdelajo do predstavitve na specializiranih sejmih in nato glede na odzive spremenijo in dopolnijo. Enako pomemben je sklop poprodajnih dejavnosti, ki močno vpliva na nadaljnje smernice razvoja in zagotavljanje kakovosti. Letna proizvodnja dokumentacijskih risb je okrog 6000.

1 UVAJANJE IN RAZVOJ

1.1 Opis uvajanja RPK

V času, tj. v osemdesetih letih, ko se je podjetje odločalo za uvajanje sistema RPK, je že uporabljalo standardno zasnovan mrežni poslovno informacijski sistem ULTRA na platformi VAX. Sistem za obvladovanje kosovnic in načrtovanja potreb pomaterialih (NPM - MRP) je bil del poslovnega informacijskega sistema. Pred odločitvijo o izboru programske in aparaturne opreme je bilo izvedeno izobraževanje o temeljnih znanjih s področja računalništva, baz podatkov in sistemov RPK. Odločitev o nabavi sistema za RPK je bila sprejeta po testiranjih več programskih paketov. Izbran je bil DIAD, produkt CADCentre iz Cambridga. Odločitvi so botrovali naslednji dejavniki:

- zaradi razmeroma preproste geometrijske oblike prikolic je bil potreben le 2D paket (risanje), pa tudi 3D paketi še niso bili na nivoju polne industrijske uporabe;
- delovanje na platformi VAX, kar je obljubljalo sorazmerno preprosto povezljivost s poslovnim informacijskim sistemom;
- paket je sorazmerno preprost za uporabo, z zelo kakovostnimi rešitvami uporabe knjižnic standardnih elementov, pa tudi ustvarjanja lastnih knjižnic objektov;
- zelo zmogljiv makro jezik za parametrizacijo objektov in variantno konstruiranje,
- tehnična podpora in izobraževanje ter odprt programski paket, ki ga je sorazmerno preprosto prilagajati željam uporabnika;
- cena.

Competition in the market is very tight and so companies are forced to continuously improve the quality of their products, very often by adding new features or updating the interior design. The production cycle is predictable, prototypes are presented at the specialised fairs and feedback is used for improvement in the final documentation preparation. Equally important are the after-sales activities, which have a great impact on quality improvement and further development guidelines. The annual number of drawings is approximately 6000.

1 CAD IMPLEMENTATION AND DEVELOPMENT

1.1 Description of the CAD implementation

The company invested in a CAD/CAM system in the early 1980s and has reached an enviable position in the design process. At the time of the CAD/CAM installation the company was already using a classically framed information system ULTRA, running on a VAX platform. The maintenance of the parts lists and the MRP (Material Requirements Planning) were performed with this system. Education with respect to computer usage, data bases and CAD systems was undertaken prior to the CAD system's implementation. The decision to purchase the DIAD CAD system from the CADCentre Cambridge, was made after extensive testing of all the available major software packages. This system was chosen because of:

- our requirement for only a 2D system, caravans have a comparatively simply geometry and 3D systems were still in their infancy;
- its ability to work on a common hardware platform, which promised relatively easy connection to the existing parts lists and MRP database;
- the systems ease of use, with powerful solutions for using libraries of standard elements and creating our own libraries of objects;
- the powerful macro language for an object parameterisation and variant design;
- good technical support and education as well as an open, and for special requests, easily adapted program system;
- price.

V začetni fazi uvajanja sistema je bila oblikovana skupina konstrukterjev, ki se je aktivno spoznala s paketom in delom z njim. V tem času je že potekala nabava programske in aparaturne opreme. Prilagoditev na delo s RPK z običajnih ročnih metod pomeni veliko spremembo pri obvladovanju risb. Sprememba sistema je na začetku vplivala na zmanjšanje produktivnosti, kar je neizbežno in je znan podatek iz raziskav. Trajanje zmanjšanja produktivnosti je zelo odvisno od kakovosti in količine usposabljanja na sistemu. Grafi na sliki 2 prikazujejo rezultate neodvisnih raziskav Richarda Sheperda o odvisnosti usposabljanja in metod usposabljanja na produktivnost konstrukcijskih oddelkov, pa tudi razmerje med produktivnostjo in uporabo tehnologij RPK. Raziskava je bila narejena v podjetjih v Veliki Britaniji in predstavljena na MCAD'95. Zaradi dobrega usposabljanja in velike motivacije je bil ta čas v Adrii zelo kratek (raven s RPK nepodprte produktivnosti konstrukcijskega oddelka je bila dosežena že v dveh mesecih). Izbira prvega projekta, ki je zelo pomembna, je bila zelo hrabra. Izbran je bil projekt konstruiranja prikolice za novo sezono, katerega terminski načrt je bil že določen. Sprva je bilo delo zelo zamudno, saj je bilo treba hkrati pripravljati še knjižnice v podjetju standardiziranih objektov in pripravljati nove metode konstruiranja ter sistem shranjevanja dokumentacije. Kljub dodatnemu delu je bila dokumentacija pripravljena pred časovnim rokom, načrtovanim za običajno konstruiranje.

Za samo uvajanje je pomembno, da so določeni uspehi vidni zelo hitro, kar bistveno pripomore k motiviranosti kadra. S tem delom je konstrukcijski oddelek podjetja uspešno končal ta del uvajanja in dokazal, da je bila naložba upravičena. Vsi načrti so bili izdelani na novo.

V času končevanja projekta se je izvajalo dodatno izobraževanje in širjenje kroga uporabnikov. Glavni konstrukter je kot najboljši uporabnik nadaljeval delo z izboljšavo metod in uporabo knjižnic in je pri izobraževanju sodeloval le občasno s seznanjanjem uporabnikov z najnovejšimi metodami. Po tej fazi je podjetje razširilo uporabo paketa na celoten konstrukcijski oddelek. Hkrati je začelo tudi sodelovati s tehnološkim oddelkom za čimbolj primerno uporabo geometrijskih podatkov paketa RPK v tehnologiji. Uporaba makro programiranja je zelo močno orodje, ki omogoča parameterizacijo objekta in sprotno določanje teh parametrov. Zgradili smo splet makro programov za popolnjevanje kosovnic na risbi, izdelavo prerezov, spreminjanje geometrijske oblike prikolic, pozicioniranje standardnih delov v sklop, kot so okna in vrata, kuhinjski ali kopalniški blok ipd. Z uporabo makro programov se je produktivnost konstrukterjev izredno zvečala in kar je še bolj pomembno, pogostost napak se je zmanjšala.

Podobni makro programi so bili narejeni tudi za programiranje številsko krmiljenih strojev (ŠKS - CNC). Posebnosti paketa so bile uporabljene za izdelavo številsko krmiljenega programa za rezkanje stene prikolice. Ti

In the initial phase of the implementation a group of designers was formed that were on active training with the system. At that time the software and hardware were purchased. Adapting to 2D CAD from manual methods was a major change in the mechanics of working with drawings. As is often reported, the change to a new system inevitably produces an initial drop in productivity, the length of which depends on the amount and level of the training given. Figure 2 shows results from a UK survey by Richard Shepherd, a researcher, presented at MCAD'95 which show the impact of training and training methods on design productivity as well as the productivity growth, depending on the use of CAD technology. Because of the well-trained and highly motivated staff the effect of the initial productivity drop at Adria was very low (the pre-implementation level of productivity was recovered within 2 months). Choosing the first CAD project was also a crucial decision. It was a very brave decision to start on a project with a fixed deadline. During the work the standard elements were produced for libraries as well as novel procedures and design methods. In spite of this the project was successfully finished before the deadline.

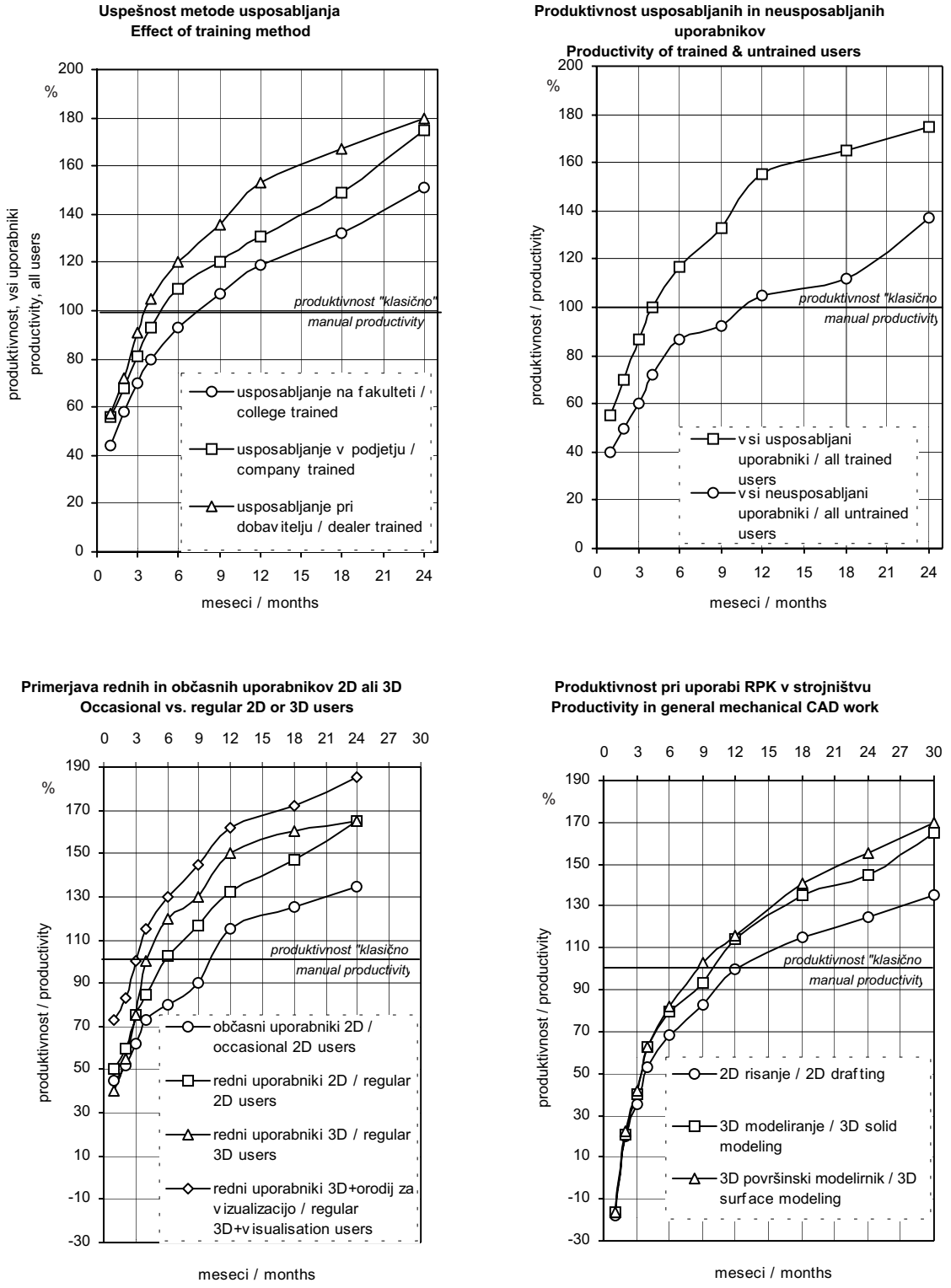
In terms of confidence in the system it was very important that encouraging results were achieved quickly. It should also be pointed out that no blueprints were scanned or included in any other way, everything was designed from scratch.

When the first project was finished the in-house training for the other designers was introduced. During this time the best user-designer was pushing the development of the methods and libraries further and occasionally providing rapid and more relevant answers at the training. The new technology was expanded to the whole design department. Later, as all designers worked on projects with the CAD technology the system was extended to support the manufacturing process with the geometry data. Macro programming is a very powerful tool where human interaction with decisions and input parameters is available. We built a set of macro programs to fill the parts list on drawings, to mark sections; to extend or shorten the caravan walls, positioning the assembly of parts such as windows, doors, cooking or shower blocks; etc. With the introduction of macro programs the productivity of the users increased significantly, and even more importantly, common mistakes were avoided.

Macro programs for design were used and upgraded for NC machine coding. Their ability to recognise geometry was used for a macro program that writes the NC code for a CNC machine used for

elementi so precej veliki, vendar geometrijsko nezahtevni (čeprav so postale določene krivulje bistveno bolj gladke). Makroprogrami za krmiljenje številsko krmiljenega stroja so pospešili delo tudi do desetkrat.

milling the caravan wall. As the elements are quite large but geometrically not very complex (although some curves become much smoother) the code was produced up to ten-times faster than before.



Sl. 2. *Odvisnost produktivnosti od usposabljanja uporabnikov in uporabe sistemov za RPK (R. Shepherd)*
Fig. 2. *Productivity related to user training and the CAD systems used (R. Shepherd)*

1.2 Prednosti in pomanjkljivosti sistema

Uvedba sistema za RPK je prinesla številne prednosti, ki se ugodno kažejo na stroških, rokih in kakovosti. Sistem zadovoljivo pokriva potrebe konstrukcije. Dosegli smo bistveno povečanje kakovosti konstrukcijske dokumentacije ob zmanjšanju potrebnega časa za njeno izdelavo. Povečala se je produktivnost konstrukterjev, pa tudi njihova motiviranost. Dosegli smo hitrejše in lažje uvajanje sprememb, ki so posledica nenehnih zahtev naročnikov in samih izboljšav. Izboljšala se je funkcionalna analiza v času razvoja, zaradi česar so se zmanjšala potrebna testiranja prototipov. Vse to je vplivalo na večje prilagajanje željam in potrebam kupcev. Uvedba sistema za RPK je imela velik vpliv na povečanje standardiziranosti konstrukcij, kar je vplivalo na zmanjšanje porabe materialov ter na lažjo in cenejšo proizvodnjo. Posebni optimizacijski algoritmi, ki so vgrajeni v makro programe za izdelavo številsko krmiljenih programov, so prispevali k zmanjšanju izdelovalnih časov.

Na drugi strani so očitne tudi pomanjkljivosti. Poglavitni problem pomeni nepovezanost in neodvisnost sistemov za RPK in NPM, čeprav delujeta na enaki osnovi. Informacij med različnimi podatkovnimi skladišči ni mogoče povezovati, niti jih ni mogoče med skladišči prenašati. Izdelava ustreznih vmesnikov je v večini primerov neizvedljiva. Zmožnosti sistema za RPK so bile dosežene po približno petih letih uporabe, ko so bile izrabljene vse možnosti tehnik konstruiranja in prenašanja podatkov v tehnologijo. V tem času se je pokazala nujnost po dograditvi ali zamenjavi sistema. Tehnologija sama ni zadovoljivo informacijsko pokrita. Izrisane risbe pomenijo začetek tehnološkega postopka, pri katerem so tehnološki podatki dodani v tekstovni obliki. Te podatke je skoraj nemogoče uporabiti v drugih primerih. Programirani so makro programi za zbiranje elementov iz enakega materiala, ki pa ne morejo dodajati imen ali kataloških številk. Podsistem za NPM je del poslovnega informacijskega sistema. V njem so podatki o materialih, standardih, zbirnikih časov, cenah in sestavnice vseh prikolic. Med sistemom za RPK in sistemom za NPM oz. med geometrijskim modelom prikolice in med sestavnico prikolice ni povezave. To je največja pomanjkljivost sedanjega informacijskega sistema. Vse sestavnice je treba ročno vnašati, v primeru sprememb na prikolicah je treba skrbeti za takojšnje popravljanje. Zaradi takega načina dela je določevanje porabljenega dela in izdelovalnih časov v veliki meri ročno. Napake pri delu so pogoste. Ocenjujemo, da je porabljen čas za izdelavo sestavnic tako velik kakor za samo konstruiranje, kar je nesorazmerno veliko. Z zmanjšanjem tega časa in z odpravo napak, bi podjetje veliko pridobilo.

Druge službe, npr.: trženje, kakovost, servis, prodaja, nabava, vodstvo itn., so si zgradile informacijske podsisteme, ki niso povezani niti s sistemom za RPK niti s poslovnim sistemom. Katalogi,

1.2 The benefits and drawbacks of the system

The introduction of the CAD system brought a number of benefits to the engineering design department that are reflected in cost savings, quality of design and time reduction. The system is able to provede the designers with what they need and significantly increase the productivity of these designers. We achieved a faster and an easier incorporation of changes or re-design resulting from different customer requirements. The consistency of the drawings improves both prototype production and testing. All of this allows us to adapt to customer wishes and requirements. The CAD-system implementation had big influence on the standardisation of the elements used, reduced material consumption, and resulted in an easier and cheaper manufacturing process. The special macro programs, which included an optimisation algorithm for the NC machines, reduced the coding time.

There are, however, some drawbacks. The main problem was the unconnected, independent information systems of CAD and MRP; even though they were on the same platform. As a consequence there was a lack of information, feedback, data sharing and manual data transfer. The different systems use a different code record so interfacing is almost impossible. The possibilities of this CAD system were exhausted after approximately five years, after this time nothing can be done to improve the CAD system any further. The need for a new system was evident. The manufacturing part of the production process had not had enough IT support. The plotted drawings were the starting point, where some technological data were added in text form. This data could not be used in other applications. Macro programs were created for collecting all the parts made from the same material, but they were not able to add part names or catalogue numbers. The MRP system is where the data on materials, standards, production-time calculations, parts prices and production costs, and parts lists of all the caravans are maintained. We had no direct connection between the CAD system and the MRP system or between the geometry model and the parts list of the caravan. The parts list from the drawing was manually transferred to the MRP system. Avoiding mistakes was almost impossible, especially when some changes were needed. It is a very time consuming job and the time to design the caravan is almost equal to the time to rewrite the data to the MRP system. Simply by eliminating this data-transfer time and avoiding the errors in data entry the company will benefit enormously.

Other services, such as marketing, quality control, sales management, administration, etc. built their own information systems that were not integrated with the CAD system nor with the company information system. Brochures, catalogues, service

prospekti, servisne knjižice, različne sheme, dokumentacija za službo kakovosti, dokumentacija za dobavitelje in poslovne partnerje ter preostala dokumentacija, nastajajo na neodvisni sistemih.

2 RPK V PRIHODNOSTI

Pomembnost tridimenzionalnega modeliranja dandanes v industriji ni več vprašljiva. Inženirji delajo s 3D modelirniki rutinsko pri razvoju in preverjanju rešitev. Ob doseženi stopnji razvoja 3D sistemov so tudi drugi udeleženci proizvodnega procesa spoznali in začeli ceniti možnosti te tehnologije za povezavo in načrtovanje.

3D modeliranje je v konstruiranju že dodobra uveljavljeno, novejše usmeritve pa nakazujejo vpeljevanje računalniške podpore v zgodnje faze konstruiranja, predvsem v fazo izdelave osnutka. To je faza konstrukcijskega procesa, v kateri je sprejetih večina odločitev o izdelku, ki bistveno vplivajo na njegovo funkcionalnost, lastnosti in stroške izdelave. To je tudi faza, ki je računalniško najmanj podprta in hkrati faza največjih inovativnosti pri razvoju izdelkov. Vse podatke, dobljene pri procesu konstruiranja bi bilo treba integrirati z naslednjimi fazami, kakor je nakazano v [1] in [2]. Še več, uporaba najnovejših večpredstavnostnih interaktivnih tehnologij za predstavitev in pripravljanje navideznih okolij omogoča izboljšanje in pospešitev procesa preverjanja in testiranja izdelka [3]. Tehnike navideznih prototipov (TNP - VP) med drugim omogočajo predstavitev kalkulacij, simuliranj obnašanja izdelkov pri uporabi, teste ergonomičnosti, preverjanje in testiranje možnosti montaže in izdelave izdelkov pa tudi potrditev lastnosti izdelka. TNP je pravzaprav uporaba dinamičnega 3D modeliranja za natančno predstavitev in razvoj potencialnih konstrukcijskih rešitev. Modeli TNP natančno predstavljajo geometrijsko obliko in kinematične lastnosti nekega objekta v resničnem svetu, pa jih kljub temu ni treba fizično izdelati. Naslednja zanimiva zamisel je digitalni model (DM - DMU) [4], ki temelji na integraciji vseh podatkov o izdelku v njegovi celotni dobi trajanja, od zasnove skozi prototip, izdelavo, uporabo do recikliranja v enotnem podatkovnem skladišču.

Zmanjševanje časa in sredstev za razvoj novega izdelka sta dandanes v industriji nujna pogoja za konkurenčnost in zmanjševanje stroškov izdelave. Prav s tem namenom se izdelujejo računalniški modeli v sistemih za RPK za predstavitev različnih idejnih rešitev. Pred procesom izdelave je treba za vsak izdelek preveriti, ali izpolnjuje vse podane funkcionalne zahteve in ali ga je mogoče izdelati. To je lahko zelo preprosto ali pa terja veliko časa in sredstev, kar je seveda odvisno od izdelka. Kot alternativa izdelave fizičnega prototipa in testiranja na njem se vse več uporabljajo računalniške simulacije, ki ponazarjajo

books, schemes, quality-control documentation, documentation for partners and co-operation companies and all other documentation is maintained manually or with separate systems.

2 CAD IN THE FUTURE

There is no question that 3D solid models have became critical to manufacturing industry. Engineers routinely rely on them to develop, verify and communicate their designs. And as 3D technology has matured, people outside of the engineering domain have begun to appreciate the value of the technology for communication and planning purposes.

As 3D modelling is well established in the design process, the trend is now to introduce computer support to earlier phases of the design process such as conceptual design. In these phases, important decisions about the product, that have a great influence on functionality, properties and the costs of a product are taken. All the data relating to a product which is collected at these stages of the product life cycle should be integrated with the downstream application of the product development process as in [1] and [2]. Moreover, using the new multimedia interactive and real-time visualisation techniques, virtual environments are used for improving and speeding-up the process of verifying and testing the product [3]. Virtual Prototyping (VP), among others incorporates the visualisation of calculations, simulations of product behaviour and ergonomic tests, prediction and checking of production and assembly possibilities and the validation of product properties. VP is the use of dynamic 3D graphic models to accurately visualise and evaluate potential designs for physical devices or manipulators. The VP models precisely represent the geometry and kinematics associated with an actual physical (real-world) model, without the need to physically fabricate the item. Another interesting concept is a digital mock-up (DMU) [4], integrating all the data about a product collected during the product life cycle, beginning from the early design phases, through prototyping, on to production, maintenance, and even recycling.

Because of competitionand cost reduction, the time and resources needed for developing a new product are nowadays very important in industry. For this reason, computer models of an engineer's ideas about design objects are created and outlined in CAD systems. Before the manufacturing process a design object should be verified in two ways: first, that all construction constrains are obeyed, and second, that the object is manufacturable. Whether this is an easy or time consuming and expensive process depends on the object. As an alternative to physical prototyping and testing, computer techniques are increasingly used to present and test the functionality

funkcionalnost izdelka. Stroški izdelave navideznega prototipa so v veliki večini primerov bistveno manjši od testiranja fizičnih prototipov.

Navidezno okolje (NO - VE) je v bistvu projekcija resničnega sveta. NO ne obstaja, vendar deluje dovolj resnično za inženirsko prakso, ki je večinoma manj zahtevna, kakor so aplikacije v svetu zabave, kjer se ta tehnologija uporablja že dalj časa. Največja posebnost navidezna resničnost (NR - VR) je občutek človeka, da deluje v navideznem svetu, ki je videti dovolj realistično. NR je kompozicija 3D računalniške grafike, orodij za simuliranje in tehnologije večpredstavnosti, ki omogočajo interaktivno v realnem času vodenje in delovanje znotraj računalniško nastalega okolja.

Obogatena resničnost (OR - AR) je mešana oblika, pri kateri so v realno okolje dodani računalniško generirani objekti. Sliki realnega sveta so dodani znaki, navodila ali računalniško generirane slike. Uporabe OR morajo imeti enake lastnosti kakor NR, prostorsko in dinamično predstavljanje objektov in interaktivnost v realnem času, dodana pa je možnost kombiniranja realnega in navideznega sveta [3]. Če NR omogoča zmanjševanje sredstev pri razvoju izdelkov in omogoča zgodnje odkrivanje napak, omogoča OR kombiniranje realnih in računalniško generiranih objektov, kar je sploh velika prednost, kadar nekateri objekti že obstajajo.

Nobena druga tehnologija dandanes ne omogoča uporabniku bolj stvarnega pogleda in testiranja novih izdelkov pred njihovo izdelavo. Glede na sposobnosti aparaturne opreme pa je treba poiskati kompromis med kakovostjo računalniško generiranega sveta in možnostjo interaktivnosti [5].

V procesu razvoja izdelkov je večina odločitev o obliki, funkcionalnosti, izdelavi, montaži, vzdrževanju in načinu uporabe izdeleka sprejeta v zgodnji fazi razvoja izdelka [3]. Te odločitve so sprejete na temelju poznavanja teorije, modelov za RPK in izkušenj, dobljenih z delom. Mnogo težav, ki se pojavijo pri izdelavi ali vzdrževanju, je odkritih zelo pozno ali celo potem, ko je izdelek že prodan. Odpravljanje takih težav pomeni ponavljanje in popravljanje postopka razvoja izdelka, kar je zelo drago in dolgotrajno. Tehnike NR omogočajo izvedbo testov funkcionalnosti in preverjanje vnaprej, česar ni mogoče izvesti samo s sistemi za RPK. Večpredstavnostni sistemi omogočajo interaktivnost med človekom in objekti, pa tudi med ljudmi, vpletenimi v postopek razvoja.

3 SKLEPI

Kot posledica zgodovinskega razvoja in vključevanja računalnikov v proizvodni proces so v podjetjih nastali ločeni poslovni in tehnični informacijski sistemi kot samostojne in nepovezane baze podatkov, kar dandanes predstavlja glavni problem pri povezovanju.

of an object. The costs involved in VP are often very much less than doing a similar test on real prototypes.

The Virtual Environment (VE) is actually a projection of the real environment on a different scale. The VE does not exist, but it is fairly realistic, real enough for engineering purposes, which do not have the demands of the entertainment world. The key feature of Virtual Reality (VR) is immersion (a realistic or believable outlook) and interaction. VR is a composition of 3D graphics, simulation tools and multimedia technologies that allows the user to control and operate within a computer-generated environment on an interactive basis and in real time.

Augmented Reality (AR) is a mixed form where computer-generated images are superimpased on a real environment. The image of the real world is augmented by signs, instructions or computer-generated images. The application in AR must have the same characteristic as VR: spatial and dynamic registration in 3D and real-time interaction, but it must also have a combination of real and virtual objects [3]. While VR reduces costs and conserves resources by detecting design errors early with a fast evaluation of the design, AR offers the possibility to mix physical and virtual objects, which is very helpful because only some objects have to be reconstructed while others exist already.

At the moment no other technology can allow the user to see and explore new products or concepts before they exist in reality in a more realistic manner. Today's hardware performance means a compromise between the realism, the image quality and rate for interactivity [5].

In industrial product development, major decisions about the design, functionality, mechanical construction, production and assembly planning, maintenance and user interface are taken at early stages of the design or development [3]. These decisions are made on a theoretical basis, CAD systems and experiences from earlier work. Many problems that emerge in production and maintenance are discovered at late stages of the production, practical tests or even after the final product is sold. To fix such problems, feedback loops are required to a design stage for modifications, which is a very time consuming and expensive procedure. The VR techniques offers the possibility of performing the functionality tests and verifications in advance, a procedure which cannot be done just from the CAD data. The multimedia techniques support the man-machine interaction as well as dialogue among the users.

3 CONCLUSIONS AND REMARKS

Typically, the MRPs which are supplied from the company information database and the technical information systems have their own databases. This represents the fundamental problem in industry, and is the result of historical

Pogosto je pojavljanje večkrat zapisanih podatkov za isti objekt in neusklajenih podatkov. To je poglavitni razlog, zakaj morajo podjetja izboljšati svoje podatkovne sisteme. Zagotovljeno mora biti načelo, da je vsaka informacija zapisana le enkrat in da je na voljo vedno in vsem, ki jo potrebujejo. Vse funkcije podjetja ali vse službe morajo biti ustrezno informacijsko podprte. Vsaka informacija mora biti zapisana v takšni obliki, da ni uporabna le za avtorja, ampak za najširši krog uporabnikov. Načelo avtomatiziranih otokov znotraj proizvodnega procesa, ki ga je vnašal osnutek RPP (CIM), se je izkazal za napačnega. Posamezni avtomatizirani otoki so se razvijali neodvisno in postali vedno bolj specializirani. Razvoj je šel tako daleč, da so posamezni otoki uporabljali različne sisteme na različnih načelih, tako da je izdelava vmesnikov skoraj nemogoča.

Poglavitna napaka je bila v našem primeru ustavitev razvoja sistema, kar pa se je zgodilo iz več vzrokov: dobavitelj je ustavil razvoj sistema za RPK in se preusmeril na novo področje, zaradi nedefiniranosti lastnika v prehodnem postopku in ustavitve investicij v podjetju. Poglavitna investicija v RPK ni le začetna nabava opreme in šolanje ter seveda samo uvajanje, temveč tudi vzdrževanje sistema, posodabljanje strojne in programske opreme, stroški obratovanja, dodatno šolanje kadra na posodobljeni opremi in uvajanje novosti. Zelo pogosto je spregledano dejstvo, da so stroški vzdrževanja večji od stroškov nabave in uvajanja.

Pri omenjanju usposabljanja lahko omenimo tudi strah in nenaklonjenost vodstva kakovostnem treningu zaradi mišljenja, da bo dober kader po usposabljanju zapustil podjetje. Takšno razmišljanje je samouničujoče, saj nezadovoljen kader zapusti podjetje v vsakem primeru. Bistveno bolje in ceneje je primerno nagrajevanje dobrega in izkušenega kadra preden se odloči zapustiti podjetje in s seboj odnese dragoceno znanje in izkušnje. Podobna napaka je aktiviranje pogodbenega kadra (ali drugega podjetja), ki je večinoma še manj dovzeten za trening in je hkrati nemogoče pričakovati velik prispevek zaradi nepoznavanja specifičnosti podjetja in njegovih proizvodnih značilnosti.

Zelo znan problem je tudi sprotno šolanje in sledenje vsem novostim v sistemih IT, ki jih je treba vnesti v znane tehnike in metode konstruiranja, seveda pri vsakodnevnem delu. Tudi proizvajalci programskih paketov se tega zavedajo, saj lahko v zadnjem času opazimo bolj pogosto dopolnjevanje sistemov z manj spremembami, kar omogoča lažje vključevanje novosti.

Kljub razmeroma preprosti geometrijski obliki v Adrii, je uporaba 3D modelirnika nujna, zaradi uporabe modelov pri sestavljanju sklopov, upravljanje prodaje, predstavitvi modelov, administraciji, predstavitvenih izdelkih, katalogih, servisnih knjižic, dokumentaciji za zagotavljanje kakovosti, dokumentaciji za poslovne partnerje in kooperante. Preskok iz 2D risanja v 3D modeliranje pomeni enako stopnjo spremembe v mišljenju in obvladovanju modelov ter organizacijski shemi dela, kakor prehod in uporaba iz ročnega dela na 2D risanje.

development. The appearance of duplicated data and unadjusted records for different applications is frequent. The principle of once-only registered data should be achieved and that data should be accessed from anywhere, and at anytime that it is needed. The entire company should use a common database and the data should be useful for a broad set of users. The principle of automated islands from the time of the CIM philosophy were definitely wrong. That automated islands developed independently from each other and became more and more specialised. The development went so far that the different systems used different code records so interfacing became almost impossible.

The problem in our case was the stopped development for various reasons: the supplier stopped the development of the drafting system due to, undefined ownership in the transformation process and investment drawback. The investment is not the only initial system implementation. There is also hardware, software tools and training; and afterwards, the system support, maintenance costs, development of design methods and updating staff with new versions and introducing them: all are more costly. Quite frequently the fact that the later costs are larger that initial ones is overlooked.

When training is planned, companies are sometimes reluctant to train staff to the highest level, feeling that they are then more likely to lose them. This is self-defeating, as unsatisfied staff will leave anyway. Far better to reward well-qualified and experienced staff before they decide to take that vital experience of your products and methods elsewhere. A compounding error is to take on increasing numbers of contract staff who you are even more reluctant to train, and who are unlikely to be able to contribute fully to concurrent engineering and manufacturability exercises.

A common problem is following the development of systems, where new possibilities should be introduced in existing design methods simultaneously with every day work. The software suppliers are aware of this, and so it is noticeable that new versions are more frequent with less changes, which makes it easier to follow the changes.

In spite of relatively simple geometry, the 3D modeller is necessary at Adria due to the use of models for assembly design, marketing efforts, sales management, administration, brochures, catalogues, service books, schemes, quality-control documentation, documentation for partners and co-operation companies. The move from 2D drafting to 3D solid modelling involves an equivalent level of change in the way of thinking about designs and in the management of the design model as an adaptation of 2D drafting from manual methods.

Ob uvajanju novih tehnologij, ki tako zelo vplivajo na celotno organizacijsko shemo podjetja, ni nujno treba poznati le specifičnosti lastne proizvodnje, ampak razumeti tudi posledice, ki jih uvajanje sproži, ne samo v konstrukcijskem oddelku, temveč v celotni sestavi podjetja. Ena najpomembnejših stvari je zagotovo prenos podatkov med posameznimi oddelki podjetja, kakor tudi z zunanjimi partnerji. Večina izdelovalcev programske opreme omogoči prenos podatkov z vmesniki in standardnimi zapisi vhoda in izhoda, ki pa jih je večinoma treba prilagoditi, da omogočajo uspešno delo med več sistemi. Prav tako je pomembna možnost uporabe sedanjih objektov in datotek v novem sistemu. Snemanje in digitalizacija risb sta zelo zamudna in nenatančna prenosa, zato nista zaželena. Prenos prek (vprašljivo) standardnih vmesnikov (npr. IGES) je uporaben le za prenašanje osnovnih oblik in kot pomoč pri ustvarjanju modelov na novo.

Razvoj svetovnega spleta (WWW) je pomemben korak pri razvoju računalniških tehnologij in komunikacije, ki močno vpliva na razvoj aplikacij. Vedno več sistemov vsebuje orodja za komuniciranje prek spleta. V bližnji prihodnosti bo vsaka pomembna računalniška aplikacija zmožna komunicirati prek spleta kot informacijskega kanala.

Sestava projektne ekipe je zelo pomembno in težavno dejanje, saj morajo člani obvladati veščine vodenja projektov, tehnične posebnosti, ekonomske učinke in organizacijske zmožnosti. Zelo pomembna je nenehna podpora in spremljanje projekta od vodstva podjetja med celotnim trajanjem projekta. V našem primeru je uvajanje 2D RPK v konstrukcijski oddelek spodbujal predvsem konstrukcijski oddelek, zaradi boljšega in bolj uspešnega dela, dopolnjevanje pa je prevzelo vodstvo podjetja, ki je spoznalo vse prednosti podatkov konstrukcijskega oddelka in vpliv ter možnosti uporabe teh v vseh dejavnostih podjetja.

Nove tehnologije NR so več ali manj še vedno v fazi raziskav in presegajo sprejemljive meje investicij, predvsem v majhnih in srednjih podjetjih. Vsekakor pa je treba biti pozoren na kasnejše možnosti širitve sistema za RPK in njihovo vključevanje v enovito podatkovno skladišče. Za izmenjavo podatkov morajo biti zagotovljeni razširjeni in dobri podatkovni vmesniki, kakršen je na primer STEP. Na sliki 3 je predstavljen 3D model prikolice in avtodoma kot startna točka za uporabo tehnik NP in NR.

Uspešnost podjetja je utemeljena na lastnih konstrukcijskih izkušjah, tako dobrih kakor slabih. Osnutek hkratnega inženirskega dela načrtuje sočasne konstrukterske dejavnosti in preverjanje posledic teh odločitev na lastnosti in funkcionalnost izdelka, pa tudi možnosti izdelave in kalkulacije stroškov.

Glede na hitrost razvoja IT je pogosto opaziti neodločnost o primernem času vpeljave novih tehnologij. Reči je mogoče le: *"Idealnega časa za začetek ni, edini zanesljiv dejavnik je potreba po spremembi."*

It is not enough to understand the production process in the company, the understanding of the process from the new-technology point of view should be attained together with all possible consequences for the organisation of production and interfaces to other processes. Data exchange with external partners should be considered, with the responsibilities for converting and adapting data input and output. Most vendors publish specified input and output formats, but these may need adaptation for successful working between different systems. It is also important to re-use the existing CAD system as much as possible, to convert existing system files into a new system. The scanning and digitising of drawings from paper are very time consuming and inaccurate processes, and should be avoided. Converting existing files through (questionable) standard interfaces (e.g. IGES) is useful only for the basic transfer of geometry data or for assistance in the creation of new models.

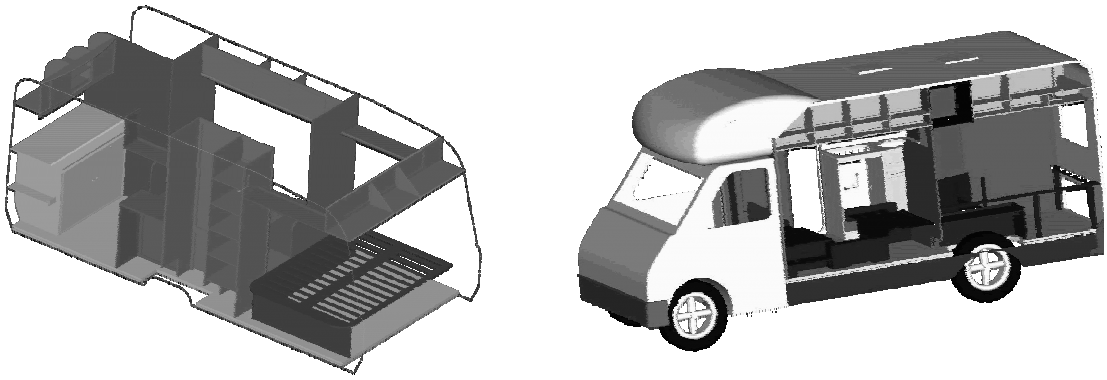
The WWW is the step in the evolution of computing that communication and immediately makes a big impact. Everyday more software products contain tools to interact with the WWW. In the very near future every major application will be able to operate with the WWW as a communication channel.

To establish the project team is a crucial and difficult task due to the need for project, technical, commercial and organisational skills. The full engagement of senior management is important and necessary. The first implementation benefitted the design department, the next one was put forward by the company management who recognised the benefits of data quality from the design department and the influence and possibilities of using design data.

New VR techniques are still in the research stage and therefore too expensive for small and medium-sized companies. What should be taken into consideration is the possibility of extending chosen CAD system with new techniques at a later stage and incorporation into the overall product-data management. For effective and easy data exchange, data formats must be widespread or at least good and reliable interfaces like STEP should be available. In figure 3, 3D CAD models of a caravan and a motorhome are presented as the starting points for VP and VR techniques.

Concurrent engineering is defined as the concept of running design activities and reflecting the effect of design influences simultaneously. A company's success is built on its own design experience, successes and failures. Clearly, concurrent engineering requires interaction between the early and later stages of design, as well as manufacture feasibility and cost analyses.

It is always a question when to start with the introduction and implementation of new IT, especially because it is developing so rapidly. But the only thing to be said is: *"There is no ideal start time, the only certain factor is the necessity for change."*



Sl. 3. *3D RPK model prikolice in avtodoma*
Fig. 3. *3D CAD models of caravan and motorhome*

4 OKRAJŠAVE
4 ABBREVIATIONS

informacijske tehnologije	IT - IT	Information Technologies
računalniško podprto konstruiranje	RPK - CAD	Computer Aided Design
računalniško povezana proizvodnja	RPP - CIM	Computer Integrated Manufacturing
navidezna resničnost	NR - VR	Virtual Reality
navidezni prototip	NP - VP	Virtual Prototype
obogatena resničnost	OR - AR	Augmented Reality
digitalni model	DM - DMU	Digital Mock-up
svetovni splet	WWW	World Wide Web

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