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30. obletnica ustanovitve Prometnotehničnega inštituta sovpada z življenjskim jubilejem njegovega prvega predstojnika, zaslužnega profesorja dr. **Branka Žnideršiča,** ki 22. januarja 1996 praznuje 85. rojstni dan. Člani Inštituta smo ponosni nanj in mu z iskrenim spoštovanjem želimo ob tem visokem jubileju še mnogo zdravja in zadovoljstva in se veselimo njegovih obiskov na fakulteti.

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GRADBENI VESTNIK

GLASILO ZVEZE DRUŠTEV GRADBENIH INŽENIRJEV IN TEHNIKOV SLOVENIJE
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VSEBINA-CONTENTS

PTI - FGG se predstavlja

Short rewiev of Traffic Technical Institute (PTI - FGG)

Prva predavanja na gradbenem oddelku nekdanje Tehniške oziroma sedanje Fakultete za gradbeništvo in geodezijo so se po ustanovitvi ljubljanske univerze (poleti 1919) pričela 2.12.1919. Do leta 1951 je bil študij gradbeništva enovit, potem pa se je razcepil v tri smeri: konstrukcijsko, hidrotehnično in prometno. Delo učiteljev je bilo izrazito usmerjeno v izjemno dobro plačano pedagoško dejavnost. To in skromna potreba po raziskavah in zahtevnih strokovnih delih sta bili vzrok, da tovrstne dejavnosti na šoli tedaj ni bilo. Učitelji so sodelovali v raziskavah v drugih, posebej organiziranih institucijah, ali pa so to delali kot samostojni avtorji za svoj zasebni račun.

Zaradi naraščanja potreb po raziskovalnem in zahtevnem strokovnem delu ter vse glasnejših očitkih javnosti o privatiziranju fakultetnih učiteljev je bil leta 1960 ustanovljen Prometnotehniški inštitut FAGG (tedaj je bil v sestavi fakultete še oddelek za arhitekturo), raziskovalna vzporednica pedagoškemu prometnemu odseku s katedrama za ceste in železnice, s svojim internim kontom za raziskovalno in strokovno delo. Praktično povsem samostojno razpolaganje s sredstvi iz tovrstne dejavnosti je omogočilo PTI, da se je sprva počasi nato pa vse intenzivneje opremljal z najsodobnejšimi pripomočki in vzporedno z ustreznim stimuliranjem povečeval tudi zanimanje strokovnjakov za delo v njem. Postal je eden izmed najmočnejših inštitutov v državi, pomemben za delo sodišč (raziskave prometnih nesreč) in investitorjev prometnih objektov (prometne študije, ekspertizna dela) ter državne uprave (sestavljanje tehniških predpisov in normativov).

Po osamosvojitvi Slovenije se je izjemno povečalo razumevanje in obseg raziskovalnega dela in začel se je intenziven razvoj na področju informatike. Posodobiti je bilo treba tehniške regulative nove države in izdelati nacionalni program za ceste. PTI je sledil temu in se usmeril skoraj izključno v te dejavnosti. Strokovnega dela, ki je imelo v preteklosti zelo pomemben delež in je zagotavljalo materialno bazo inštituta, sedaj praktično ni več. Ostale so le ekspertize in dajanje strokovnih mnenj za potrjevanje najzahtevnejših strokovnih odločitev na področju prometa in prometne infrastrukture (ceste, železnice) in ohranilo se je izvedeniško delo za potrebe sodišč. PTI je izjemno pomembno vključen tudi v

The Ljubljana University was established in the summer of 1919. First lectures on the Technical High School, which was soon split to diferent Faculties, began on December 02, 1919. One of these divided Faculties was Faculty of Architecture, Civil Engineering and Geodesy (FAGG), today separated to Faculty of Architecture (FA) and Faculty of Civil Engineering and Geodesy (FGG). The study of Civil Engineering was uniform till 1951, when it was divided to the studies of Construction, Hydrotechnic and Traffic. The engagement of lecturers was exclusively pedagogical and extremely well paid. Due to several considerations the research and technical works were not present. On the research field the lecturers took an active part in the research works of other, extra organised institutions or executed it for their own account.

As the needs of research and high technical works have grown up and to eliminate negativ public opinion about privatisation of lecturers in year 1960 Traffic Technical Insitute (Prometnotehni'ki in'titut - abbr. PTI) was established as a parallel to the pedagogical work of the chairs of roads and of railways. Thanks to its own account (first in the history of Faculty) PTI soon developed its equipment and very good paying conditions increased experts' interest in taking part in Institute's work. Slowly it has grown up as one of the strongest traffic-institutes in the state; an Institut of great significance for the Court of Justice (researches of traffic accidents), for the investors of great traffic-communication objects (traffic studies, expert works) and for the Slovenian Government (technical norms and standards, technical advisory works).

After Slovenian state-independence the understanding and the extension of research work has extremely increased and an intensive evolution of informatics has begun. The new state needed the updated technical norms for the road-designing and National motorway construction program. The main activity of PTI was in this time turned to these fields of work. Universal technical work, essential for the earning the living in the past, was reduced to experts' reports and advisoring for the most important technical decisions in the field of traffic policy and traffic infrastructure (roads, railways). The experts' reports for the needs of Court of Justice were preserved.

slovenski "projekt stoletja" - izgradnjo avtocestnega sistema. Pripravil je in vodi strokovna dela za Nacionalni program izgradnje avtocest in opravlja svetovalna in najzahtevnejša ekpertizna dela za DARS, d.d.. Strokovnjake PTI je Vlada Republike Slovenije izbrala in povabila k delu v Projektnem svetu DARS, kjer se sprejemajo vse ključne projektne odločitve za slovenske avtoceste.

Področje informatike je v zadnjih letih tudi v PTI zadobilo največji zagon. Razvila se je skupina specialistov, ki samostojno in v povezavi s številnimi inštituti po Evropi in v ZDA razvija in uvaja nove in posodablja obstoječe računalniške sisteme in usposablja kadre za njihovo uporabo. Poleg študentov, za katere je to usposabljanje del rednega študija, se v posebnih "delavnicah" usposabljajo neposredni uporabniki. To je ena izmed dejavnosti, ki jo kot dodatno pedagoško delo izvaja PTI. Izjemno visoka strokovnost na tem področju je dobila svojo potrditev v odločitvi IRF (International Road Federation) na zadnjem zasedanju njene generalne skupščine v Glasgowu, da bo PTI razvijal in postopno oblikoval banko podatkov o evropskem cestnem omrežju.

Strokovnjaki-raziskovalci PTI se redno udeležujejo domačih in mednarodnih kongresov in drugih srečanj, kjer strokovni javnosti aktivno predstavljajo svoje dosežke. Odmevnost na te predstavitve je velika. Najsodobnejši pristop k raziskovalnemu delu in njegova kakovost sta očitno pravilni usmeritvi PTI, ki mu omogočata, da pomembno deluje tudi na svetovnem prizorišču.

Nowadays, PTI is deeply engaged in slovenian so-called "Project of the Century" - Slovenian Motorway Construction Project. The main technical works for the "National motorway construction program" were prepared and led by the experts of PTI and some of them were appointed by Slovenian Governement as members of Project-council of DARS (Motorway company in the Republic of Slovenia, Ltd.) where all the most important environmental and technical decisions are reached. General expert and advising reports of PTI experts support the technical execution of motorway programme.

The field of informatics has enormly increased in the last years. In the PTI a special group of experts has been formed to develop and to introduce new computer systems and programs. In few cases in cooperation with several institutes in Europe and the US. The education is one part of this job. While the education of students in the field of informatics is a normal step in their study, special courses are arranged for the already employed engineers to enable them to use informatics programs in their own companies or state governement divisions. Very high professionality of our experts was confirmed by the decision of the last General Assemble of IRF (International Road Federation) confiding the development and step by step forming of European motorways net data-bank to PTI.

The experts of PTI regularly take part in domestic and international congresses and symposia and publish the results of their research work. Great responses confirm the correctness of the decision for the quality and up-to-date researche work in PTI which enable it to be present world-wide.

Predstojnik **PTI**
dr. Tomaž Kastelic

GIS IN MULTIMEDIJA NOVE METODE MERJENJA DOLŽINE IN ZBIRANJA TER PRIKAZOVANJA PODATKOV O CESTAH

GIS and MULTIMEDIA new solution for road data capturing and presenting

UDK: 656.1.01:681.32

TOMAŽ KASTELIC

POVZETEK

Zbiranje podatkov je najtežji korak pri implementaciji GIS projekta. Znane metode so za zbiranje podatkov o cestah neprimerne, predvsem zaradi oviranja normalnega prometa in prometne varnosti. Zaradi velikega števila podatkov na razvejenem omrežju so časovno in kadrovsko prezahtevne. Zato smo za zajem vidnih objektov vzdolž cest (signalizacija in oprema cest) uporabili video sistem. Lokacijo določamo s pomočjo merskega kolesa oziroma načrtujemo uporabo GPS. Tako posneta video slika nam rabi za vnos podatkov v bazo; za zajem različnih objektov posnetek enostavno večkrat zavrtimo, uporabljamo ga za kontrolo, itd. Z nekaj posebne opreme lahko isti posnetek uporabimo tudi pri predstavitvi v ARC/INFO okolju. Poleg prikaza ceste in opreme na poljubno izbrani podlogi (skenirane karte) nam oznaka na osi ceste kaže mesto, ki ga trenutno prikazuje video posnetek. In narobe: z izbiro lokacije na cesti nam sistem pokaže video posnetek na tem mestu. Uporaba video sistema pomeni velike prihranke v času, ljudeh in seveda denarju, daje pa bolj natančne rezultate kot dosedaj.

SUMMARY

Data collecting is the hardest step in the GIS project implementation. Known methods are unsuitable for road data capturing because of the traffic safety and they are time consuming for a lot of different data on the widespread network. So we use video system to take visible objects along the road (road signalization and equipment). Location is determined by measurement wheel or with the GPS. Video picture is used as the base for data input; we can play it many times for different data input, for control, etc. With some special equipment the same video picture can also be used in presentations in ARC/INFO environment. Beside displaying the road and its equipment on selected background (scanned maps) also the point shows the location on the road while the video picture is moving. Opposite, with click on the selected location on the road we get from video the situation of this part of the road. Using video system results big savings in time, people and of course money and give much more accurate data as before.

AVTOR:
Prof. dr. Tomaž Kastelic, dipl. gr. ing.
Professor Tomaž Kastelic, Ph. D.

1. UVOD

Gospodarjenje s prostorom in objekti v njem zahteva od upravljavca v prvi vrsti natančno poznavanje trenutnega stanja objektov, s katerimi gospodari. To pomeni, da mora obvladovati ogromne količine različnih podatkov, kar je možno le s pomočjo računalniško podprtih informacijskih sistemov.

Pri realizaciji informacijskega sistema pomeni največjo oviro zbiranje podatkov. Ko govorimo o prostoru, je to delo še zahtevnejše, saj običajno zahteva ogromno terenskega dela. Le-to je izredno zamudno, kar bistveno vpliva na časovno in cenovno možnost vzpostavitve takega informacijskega sistema. Ker pa se prostor in objekti v njem izredno hitro spreminjajo, postane s tem vprašljiva tudi zmožnost ohraniti ažurnost podatkov v zbrani bazi. Zbiranje podatkov o cestah je še dodatno oteženo, ker je potrebno vse meritve in opazovanja izvesti, medtem ko promet nemoteno poteka. Cest zaradi meritev ne moremo enostavno zapreti, delo med prometom pa bi preveč ogrožalo prometno varnost, tako popisovalcev, kot tudi ostalih udeležencev v prometu. Pa tudi če te omejitve ne bi bilo, bi bile vse dosedaj poznane metode zbiranja podatkov prepočasne zaradi ogromne dolžine in razvejenosti cest in velikega števila objektov na njih.

V članku je predstavljena nova metoda zbiranja podatkov o cestah, ki se nam ponuja z zadnjimi dosežki na področju informatike. Možna rešitev problema zajema podatkov se je pokazala v snemanju situacije na terenu in kasnejši zajem podatkov s posnetka.

2. MERJENJE DOLŽINE CESTIŠČ IN REGISTRACIJA OBJEKTOV

Merjenje dolžine cestišč in registracija obcestnih objektov zahteva posebno opremo, ki nam poleg kakovostne slike omogoča tudi natančno določanje lokacije objektov v prostoru.

Prvi del opreme sestavlja profesionalna video oprema: kamera, SVHS videorekorder, video monitor in mikrofon. Kamera je fiksno pritrjena v vozilu za vetrobanskim steklom, kjer ima odprt pogled na cesto pred sabo, istočasno pa je zaščitena pred zunanjimi vplivi, predvsem prahom in umazanijo na lečah. Zaradi boljše preglednosti je priporočljivo uporabljati vozilo z višjim sedežem, npr. kombi. Sopotnik poleg spremljanja posnetka na video monitorju prek mikrofona sporoča morebitne opombe o objektih (material, težko ločljivi napisi, znaki skriti za zelenjem, vsebina znakov, ki stojijo vzporedno s cesto, itd).

Drugi del opreme predstavlja merilnik za merjenje dolžine poti s katerim merimo odmik od začetne točke (stacionažo), ki je običajno začetek odseka. Med merilniki, ki smo jih imeli na razpolago (GPS, merilni disk s pritrditvijo na avtomobilsko kolo, CORREVIT L-CE zaznavalo), smo se odločili za najbolj natančno in zanesljivo merilno kolo. Pritrjeno je za vozilom in prek optoelektronskega pretvornika, ki rabi za pretvarjanje mehanske merilne veličine v električno, sporoča spremembo stacionaže posebnemu vmesniku. Ta je povezan s PC računalnikom, kjer se

1. INTRODUCTION

An effective management of environment and its objects requests at least that the condition of objects is known as exact as possible. This means that a lot of different data must be maintained, which is possible only with the help of modern computer based information systems.

Data collecting is the hardest step in the building of information system. When we talk about the space the problem is even greater because normally a lot of terrain work is needed. The terrain work is very time consuming what essentially impact on time and price component of the implementation of such an information system. The space and objects in it are changing very quickly, so there is not enough only to collect the data but we must keep the data up to date. Collecting data about the roads is even more difficult because all the measurements and observations must be done while the traffic normally runs on. We can not simply close the road while the collecting of data is done. Working in the middle of the traffic is to dangerous for the people making the measurements and also for the other participants in the traffic. Also in the case there is no such limitations all known methods are unsuitable and to slow because of long and widespread road network and a great number of objects on it.

In paper is presented new method for road data capturing which is offered by last achievement in the field of informatics. Possible solution of road data capturing is shown in recording the road situation with the video system and later collecting data from the video picture.

2. RECORDING THE SITUATION ON THE ROAD

Recording the situation on the road demands special equipment that, besides a good picture, makes possible that the location in the space can be defined to recording. First part of equipment is put together from the special video equipment: camera, VCR, video monitor and microphone. Camera is fixed in the vehicle behind the windshield where the view on the road is clear, and at the same time the camera is protected from the outer influences, especially dust and dirt on lenses. Because of better lucidity it is recommended to use vehicle with higher seat, the van for instance. Co-driver's task is, besides watching the recording on video monitor, to inform eventual remarks about the objects (material, hardly separable inscriptions, signs hidden behind the trees, contents of the signs that stand parallel to the road, etc.).

Second part of equipment presents measuring wheel that measure distance from the beginning of the road segment. It is fixed behind the vehicle and give signal to the computer in the vehicle about the change of mileage for every meter through the special interface.

Of course, it is necessary to get synchronization between recording and mileage. Special interface was developed for that purpose and communicates with video equipment and measuring wheel. Thus, through the computer it is possible to direct working of the video equipment entirely (beginning, end of recording, pause, returning to selected

shranjujejo istodobni podatki o metraži in števca traku na videorekorderju.

Seveda je potrebno zagotoviti sinhronizacijo med posnetkom in stacionažo. Z ta namen je bil razvit poseben vmesnik, ki komunicira tako z video opremo kot z merskim kolesom. Tako prek računalnika upravljamo celotno delovanje videorekorderja (začetek, konec snemanja, premor, vračanje na izbrano lokacijo, itd.) in krmilimo tudi mersko kolo (postavitev števca na izbrano vrednost in pričetek oddajanja signala).

Poseben problem je predstavljalo napajanje vse te opreme v vozilu. Običajni pretvorniki avtomobilske napetosti z 9V v 220V so bili prešibki za napajanje celotne opreme, zato je bilo potrebno tudi ta del opreme ustrezno okrepiti.

Kljub profesionalni opremi pa lahko pri meritvah prihaja do manjših odstopanj. Praktično nemogoče je zagotoviti, da bi mersko kolo stalno vozilo po osi ceste (razmišljamo o vakuumski pritrditvi merilnika ob strani vozila). Prav tako vožnja skozi krivine v eni in drugi smeri povzroča določena odstopanja. Zato je umestno razmišljati o nadomestitvi merskega kolesa s satelitsko navigacijo - GPS (Global Position System). Hiter razvoj tehnologije na tem področju nam že omogoča natančnost pozicioniranja okoli 1m (z diferenčno metodo - sinhronizacija fiksnega in gibljivega sprejemnika), pri čemer je možno dobiti podatek vsako sekundo. Natančnost je za naše potrebe povsem zadovoljiva, medtem ko je nekaj več problemov pri frekvenci meritev. Pri poprečni hitrosti vozila pri snemanju 40km/h pomeni podatek vsako sekundo prevoženih približno 11m. Vsa vmesna stanja je potrebno ustrezno izračunati, medtem ko smo pri merskem kolesu imeli pri hitrosti, manjši od 90 km/h, sinhronizacijo s posnetkom na vsak meter (problem tehnologije video slike - 25 slik/sek). Novi izdelki napovedujejo večje frekvence lociranja (2 meritvi na sekundo), s čimer se problem zmanjšuje.

Bistvene prednosti GPS so v večji natančnosti na ta način lociranih podatkov in njihovi takojšnji postavitvi v prostor (koordinatni sistem). Pri merskem kolesu moramo lokacijo v prostoru določiti s pomočjo izmerjenih odmikov prek grafičnih podlog (osi cest), implementiranih v GIS okolju. Tu prihaja do odstopanj, tako pri meritvah kot pri zajemu grafičnih podlog. Razvoj sistema je zagotovo v uporabi GPS, vendar trenutno v Sloveniji ta tehnologija še ni uporabljena v večjem obsegu, kar naj bi zagotavljalo nekatere temeljne pogoje za delo (mreža referenčnih postaj, problemi z uporabo GPS v naseljih z visokimi stavbami, hribovita in gorska območja, itd.).

3. VNOS PODATKOV V BAZO

Vnos podatkov v bazo na podlagi video posnetkov poteka v posebej za to opremljenem studiu. Osnovo predstavlja video posnetek, ki ga s pomočjo videorekorderja spremljamo na monitorju (lahko TV). Na računalniku za vnos podatkov teče poseben program, ki komunicira tako z videorekorderjem kot z dodatnim računalnikom, kjer imamo zapisano sinhronizacijo video posnetka in metraže. Podatke vnašamo prek grafičnih podlog na digitalni plošči, ki so za uporabnika mnogo bolj prijazni in zagotavljajo hitrejše in bolj natančno delo.

location, etc.), and pilot the measuring wheel (setting the counter to selected value, beginning of signal transmission). For the needs of synchronization the computer saves the data of counter and distance, for later processing.

Special problem was to get enough power for all that equipment in the vehicle. Normal transformer of vehicle tension from 9V to 220V were not strong enough to get enough power, and because of that it was necessary to fix that part of equipment, too.

In spite of professional equipment, it is possible to get minor deviations. Practically it is impossible to assure to pilot the measuring wheel through the axis of the road all the time. Driving through the turns in one and the other direction also cause certain deviations. Because of that it is convenient to think about replacement of measuring wheel with satellite navigation - GPS (Global Position System). Very fast development of technology in this area enables accuracy of positioning around 1m (with differential method - synchronization of fixed and movable receiver), and with this it is possible to get data every second. Accuracy is satisfactory for our needs, but in the meantime one can find more problems with frequency of measurement. When recording with vehicle's average speed of 40km/h, computer gets data every second or on every 11m. Every intermediate conditions are necessary to compute, meanwhile with measuring wheel we had synchronization with recording for every meter. But new products announce bigger frequencies of localizing (2 measurements per second), and the problem will reduce.

GPS essential advantages are in greater accuracy in such a manner localized data, and in their immediate settings in the space (coordinate space). Using the measuring wheel, we have to use mileage data of the object on the digital presentation of the road (axis of road) implemented in GIS to define location in the space. The result of that are deviations, caused both with measurements and capturing the graphic linings. Development of the system is definitely in GPS use, but right now this technology is not used to greater extent in Slovenia. This technology would assure some of the basic conditions for work (net of reference stations, problems with GPS use in the settlement with high buildings, mountainous and alpine areas, etc.).

3. DATA ENTRY

Entering data in the database on the basis of video recordings runs in specially equipped studio. Situation of the road is presented on the monitor (could be TV) with the help of VCR. On the computer for entering data runs special program that communicates with VCR as well as with additional computer. Additional computer stores data of video recording's synchronization and mileage. Data are entered over graphic input menu on the digitize tablet. Graphic interfaces are more user friendly and they assure faster and more accurate work.

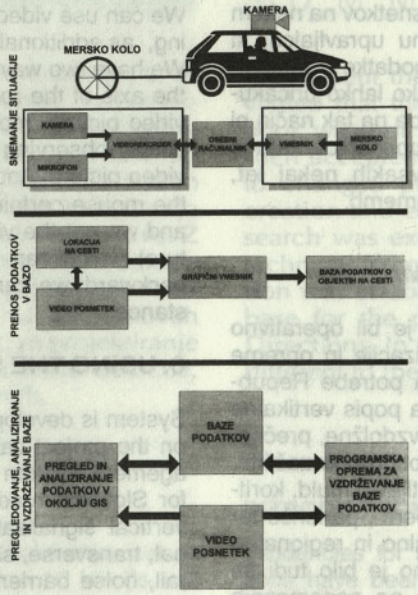
With help of revolving button on VCR, we move the picture until we find one of the objects that we want to enter (we can move the picture backward and forward with optional speed independently of the speed of the vehicle while recording). At the chosen object we stop the picture and

S pomočjo vrtljivega gumba na viedorekorderju vrtimo posnetek, dokler ne najdemo enega od objektov, ki ga želimo vnesti (posnetek lahko vrtimo naprej in nazaj s poljubno hitrostjo neodvisno od hitrosti vozila pri snemanju). Ob izbranem objektu posnetek zaustavimo in objekt poiščemo na grafičnem menuju digitalnika. S pritiskom na gumb na izbranem objektu se nam avtomatično v bazo vpiše koda objekta in stacionaža na odseku. Prek menijev lahko vnesemo še ostale podatke o objektu, za morebitne posebnosti pa lahko uporabimo tudi tipkovnico. Nato lahko nadaljujemo s pregledom posnetka, dokler ne pridemo do konca odseka. Za vnos ostalih objektov prevrtimo posnetek na začetek, zamenjamo menu na digitalni plošči in lahko pričnemo z novim vnosom.

Tak način dela se je izkazal kot izredno učinkovit. Na terenu potrebujemo minimalno število oseb, ki v kratkem času lahko posnamejo obsežne dele cestnega omrežja. Vnos podatkov v bazo nato poteka doma v mirnem okolju, z možnostjo kontrole vnešenih podatkov, kar zagotavlja bistveno višjo kakovost podatkov.

look for the object on the input menu. With the press on the button on the chosen object, code of the object and mileage on the segment are automatically entered in the database. Over the input menu we can enter the other data about the object; for the eventual specialties we can also use keyboard. Then we can continuo with the survey of the recording until we come to an end of the segment. For entering the other data, we can rewind the recording on the beginning of segment, change the input menu on the digitize tablet and we can start with the new enter.

Such manner of work showed to be very effective. On the road we need minimal number of people who can record extensive parts of road network. Data entering goes on at home in the quiet environment with a chance of entered data control which means higher quality of data.



4. PRIKAZ PODATKOVNE BAZE V GIS OKOLJU

Nadgradnjo podatkovne baze predstavlja pregledovanje in analiziranje zbranih podatkov v GIS okolju, kjer si poleg lastnosti objektov lahko predstavimo tudi njihovo lokacijo v prostoru. Za prikaz uporabljamo programsko orodje ARC/INFO, kjer na osi ceste oziroma ob njej prikazujemo različne objekte iz baze. Za podlogo običajno uporabljamo skenirane karte od meril 1:5000 do 1:50000, odvisno od potreb uporabnika sistema. Uporabljamo lahko tudi vse druge prostorske digitalne baze, ki trenutno že obstajajo za določen prostor (obrisi naselij, gozdov, vode, ROTE, EHIŠ, itd.). Seveda pa nam GIS poleg vizualizacije lege objektov omogoča tudi stalen dostop do vseh atributivnih podatkov o teh objektih.

4. DATABASE UPDATE

Special problem also represents maintenance such an extensive database. Base without proper maintenance loose its value very fast. We can make the database to be up to date only with constant data entering at local road work performer. For that manner the simple system is made for database managing that enables adding, changing, deleting of data and simple analysis. At the same time it also records all the history of changes in the database.

Immediately after capturing the data on the basis of recordings at certain area, the database is transferred to local manager who then maintains that base and mediates data to common database in regular time intervals. Only with that way we can expect the common database

Pri pregledovanju lahko kot dodatno informacijo uporabimo tudi video posnetek, ki smo ga naredili za potrebe vnosa podatkov. Imamo dve možnosti uporabe. Prva je, da se skupaj z video posnetkom premika tudi oznaka na osi ceste, ki prikazuje trenutno lokacijo video posnetka; na ta način lahko enostavno pregledujemo stanje na odseku preko video posnetka. Druga možnost pa je, da z miško izberemo določeno lokacijo na odseku, ki nas zanima in dobimo tudi video posnetek na tej lokaciji (stoječa slika), ki ga lahko potem poljubno premikamo naprej in nazaj; na ta način lahko npr. preverjamo vidljivost v določeni krivini.

5. VZDRŽEVANJE PODATKOVNE BAZE

Poseben problem predstavlja tudi vzdrževanje tako obsežne podatkovne baze. Baza brez ustreznega vzdrževanja kaj hitro izgubi vso svojo vrednost. Njeno ažurnost lahko zagotovimo le s sprotnim vnosom podatkov pri lokalnem izvajalcu del na cesti. Za ta namen je izdelan enostaven sistem za upravljanje podatkovne baze, ki omogoča vnos, spreminjanje, pregledovanje podatkov in enostavne analize, hkrati pa vodi tudi zgodovino vseh sprememb v bazi.

Takoj po zajemu podatkov na podlagi posnetkov na nekem območju se baza prenese k lokalnemu upravljalcu, ki potem vzdržuje to bazo in posreduje podatke v skupno bazo v rednih časovnih intervalih. Le tako lahko pričakujemo ažurno skupno bazo. Jasno pa je, da na tak način ni možno rešiti problema zastaranja video posnetkov, zato je potrebno izvesti ponovno snemanje vsakih nekaj let, predvsem na odsekih, kjer je veliko sprememb.

6. PRAKTIČNA UPORABA SISTEMA

Sistem je razvit in izdelan v celoti in je bil operativno uporabljen na projektih Kataster signalizacije in opreme cest ter Kataster obcestnih objektov za potrebe Republiške uprave za ceste. Projekta obsegata popis vertikalne signalizacije, horizontalne signalizacije (vzdolžne, prečne, oznake v križiščih), varnostnih ograj, protihrupne zaščite, svetlobno signalnih naprav, javne razsvetljave, muld, koritnic, jarkov, kanalet, brežin, preglednih berm, parkirišč ter lokacij priključkov in križišč za magistralno in regionalno cestno mrežo (prek 4500 km). Izvedeno je bilo tudi že šolanje vzdrževalcev podatkovne baze po posameznih cestnih podjetjih, kjer je baza že vnesena in se koristno uporablja.

7. SKLEP

V članku je predstavljena možnost uporabe različnih sodobnih informacijskih orodij (GIS, video, GPS), povezanih v učinkovito celoto. Računalniško podprti video sistem kot celota bistveno prispeva k uspešni nastavitvi prostorskih baz podatkov in njihovi uporabi ter s tem bodočim uporabnikom omogoča učinkovitejše gospodarjenje s svojim prostorom in objekti v njem. Sistem je preizkušen s tekočim delom na obsežnem projektu državnih cest.

Alternativa je v razvoju video sistema na raven avtomatskega prepoznavanja obcestnih objektov in določanje natančne lege objektov na cestišču in ob njem s pomočjo stereo video slike.

to be up to date. But it is also clear that it is impossible to solve the problem of aging of the video recordings on that manner. That is why it is necessary to make recordings every couple of years, especially on the segments where one can find a lot of changes.

5. PRESENTING DATA IN ARC/INFO ENVIRONMENT

Database upgrade represents controlling and analyzing of collected data in GIS space, where one can represent location of the objects in this space, and also properties of the objects. We use ARC/INFO software, where we show different objects from the base on the axis of the road. For background we usually use scanned maps of measuring scale from 1:5000 to 1:50000, depends what are the needs of the system user. We can also use other different space digital bases that right now already exist for certain area (shapes of settlements, woods, water, territorial units, houses centroids, etc.). Of course, besides objects position's visualization, GIS also enables constant access to all attributive data about these objects.

We can use video picture, made for the use of data entering, as additional information when the data is presented. We have two ways of use. The first one where the sign on the axis of the road, which shows momentary location of video picture, moves together with video picture; we can simply observing the condition on the fragment over the video picture. And the second one where we choose with the mouse certain location on the road that is in interest and we get the video picture on this location (frozen picture) which can be later optionally moved forward and backward; we can check visibility in certain curve for instance.

6. USING THE SYSTEM

System is developed entirely, and right now it is operative on the project called KATSIG - Inventorisation and Management System for Road Signalization and Equipment for Slovenia road administration. Project includes list of vertical signalization, horizontal signalization (longitudinal, transverse, signs in the crossroads), protective guard rail, noise barriers, traffic lights, public lightning, parking and locations of connections and crossroads for primary and secondary road network (over 4500km). Education of database maintainers through particular road companies, was already accomplished. Along the software installation at particular road companies, the test database was also installed which is used for education of new users, and its purpose is to decrease possibilities of unwanted mistakes later.

7. CONCLUSION

This article represents the possibility for using different information tools (GIS, video, GPS) connected in the effective whole. System as a whole essentially contributes to successful settings of space databases and their use. Users are enabled to manage more efficiently with their space and objects. System is tested through fluent work based on extensive project of national roads.

NASTAJANJE SLOVENSKIH SMERNIC ZA PROJEKTIRANJE CEST

FORMING A NEW SLOVENIAN ROAD-DESIGNING DIRECTIONS

UDK: 656.1(497.12):625.7/.8

ALOJZ JUVANC*

POVZETEK

V prispevku so predstavljene ovire in razlogi, ki so preprečili, da bi dosedanji YU-Pravilnik za projektiranje cest enostavno samo dopolnili in minimalno popravili in ga razglasili za nov slovenski tehniški predpis. Zaradi spremenjenih pogledov na izrabo prostora, kreiranje cest in upravičenost investiranja je bilo treba izvesti dodatne predhodne raziskave. Z njimi so bila opredeljena nova izhodišča za dimenzioniranje cestnih elementov ter ugotovljene možnosti za njihovo racionalizacijo. Na teh osnovah pripravljamo predlog novih Smernic za projektiranje cest. Tokrat predstavljamo predvsem tiste določbe, ki so bistveno drugačne od dosedanjih.

SUMMARY

We present the obstacles and the reasons that prevented that the existing YU-Road Designing Rulebook was not simply fulfilled and corrected and as such accepted as a new Slovenian rule-book. Due to changed public opinion about land-use, road creation and economy of investments additional research was executed. So, new statements for road technical elements dimensioning and its rationalisation was established. These statements are now the base for the preparation of new Road Designing Directions. In this paper only the directions that are different to the existing ones are introduced.

UVOD

Težnje po posodobitvi predpisov za projektiranje cest so prisotne v slovenski javnosti že več kot 10 let. Že več delovnih skupin se je ukvarjalo s tem, vendar do nekih oprijemljivih rezultatov niso prišle. S slovensko osamosvojitvijo so se razmere spremenile. Novi predpisi so naenkrat dobili poleg strokovne še državotvorni pomen in Družba za raziskave v prometni in cestni stroki je poverila nalogo priprave predloga Prometnotehničnemu inštitutu FAGG (sedaj FGG).

Prva zamisel je bila, da bi enostavno samo nekoliko popravili in dopolnili dosedanji jugoslovanski Pravilnik za projektiranje cest (dalje v tekstu YU-PPC), ki mu ni moč očitati velikih pomanjkljivosti. Je namreč zelo pregleden

INTRODUCTION

Tendencies for the updating the road designing regulations have been present in Slovenia for more than 10 years. More working groups dealt with this problem but they have not found reasonable results. The independency of state Slovenia brought new impact to this problem. The new Rule-book became very important besides being a professional also as the state forming meaning. PTI (Traffic Technical Institute) at FAGG was authorized to prepare the proposal of rules.

At start the suggestion was only to correct the existing Yugoslav Road Designing Rule-book (shorter YU-PPC) which is just perfect. It is clear and its rules are understandable. Due to strong changes in philosophic aspect

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in njegova določila korektna. Kljub temu pa je bilo treba to zamisel kmalu opustiti, ker se je v Sloveniji v zadnjem obdobju korenito spremenila filozofija odnosa do zadovoljevanja prometnih potreb. YU-PPC je bil namreč sestavljen izključno na pogojih zagotavljanja prometne varnosti, medtem ko so pri nas prišli v ospredje še drugi pomembni pogoji: zaščita naravnega in bivalnega okolja, omejevanje hitrosti in racionalno investiranje v ceste. Pri tem miselnem zasuku so postala določila YU-PPC zaradi svoje enostranskosti in togosti prava ovira.

Celoten postopek priprave novega PPC se je zato spremenil. Da bi lahko njegova določila čimbolj razjasnili in utemeljili, smo predhodno izvedli posebno raziskovalno nalogo. Rezultati raziskave so temelj za pripravo Smernic za projektiranje cest (nadalje v tekstu SPC), ki bodo sestavni del novega slovenskega PPC.

V tem prispevku želimo pokazati potek in rezultate predhodnih raziskav, pojasniti obseg in grobo vsebino novih smernic (SPC) ter opisati in pojasniti tista določila, ki so bistveno drugačna od dosedanjih.

PREDHODNA RAZISKAVA

Preveritev ustreznosti oziroma zadostnosti določil sedanjega YU-PPC, izvedba primerjave teh določil z določili v tujih tehniških predpisih in raziskava možnosti za racionalizacijo cestnih elementov so bile izdelane pod skupnim naslovom "Možnost racionalizacije gradnje cest z vidika projektiranja". Med delom se je pokazala potreba po funkcionalni ločitvi te naloge na tri zaporedne dele, ki so bili vsak posebej obdelani v poročilih. Podnaslovi teh poročil so RACIPROC (julij 1990), OPTIPROC I. (maj 1992) in OPTIPROC II. (julij 1993).

Najpomembnejša spoznanja iz raziskave RACIPROC

V prvem delu (RACIPROC) smo raziskali ustreznosti določil dosedanjega YU-PPC, izvedli primerjavo s tujimi tehniškimi predpisi in preverili možnosti racionalizacije tehničnih elementov cest. Interesi investitorjev in uporabnikov cest so glede sodobnosti predpisov in racionalizacije zelo podobni, saj smo uporabniki skozi proračun končno tudi investitorji. Najpomembnejši med interesi so:

- kakovostna izraba prostora (kompleksno upoštevanje interesov vseh vrst izrabe)
- vplivi na okolje (ohranjanje in zaščita naravnega okolja)
- poraba energije (zmanjšanje porabe, kar je tako ekološki kot okoljevarstveni cilj)
- prometna varnost (splošen in vsestranski interes)
- ekonomičnost investicij (investirati v sorazmerju z realnimi potrebami in z optimalnimi stroški)
- mobilnost (prosta izbira prometnih sredstev)
- socioekonomičnost (skladen sociološki in gospodarski razvoj cele države in dostopnost dobrin)
- kakovost ceste (udobnost, čas potovanja, zagotavljanje trajnosti konstrukcije, zunanji videz)
- enotni tehniški predpisi za vse javne ceste (ne samo za državne).

Glede na te interese smo v YU-PPC ugotovili naslednje pomanjkljivosti:

for traffic needs fulfillment in Slovenia we dropped this idea. Why? YU-PPC was formed completely on the base of the traffic safety. So other important conditions like nature and environmental protection, speed restrictions and rational road investments were not observed. We can say that YU-PPC appeared one-sided and rigid and as such an obstacle for up-to-date designing.

The whole procedure for the preparation of a new PPC changed. To make the regulations as clear and as founded as possible a special research work was done. The results are the bases for the preparation of Road Designing Directions (in the following text SPC) which are a technical part of a new Slovenian Road Designing Rule-book (PPC).

In the following text we would like to show the procedure and the results of previous research, to explain the extent and the rough content of SPC as well as to describe and explain those directions that differ from the previous ones.

PREVIOUS RESEARCH

Checking the suitability or sufficiency of directions of the existing YU-PPC, the comparison of these directions with foreign technical regulations and the research of the possibility for rationalization of road elements were done under the common title "The possibilities of the rationalization of road construction from standpoint of designing". During this work the need for functional separation of the work on three successive parts appeared. They were separately dealt in reports. The subtitles of them are RACIPROC (July 1990), OPTIPROC I (May 1992) and OPTIPROC II (July 1993).

The most important findings from RACIPROC

In RACIPROC we investigated the suitability of the existing YU-PPC, we compared them with foreign technical regulations and we checked the possibilities for rationalization of technical road elements. The interests of investors and road users are very similar regarding the updating and rationalisation, as the road investments are the budget costs.

The most important interests are:

- quality land-use (complex consideration of interests of all kinds of use)
- environmental impact (to save and to protect the nature)
- energy consumption (reduction of consumption, which is ecological and environmental preserving aim)
- traffic safety (common and all concerning interest)
- economy of investments (to invest in correlation with real needs and with optimal expenses)
- mobility (free choice of traffic means)
- socioeconomy (equivalent sociological and economic development of the whole state)
- road quality (comfort, traveling time, reassuring of permanency of construction, outer appearance)
- unique technological regulations for all public roads (not only for the state roads)

Considering all quoted above YU-PPC has the following deficiencies:

- upoštevani so izključno samo pogoji zagotavljanja prometne varnosti in prepustnosti ceste
- veljajo izključno le za ceste zunaj naselij
- ne loči med različnimi funkcijskimi vrstami cest (kakovost in vsebina ureditev - kategorija)
- ne obravnava prometnega dimenzioniranja ceste
- dimenzije tehničnih elementov so odvisne izključno od vnaprej določene računske hitrosti, ki je odvisna od prometne obremenitve in vrste terena
- opredeljuje izključno samo mejne vrednosti dimenzij tehničnih elementov osi ceste in cestišča
- ne pozna pojmov potovalne hitrosti, projektne hitrosti, maksimalni vzdolžni nagibi so pri enakih terenskih pogojih različni za različne prometne obremenitve, ne opredeljuje mejnih vrednosti za kritične elemente pri velikih objektih (viadukti, predori, križišča), pa tudi merodajna prometna obremenitev ni opredeljena
- nesodobna so določila o koeficientu drsnega trenja, o določitvi zaustavne dolžine in o določanju velikosti parametra prehodnice pri voznodinamično kreirani trasi

Prva ugotovitev v raziskavi je bila, da pojma racionalizacije ne gre enačiti s pojmom zniževanja pogojev in zahtev za tehnične elemente osi in profila ceste, kot je bilo sprva predlagano. Voznodinamični in prometni pogoji so nedvoumno odvisni izključno samo od računskih hitrosti. Vprašanje racionalizacije tehničnih elementov se tako skrči na vprašanje določevanja teh hitrosti. Te pa ne morejo biti odvisne izključno samo od prometne obremenitve in vrste terena kot dosedaj, ampak morajo odsevati še vse ostale interese v prostoru in izhajajo iz prometne funkcije posamezne cestne povezave in možnosti v prostoru, po katerem cesta poteka. Torej je racionalno, da v primeru dveh prometno enako obremenjenih cest, ki na enako razgibanem terenu povezujeta dva prometno različno močna prometna cilja, uporabimo za dimenzioniranje različni računski hitrosti. Prometno različno pomembnim cestam je torej možno prisoditi povsem različne potovalne hitrosti. V smislu racionalizacije je treba torej vse ceste ustrezno razporediti - kategorizirati - in jim prisoditi kategoriji primerne potovalne (in druge odvisne) hitrosti.

Nadalje smo ugotovili, da je racionalizacija posameznih tehničnih elementov sicer možna, vendar le v primeru, da obstajajo razlogi za to. Najdemo jih v psihofizičnih odzivih uporabnikov cest, ki so na cestah z različnimi prometnimi funkcijami precej različni. Voznik na daljinski cesti se drugače odziva na cestne pogoje kot voznik na neki regionalni povezavi ali v domačem okolju na lokalni cesti. To spoznanje omogoča, da se racionalizira tudi druge parametre, ki odločilno vplivajo na dimenzije cest. To sta predvsem dopustni delež koeficienta drsnega trenja in reakcijski čas. Seveda je spet predpogoj pravilna razporeditev cest v omrežju.

Nedvoumen zaključek raziskave RACIPROC je, da je treba racionalizacijo pri gradnji cest iskati skoraj izključno v pravilni razporeditvi (kategorizaciji) cest v cestnem omrežju in dimenzije cest prilagajati predvsem njihovi prometni funkciji v prostoru. To pomeni, da ne moremo govoriti samo o racionalizaciji temveč o optimizaciji tehničnih elementov.

- only conditions for reassuring traffic safety and level of service are taken into consideration
- they are valid only for rural roads (state-roads)
- it does not differ among various functional kinds of roads (quality and category)
- it doesn't count traffic dimensioning of the roads
- technical elements dimensions depend only on fixed design speed in advance (based on traffic volume and kind of terrain)
- defines only limit values of technical element dimensions of the axis and the roadway
- it doesn't know the expressions like travel speed and design speed, maximum longitudinal grades are different at equal terrain conditions for various traffic volumes, limit values for critical elements concerning huge objects (viaducts, tunnels, cross-roads) are not fixed, and traffic dimensioning is not defined
- the definitions of friction coefficient, stopping distance and the definition of length of transition curve at drive-dynamic designed road are old fashioned.

The first finding out of the research was that the term rationalization can not be identical with the term of lowering the conditions and demands for the technical elements of axis and road profile, which was neglected initially. Drive dynamic and traffic conditions are depending of design-speed only. So the question of technical elements' rationalisation is reduced then to the question of speed definition. The speed can not be dependant explicitly from the traffic volume and the kind of terrain as practised, but they must reflect also all other interests in the physical space. It origin from traffic function of a single slip road and of the possibilities in the landscape where it courses. It is nonsense to build up two roads of the same traffic volume with the same technical dimensions when its traffic functions are quite different (arterial and loco). In sense of rationalization all roads need to be suitably ranked - categorized - and must get suitable category depended driving speeds.

Further it was observed that the rationalisation of individual technical elements is possible only, if very strong reasons exist. They can be found in psychophysical responses of drivers, which are very various on the roads with various traffic functions. A driver on a heavy duty road responds differently on road conditions than a driver on a local road of a home place. This finding enables rationalization of other parameters which decisively effect on road dimensioning like acceptable part of the coefficient of friction and drivers' reaction time. In this case the correct categorization is the most essential factor.

The obvious result of RACIPROC research is that the realization at road construction must be almost explicitly found at correct road categorization and the dimensions of road elements must be adapted to suitable traffic function. This means that we can not talk only about rationalization but also about optimization of technical elements of the roads.

Najpomembnejša spoznanja iz raziskave OPTIPROC o kategorizaciji in tehničnih elementih

Zato smo izdelali še študijo OPTIPROC, ki je v svojem I. delu obravnavala razloge in pogoje za novo kategorizacijo cest ter od nje odvisne racionalne dimenzije elementov cest v tlorisu in v profilu, v II. delu pa odvisnost dimenzij cest glede na stvarne prometne potrebe.

Sedanja razvrstitev cest v cestni mreži Slovenije (leta 1988) je bila izdelana na podlagi t.i. geopolitične razdelitve cest. Razvrstitev obsega 6 kategorij: avtoceste (AC), magistralne ceste (M1 in M2) in regionalne ceste (R1 in R2) v pristojnosti republike ter lokalne ceste (L) v pristojnosti občin. Pri tej kategorizaciji je bila najpomembnejši kriterij količina in vrsta prometnih obremenitev. Vendar se je od tega kriterija zelo pogosto odstopalo, kar kaže na podrejenost razvrščanja v kategorije političnim interesom lokalnih skupnosti (občin). Zlasti je to opazno pri uvrščanju cest v kategoriji M2 in R1. Tja so bile uvrščene tudi ceste, ki največkrat niso presegale funkcije lokalnih povezav in imele, v nasprotju s kriteriji, zelo skromno prometno obremenitev. Ker so bile vse ceste dimenzionirane samo na podlagi prometa in terena (YU-PPC), so nastale izredno velike razlike pri dimenzijah in zunanjemu videzu cest v isti kategoriji. Očitno je bil poglavitni cilj dosedanje kategorizacije določevanje prioritete pri vzdrževanju in obnavljanju cest ter zagotavljanju prevoznosti. Zato kategorija ceste sama ni imela nobenega vpliva niti na videz ceste in še manj na njene dimenzije, kar je v svetu normalno.

Raziskali smo pojem kategorije ceste. Kategorija ceste je določena vrsta ceste, ki z ustreznimi lastnostmi pri poteku skozi prostor omogoča izvajanje določene prometne funkcije; od najpomembnejše do najmanj zahtevne. Glede na vrsto prostora, po katerem poteka, so vzdolž ceste iste kategorije možne različne tehnične, gradbene in oblikovne rešitve. Te rešitve so zaradi različne pomembnosti cest pri različnih kategorijah različne. Zato smo uvedli pojem kakovosti ceste, ki ga opredeljujejo splošni strokovni kriteriji in družbeno verificirani atributi, prisojeni posamezni kategoriji ceste.

Splošni strokovni kriteriji za zagotavljanje različnosti med kategorijami cest so:

- prometna funkcija (daljinsko povezovanje, povezovanje, zbiranje in dostop)
- čas potovanja (potovalna hitrost, psihofizične lastnosti voznikov, zamude, tekoča vožnja in ustrezna kakovost uslug na cesti)
- vodenje skozi prostor (zunaj naselja, skozi naselje - obzidano, neobzidano)
- prometni režim (omejevanje uporabe, diferenciranje priključevanja drugih cest, ureditev križišč, dimenzioniranje profila cestišča, definiranje dopustnih hitrosti)
- varovanje in ohranjanje okolja (koncentracija težkega in sploh prometa na pomembnejših smereh, opredelitev stopenj zaščite, različnost pristopa pri projektiranju, pomembnost vpliva posameznih prostorskih omejitev)
- vodenje prometa (zahtevnejša ali skromnejša oprema ceste, kontinuiteta vodenja pomembnejše smeri v križiščih ipd)

The most important findings from OPTIPROC about categorization and technical elements

OPTIPROC in its first part deals with the reasons and conditions for a new road categorization and with the dependence of rational dimensions of road elements in layout and in profile. In its second part the research deals with the dependence of road elements dimensions regarding to actual traffic needs.

The existing road categorization in Slovenia was done in 1988 on the ground of so called geopolitical road division. It consists of 6 categories: motorways (AC), major roads (M1 and M2), regional roads (R1 and R2) under the authority of the State and local roads (L) under the authority of the community. The most important criterion was the quantity and structure of traffic volume. Because of political interests of loco communities this criterion was very often neglected. It was very obvious at road categories M2 and R1 where some roads were ranked higher than the criteria allowed. The dimensioning, related only to traffic volume and terrain, caused great differences at dimensions of the elements and at outlook of the roads of the same category. Obviously the main aim of former categorization was the determination of priority at road maintenance and reconstruction and to assure the passability. That is why the category itself did not have any influence on road outlook and dimensions of the elements what is normal in the developed countries.

First of all the term "category" was researched. The category of road is a definite kind of a road which with some suitable characteristics at its course through the landscape makes some traffic functions possible - from the last to the most demanding. Regarding the kind of landscape where it lies, all along the roads of the same category various technical, constructive and outlook solutions are possible. They differ from a category to a category. That is why we introduced the term "road quality" that is defined by general professional criteria and socially verified attributes added to each road category.

General professional criteria to assure the differences among categories are:

- traffic function (long distance, connection, collection and access)
- travel time (travel speed, psychophysical drivers' abilities, delays, current traffic flow, convenient level of service)
- tracing through the landscape (rural or urban roads)
- traffic regime (restrictions of the use, differentiation of connections, type of cross-roads, dimensioning of the elements of road cross-section, acceptable speeds)
- protection and preservation of the environment (concentration of heavy traffic on the main roads, step of protection, difference in designing, importance of the influence of landscape restrictions)
- traffic control (the quality of the equipment of road, continuity of the main traffic flow in the crossings)

According to these criteria the different dimensions of road elements and its outlook are defined. The step of quality for these parameters, awarded to each category of roads, depends of professional and general social deci-

Po teh kriterijih se za različne kategorije cest določijo različne dimenzije elementov in njihov zunanji izgled. Kako zahtevne naj bi bile izvedbe pri posamezni kategoriji pa je odvisno od strokovne in splošne družbene odločitve. Vse tovrstne odločitve so za posamezno kategorijo cest obveza in predstavljajo njen tehnični in/ali urejevalski pogoj - atribut.

V raziskavi smo predstavili 7 različnih skupin atributov, dodatne predloge pa pričakujemo Iz javne obravnave:

- funkcionalnost ceste (povezovanje v mreže, dopustnost priključevanja cest nižjih kategorij, dopustnost infrastrukturnih vodov v cestnem telesu, časovna dosegljivost ciljev, dopustnost nivojskega križanja z železnico ipd)
- prometne lastnosti (vrste uporabnikov, delež vozil v relativnem tranzitu, zagotavljanje prioritete vzdrževanja in obnavljanja ipd)
- prometna varnost (dopustna vozna hitrost, obveznost preverjanja voznodinamične ustreznosti ceste, dopustna prometna obremenitev, zahteva po ločenih voziščih za vsako smer vožnje, minimalne dimenzije elementov prečnega profila in dopustnost združevanja različnih uporabnikov, dopustnost različnih vrst združevanja tekočega in mirujočega prometa, vrsta in opremeljenost križišč, gostota in način priključevanja nekategoriziranih cest in individualnih lokacij, obseg in zahtevnost ter značilnost opreme na cesti ipd)
- ekološka vplivnost (različnost podrejanja ali prednosti pred zahtevami za varstvo in ohranjanje okolja, stopnja izvedbe zaščite ipd)
- tehnični parametri (možne računske hitrosti, dopustna izraba keoficienta drsnega trenja v radialni smeri, obveznost uporabe prehodnice, stopnja skladnosti zaporednih geometrijskih elementov, stopnja zagotavljanja čimbolj enakomerne vozne hitrosti, reakcijski čas, rezervacija ceste samo za motorni promet ipd)
- ekonomičnost (stopnja prometne izkoriščenosti - raven uslug, faznost gradnje, trajnost konstruktivnih elementov, zahteva po izračunu ekonomičnosti ipd)
- planske karakteristike (prioriteta zimske službe, prioriteta vzdrževanja in obnavljanja ipd)

Prometne obremenitve, ki je bila v dosedanji kategorizaciji zelo pomemben kriterij, tukaj ne najdemo, ker nima neposrednega vpliva na funkcionalnost cestne smeri. Vpliva namreč samo na dimenzije ceste v prečnem profilu in po potrebi na povečanje dimenzij elementov cestne osi zaradi zagotavljanja prepustnosti. Vsak drugačen pristop pomeni negospodarno obnašanje.

Za izvedbo kategorizacije se v stroki uporabljata funkcionalna in prostorska klasifikacija. Pri tem je dopustno in racionalno, da se v primeru močno različnih zahtev in možnosti uvedejo še podkategorije. Različnim podkategorijam cest je potem možno prisoditi diferencirane tehnične zahteve in pogoje. Za razvrščanje posameznih prometnih smeri v posamezno kategorijo je treba upoštevati:

- kategorizacijske kriterije (pomembnost smeri, prostorsko razsežnost, vrsto prometne funkcije in delež relativnega tranzitnega prometa) in
- omejitvene kriterije (zgoščenost cest v cestni mreži, dopustna kategorija vzporednih cest in reliefne omejitve).

sion. All these decisions become the obligation and can be considered as technical or designing conditions - attributes. In our research-work we have suggested 7 different attributes:

- functionality of the road (forming of road-nets, lower category connections, infrastructure objects in road cross-section, considerable travel time between neighbour urban centers, allowance of level railway crossings)
- traffic features (type of users, share of vehicles in relative transit, priority of maintenance)
- traffic safety (speed limitation, obligatory checking of drive dynamic suitability of the road, traffic volume, demand for the separation of the carriageway, minimal element dimensions of cross-section and allowance of various users implementation in it, kind and equipment of crossroads, density and the mode of points of access of non-categorized roads and individual locations, quantity and quality of the equipment on the road)
- ecological influence (higher or lower, different steps of protection and preserving)
- technical parameters (possible design speed, allowed value of friction coefficient in radial direction, obligatory use of transition curve, step of coordination of successive geometrical elements, assuring of the most equal drive speed along the road, driver's reaction time)
- economy (level of traffic exploitation - level of service, phase build-up possibility, demand of durability of construction elements, demand for economical calculation)
- planning characteristics (winter service priority, maintenance and re-building priority)

Traffic volume, which was very important criterion in the former categorization, is not present in these criteria and attributes, because it does not have a direct influence on the functionality of a road direction. It has its influence only to the number and dimensions of traffic lanes and if necessary for increasing of dimensions of road axis elements to assure the flow. Any other treatment will be considered as uneconomical.

To realize the categorization in practice a functional and landscape classifications are used. It is rational and acceptable that in case of strongly different demands additional sub-categories can be introduced. For the ranking of the roads in the road-nets following criteria are to be considered:

- criteria of categorization (importance of the connection, spacious extensivity, kind of traffic function, share of relative transit traffic) and
- restrictive criteria (density of roads in road-net, allowed category of parallel roads, relief restrictions)

A sample of a new road categorization was achieved. The quality of each category was presented with suitable attributes, different for rural and urban roads. We also suggested the naming of the roads of individual category, when passing the urban zone. The graphic presentation (map) was shown too. The basic attribute of each category is the travel speed, which in connection with defined traffic flow and restrictions in the landscape identify so called design speed, to which all dimensions of the elements are related. Due to different demands of traffic function all other influential parameters (friction, reaction)

V študiji smo izdelali konkreten predlog nove kategorizacije cest, z atributi pokazali kakovost posamezne kategorije v zunajurbanem in urbanem prostoru, predlagali poimenovanje cest v urbanem prostoru, ki ustreza posamezni kategoriji in izdelali grafični prikaz. Osnovni atribut je potovalna hitrost, ki v povezavi z opredeljeno prepustnostjo in omejitvami v prostoru opredeljuje t.i. računsko hitrost in s tem dimenzije tehničnih elementov cest. Različne stopnje zahtevnosti drugih vplivnih parametrov (trenje, reakcijski čas), ki dodatno vplivajo na velikost teh dimenzij, so pri tem odvisne od zahtevnosti prometne funkcije. Vse ostale odvisnosti so pogojene s fizikalnimi zakoni in vozno dinamiko in tega ni možno spreminjati.

Najpomembnejša spoznanja iz raziskave OPTIPROC o dimenzijah vozišča

Dimenizije širine vozne in njej vzporednih površin so odvisne predvsem od prometne obremenitve in z njo povezane prepustnosti, prometne varnosti in gospodarnosti in le posredno vplivajo na višino vozne hitrosti. Določilo YU-PPC, da je širina voznega pasu odvisna izključno od računske hitrosti, ni sprejemljivo. Tuje raziskave (Köppel, Nemčija) in domača opazovanja so pokazala, da je vozna hitrost na cesti odvisna predvsem od iztegnjenosti posamezne trase in seveda od gostote prometnega toka in bolj malo od same širine voznega pasu. Nasprotno pa večja širina voznega pasu omogoča svobodnejšo izbiro vozne linije v krivinah ("sekanje" ovinkov) in s tem večjo iztegnjenost trase ter višjo hitrost. Nepotrebno široki vozni pasovi so torej neracionalni in v nasprotju z načelom omejevanja voznih hitrosti, ki je že dalj časa prisotno po vsem svetu.

Odvisnost širine voznega pasu od prometne obremenitve ni posebej izrazita. Ugotovljeno je, da širine nad 3,50 m skoraj ne prispevajo povečanju prepustnosti, medtem ko je znatno zmanjšanje prepustnosti (nad 15%) opazno šele pri širinah voznih pasov pod 3,0 m. Nekaj temu prispeva še vzdolžna ureditev ob vozišču (bankina), vendar ne bistveno. Zato večina držav sedaj opušča širino voznega pasu 3,75 m in uveljavlja kot največjo širino 3,50 m. V ZDA je največja širina voznega pasu določena na 3,65 m. Ni razloga, da bi v Sloveniji ravnali drugače.

Vpliv širine voznega pasu na prometno varnost gotovo obstaja. Vendar so pri tem neke značilnosti. Bistvene razlike med stopnjami prometne varnosti pri širinah med 3,25 m in 3,75 m ni. Pri ožjih voznih pasovih se ta stopnja poveča, če je prisoten velik delež težkih vozil, sicer pa ne. Najbolj značilno pa je, da je ta stopnja precej večja od običajne pri sorazmerno majhni prometni obremenitvi (pod 5000 vozil/dan). Temu so vzrok višje vozne hitrosti vozil v prostem prometnem toku. Trditev, da je širši vozni pas prometno varnejši, torej ne drži vselej!

Širina voznih pasov naj bi bila zato odvisna predvsem od kategorije ceste in strukture prometne obremenitve ter oblike izvedbe obcestja. Za primer: dvignjen robnik zahteva širino voznega pasu najmanj 3,25 m, če so v strukturi prometa tudi redni avtobusi ali znatno število težkih vozil. Vsako dodatno širjenje voznih pasov je pogojeno izključno le z zahtevano prepustnostjo.

additionally effect on the size of these dimensions. All other relations are regulated by physical laws and drive dynamic and can not be changed.

The most important findings from OPTIPROC about carriageway dimensions

The width of a road surface and parallel areas are dependant from traffic volume, capacity, traffic safety and feasibility of the road. They have only indirect effect to the height of driving speed. Foreign research (Köppel, Germany) and our observations proved that the driving speed depends above all on extension of individual trace and on density of traffic flow and less on the very width of a lane. On the other side larger width of a traffic lane enables freer choice of driving line in curves ("cutting" the curves) that causes larger extension of trace. Higher speed is a normal result. Unnecessary wide driving lanes are illogical and in the opposition to the principle of driving speed reduction, which is very actual for some time.

The dependence between the width of a lane and traffic volume is not extra evident. It is found out the widths above 3,5 meters contributed hardly anything to increase the capacity. On the other hand a greater decrease of capacity is evident with the widths under 3,0 meters. The shoulder contributes in some extent, but not essentially. So the width of lane 3,75 meters has been slowly dropping in several states and 3,50 meters is being introduced. There is no reason the widths will be different in Slovenia.

The influence of the lane-width on traffic safety surely exists. But there are some characteristics. No essential differences among the degrees of traffic safety are found out for the dimensions among 3,25 and 3,75 meters wide lanes. By narrower lanes this degree increases if a great part of heavy vehicles is present. It is the most essential that this degree is much higher at a comparatively low traffic volume (under 5000 v/d). The reason is higher driving speed in a free traffic flow. The statement that a wider lane is safer is not always valid!

The lane width could be dependant from a road category, from the structure of traffic volume and from the form of by-carriageway elements. E.g.: high curb demands at least 3,25 meters wide lane if there are line buses or a considerable number of heavy vehicles on the road. Any additional widening of lanes depends exclusively to assure the demanded capacity or LOS.

The capacity (or service volume) depends on lane width, on the arrangements on sides of a carriageway (obstacles and their distance) and on trace extension (design speed). The basic indicator is "travel speed" where psychophysical abilities of drivers are taken into consideration as well as travel time economy and the lowest quantity of the exhaust gases and noise. In connection with defined service volume this speed enables to get the design speed and all the dimensions depended of it. The service volume is well known as traffic flow under certain LOS conditions - travel speed and density of traffic flow. In this parameter also the economy of investment can be found. So we suggest for this parameter a new expression "degree of traffic suitability" (SPU).

Prepustnost je (bolj malo) odvisna od širine voznih pasov, ureditev ob vozišču (oddaljenost in oblika ovir) ter od iztegnjenosti trase (računske hitrosti). Njen osnovni kazalec je potovalna hitrost, s katero upoštevamo psihofizične sposobnosti voznikov, ekonomiko časa potovanja in najmanjšo količino škodljivih emisij vozil na posamezni cesti. Ta hitrost v povezavi z opredeljeno stopnjo izkoriščenosti kapacitete ceste omogoča, da se določi računska hitrost ceste in z njo vse tehnične dimenzije. Stopnjo izkoriščenosti kapacitete ceste poznamo v stroki kot LOS (level of service - ZDA), ki označuje stopnjo usluge, ki jo cesta nudi uporabnikom - potovalno hitrost in gostoto prometnega toka. Ker se v tem parametru "skriva" tudi gospodarnost investicije, predlagamo zanj izraz "stopnja prometne ustreznosti" (SPU), saj istočasno zagotavlja predvideno potovalno hitost, dopustno izkoriščenost kapacitete ceste in optimalne dimenzije elementov.

Da bi zagotovili racionalnost in tipičen zunanji videz cest posamezne kategorije, je treba zanje določiti minimalne in alternativne normalne prečne prereze (NPP). Izdelali smo tak predlog in vzporedno pokazali še ureditve ostalih površin v profilu (obcestje). Le-te so v mnogočem odvisne tudi od možnosti vzdrževanja (n.pr. širina stroja za košnjo v ločilnem pasu) in jih je smotrno poenostaviti in poenotiti. Predlagani NPP za avtoceste so bili medtem že upoštevani v Nacionalnem programu izgradnje avtocest v Sloveniji. Ostali NPP so še v pripravi.

PREDLOG NOVIH SMERNIC ZA PROJEKTIRANJE CEST (SPC)

Dosedanji YU-PPC je obravnaval samo elemente cestne osi in profila vozišča. Zato smo predlagali, da se izdelajo tudi smernice za izvedbo križišč, servisnih površin ob cestah, odvodnjavanja, obcestja, ekologije pri načrtovanju cest in prometne opreme. Smernice za dimenzioniranje elementov cestne osi in profila, ki jih izdelujemo, so sedaj v strokovni obravnavi na Ministrstvu za promet in zveze.

Pri izdelavi predloga smo upoštevali določila predloga novega Zakona o cestah, tuje smernice (Nemčija, Avstrija, Francija, Hrvaška, ZDA) in ugotovitve lastnih raziskav. Poglavja SPC so:

1. Uvodna določila (splošna določila, položaj ceste v prostoru)
2. Razvrstitev cest (upravna kategorizacija, tehnična razvrstitev)
3. Osnove za določitev tehničnih elementov (merodajne hitrosti, voznodinamične količine, voznodinamične zahteve, normalni prečni profil, karakteristični prečni profil)
4. Prometno dimenzioniranje (prometna obremenitev, merodajna prometna obremenitev, prepustnost, dopustna izraba kapacitete, tipični NPP po kategorijah)
5. Preglednost (zaustavna dolžina, zaustavna preglednost, prehitevalna preglednost, pogoji za zagotavljanje preglednosti)
6. Horizontalni elementi cestne osi (prema, krožni lok, prehodnica)
7. Elementi v podolžnem profilu (niveleta, podolžni nagib, zaokrožitve)

To assure the rationality and a typical road outlook of each category, minimal and alternative normal cross-sections (NPP) must be defined. Such a suggestion was found and parallel we showed also the arrangements of by-carriageways elements. They are much dependent on the maintenance possibilities (e.g. width of a grass-enter mover in lane separator) and they need simplification and unification. The suggested NPP for motorways have already been taken into consideration in the National program for motorways in Slovenia. Other profiles are in preparation.

SUGGESTION FOR A NEW APPROACH FOR ROAD DESIGNING

The existing YU-PPC was dealing only with elements of center-line tracing. Therefor we suggested that new approaches for cross-roads designing, service-areas, drainage, by-carriageway elements, ecological designing and traffic equipment should be additionally executed. Our proposal for new approach for road designing (SPC) is already in the revision by Ministry of traffic and communications.

Designing this approach we considered definitions for new Slovenian Road Code, foreign directions (Germany, Austria, France, Croatia, US) and the results of our own researches. The chapters of SPC are:

1. Introductory specifications (general regulations, road and landscape)
2. Road classification (Road Code classification, technical classification)
3. Bases for determination of technical elements (allowed speeds, drive-dynamic qualities, drive-dynamic demands, normal cross-sections, characteristic cross-sections)
4. Traffic dimensioning (traffic volume, maximum hourly volume, capacity, degree of traffic suitability, typical NPP according to categories)
5. Sight distance (stopping length, stopping sight distance, overtaking distance, conditions for reassuring sight distance)
6. Horizontal elements of axis (straight, arc, transition curve)
7. Elements in longitudinal profile (nivelete, gradients, vertical alignment)
8. Elements in cross-section of carriageway (kinds of gradients, limit values of gradients in arc, screwing, widening in curves, widening for additional lane)
9. Loop curves
10. Compulsory details (curbs, safety rails)

The main characteristic of new SPC is that they are prepared for designing all public roads - urban and rural. To overcome the definitions of the Road Code regarding categorization that officially classified urban roads differently than rural ones and to notify these categories regarding to types of users (traffic function), we introduced technical road classification. It consists of 4 groups (A, B, C and D) with typical driving-dynamic demands. Group A has the greatest driving-dynamic demands and in the group D are the roads where only passability is to assure, without any driving-dynamic demands.

8. Elementi v prečnem prerezu vozišča (vrste nagibov, mejne velikosti, velikosti v krožnem loku, vijačenje, posebnosti, razširitve v krivinah, razširitve za dodatne pasove)
9. Serpentine
10. Obvezni detajli (robniki, varnostne ograje)

Poglavitna značilnost novih SPC je, da so namenjene za projektiranje vseh javnih cest - urbanih in zunajurbanih. Da bi presegli določila zakona o cestah glede kategorizacije, ki upravno razdeli urbane ceste drugače kot zunajurbane, in istočasno te kategorije opredelili glede na tipične uporabnike (glede na prometno funkcijo), smo uvedli tehnično razvrstitev cest. Le-ta obsega 4 skupine (A,B,C in D) s tipičnimi voznodinamičnimi zahtevami (izraba trenja, reakcijski čas, obveznost skladnosti elementov in uporabe prehodnice, prehitevalna preglednost). V skupino A so uvrščene ceste z največjimi voznodinamičnimi zahtevami, v skupino D pa tiste ceste, na katerih je treba zagotavljali zgolj prevoznost brez voznodinamičnih zahtev.

Vse po zakonu o cestah določene kategorije cest smo razvrstili v te 4 skupine in jim določili potovalno hitrost in druge voznotehnične lastnosti (vrsta prometa, dopustna hitrost, NPP, tipe križišč in možne zasnovalne hitrosti). Vse hitrosti so določene v razponih in omogočajo projektantu izbiro glede na omejitve v reliefu in prostoru sploh. Pri tem je treba posebej poudariti, da so predlagane dopustne hitrosti take, da odsevajo realna dogajanja in obenem omogočajo normalno izrabo voznih površin v različnih okoljih. Privzet je sistem hitrosti 50, 70, 90, 110 in 130 km/h, ki glede na sposobnosti vozil omogoča uporabo ustreznih prestavnih razmerij pri manjših obratih v motorju. Obenem je to tudi bistvena ekološka prednost. Hrup motorja je tedaj minimalen in emisije plinov v mejah sprejemljivosti. Predlog je v izrazitem nasprotju s predlogom novega Zakona o varnosti v cestnem prometu.

V SPC je opredeljen postopek za izračun prepustnosti in navedene merodajne količine, ki jih je treba upoštevati kot prometno obremenitev, kadar poseben izračun ni zahtevan. Naveden je tudi postopek izračuna za primer uvedbe dodatnih pasov za težka vozila. Dodatni vozni pasovi za težka vozila se na koncu ne zaključujejo (kot sedaj), ampak se tam zaključuje prehitevalni pas. S tem želimo preprečiti težave, ki nastajajo na tem mestu pri vključevanju težkih vozil, ko se gostota prometa na cesti zelo poveča. Seveda je pri izvedbi zaključevanja prehitevalnega pasu upoštevana visoka vozna hitrost in predvideni ukrepi za zagotavljanje prometne varnosti. Za enostavnejšo uporabo so po nemškem vzorcu pokazani za vsako kategorijo cest možni NPP in njim pripadajoče količine pri določeni stopnji izkoriščenosti kapacitete (potovalna hitrost, število vozil).

Nanovo smo uvedli pojem projektne hitrosti. To je hitrost, ki jo omogočajo dejanski geometrijski elementi ceste (v projektu ali na obstoječi cesti) in jo v stroki poznamo kot hitrost v prostem prometnem toku ($V_{85\%}$). Običajno se ta pokaže s profilom projektne hitrosti. Navedene so vse obveznosti, ki nastajajo s tem v zvezi.

Uvedli smo novo PIARC formulo za največjo dopustno vrednost koeficienta drsnega trenja in izračunali zaustavne razdalje po točni formuli (integral). Odpravili smo doseda-

All the categories defined according the Road Code are lined into one of the 4 groups. For each of these groups different travel speed and other driving-technical features (traffic mode, speed limit, NPP, types of crossings, design speed) are defined. All the speeds are defined in spans and allow the designer the choice regarding to the landscape restrictions. It is necessary to emphasize that the suggested speed limits reflect the actual happening and allow a normal use of driving areas in different surroundings at the same time. The system 50, 70, 90, 110 and 130 km/h was taken which regarding the ability of vehicles allows at the same time the use of available gear relation at lower turnings of the motor. This means the essential ecological advantage. The engine noise is then minimal and the exhaust gases are still acceptable. Our proposal is in great opposition with the proposed new Slovenian Traffic Safety Code.

In SPC the procedure for the calculation of capacity is defined as well as the volume quantities that must be considered when a special traffic study is avoided. The procedure for the calculation of additional lane(s) for heavy vehicles is cited. A new suggestion about the finish-part of the additional lane for heavy vehicles is given. Instead of additional lane the overtaking one is ended. We would like to prevent the troubles that arise at the section where heavy vehicles merge to the right lane in the conditions of great density of traffic flow. It is obvious that a very high operating speed on the overtaking lane needs special length of "safety area" to reduce speed and to merge to neighbor lane. To be easily used, following the German sample, all possible NPP, equipped with the quantities of service volume and travel speeds for each category are given.

The term of "operating speed" was newly introduced. This is the speed that is actually allowed (in a design or on the existing roads) by geometrical elements of road. In our branch it is known as the speed along the road in free traffic flow conditions ($V_{85\%}$). Usually it is shown in an operating speed profile. All obligations concerning this speed are quoted.

A new PIARC formula for limit value of coefficient of friction was introduced and new sight distances were calculated following the exact formula. We abolished the existing definitions about three possible sight distances (on the dam, normal and STOP) in YU-PPC. It is let to designers to choice and to explain any other value if needed. The definition for overtaking distances was corrected. Minimum lengths were defined as an envelope of minimum possible values for different speeds of vehicles included. A special computer program was prepared for this job.

The limit values of all geometrical elements were defined for each technical group separately. So each group has its own value for minimal radii of circle, different transition-curve length and limit down-grade. The latter was defined regarding the designing speed which by itself restricts its maximum value. This maximum value is in the correlation with the friction coefficient and does not depend on traffic volume or terrain conditions as it has been defined in YU-PPC. For all geometrical elements special restrictions for the use in the area of very important objects (viaducts,

nja določila o treh možnih zaustavnih razdaljah (na nasipu, normalna in STOP) in prepustili projektantom, da v posebnih pogojih sami utemeljijo drugačne dimenzije. Prehitevalno razdaljo smo raziskali s posebnim računalniškim programom. Ovojnica najmanjših razdalj, izračunanih pri različnih razmerjih voznih hitrosti udeleženih vozil in izrisanih v diagramu, predstavlja minimalne potrebne dolžine.

Velikost mejnih geometrijskih elementov smo opredelili za vsako tehnično skupino cest posebej. Na ta način smo dosegli racionalizacijo tehničnih elementov glede na prometno funkcijo, ki jo ima posamezna kategorija ceste. Maksimalno vrednost vzdolžnega nagiba smo opredelili glede na računsko hitrost, ki sama po sebi omejuje njegovo velikost. Posredno je tu upoštevan vpliv koeficienta trenja in ne vpliv velikosti prometne obremenitve ali terenskih pogojev, kot je bilo to v YU-PPC. Za vse geometrijske elemente smo zapisali tudi določila o njihovi uporabi v območju zahtevnih objektov (viaduktov, predorov, križišč ipd), česar v YU-PPC ni. Velikost sedanjega maksimalnega prečnega nagiba v loku smo ohranili in dopustili njegovo izjemno povečanje za 1% (na 8%), kadar pri obnovi obstoječih cest z drugačnim ukrepom ni mogoče urediti voznodinamičnih razmer v posameznem krožnem loku.

Zaradi uvedbe projektne hitrosti smo izključili možnost proste izbire minimalne velikosti prehodnic. Ker obstaja neposredna voznodinamična soodvisnost velikosti polmera krožnega loka in možne vozne hitrosti na njem, je minimalna velikost prehodnice za ta polmer samo ena. Vsakemu polmeru torej pripada samo ena minimalna velikost parametra prehodnice. Ta določitev omogoča spremembe v tehnologiji projektiranja cestne osi z računalnikom.

Z novimi SPC želimo omogočiti projektantom kreativno delo, investitorjem gospodarno investiranje in uporabnikom prometno varno ter prometnim potrebam ustrezno uporabo ceste, ki naj bi imela na okolje čimmanj kvarnih vplivov. Predvsem pa s temi SPC izenačujemo tehnične pogoje in zahteve na vseh cestah - urbanih in zunajurbanih, saj smo dosedaj projektirali ceste v urbanih okoljih kar po YU-PPC, kar je bilo neracionalno. Izjema je Mesto Ljubljana, ki ima svoj Pravilnik za projektiranje mestnih cest.

tunnels, crossings) have been given. The value of existing radial grade of carriageway in arc was obtained. Additionally an extreme increase of 1% (to 8%) was allowed to apply in special conditions of re-building of existing carriageway where no other solution is available to avoid driving-dynamic danger in circle.

Introducing of an operating speed it is not reasonable to allow completely free choice of minimal length of transition curve for different radii of circles. There is a direct driving-dynamic connection between a circle arc radius and operating speed in this arc and the minimum length of transition curve is only one - driving-dynamic defined. So each radius of circle has its own length of transition curve. This solution enables new possibilities for the computer created road axis.

With a new SPC we wish to enable a quality work of designers, rational investments for the investors and a safe and to traffic needs suitable use of the road with minimum damage to the environment. Above all we want to identify technical conditions and demands on all roads - rural and urban and to get them rational solutions about dimensions and shape.

PROSTORSKI INFORMACIJSKI SISTEM EVROPSKIH AVTOCEST

EUROPEAN MOTORWAY DATABANK and GIS

UDK: 656.13(4):007.52

DUŠAN FAJFAR*, TOMAŽ KASTELIC, TONE ŽAGAR

POVZETEK

Konec leta 1994 je mednarodna cestna zveza (IRF – International Road Federation, Geneva, Switzerland) zbrala in izdala osnovne podatke o avtocestnem omrežju v Evropi. V bazi so zbrani podatki o obstoječi in o načrtovani avtocestni mreži. Podatki avtocestnega omrežja obsegajo na primer lokacijo in dolžino avtocestnega odseka, status odseka, število voznih pasov, povprečni dnevni promet ločeno za osebna in tovorna vozila, vrsto vozne površine, podatke o prometni varnosti, upravljalca ceste, prioriteto izgradnje načrtovanih odsekov, itd. Vsi podatki opisujejo trenutno stanje, prav tako pa je podana tudi napoved za leto 2010. Banka avtocestnih podatkov je bila izvedena s programskim paketom MS ACCESS. Zbrane podatke je možno predstaviti v obliki različnih tabelaričnih poročil, dopolnjenih z ustreznimi grafikoni. Vendar pa uporabnik običajno le s težavo ustvari pravo sliko stanja na avtocestnem omrežju zaradi velike količine podatkov. S prostorsko predstavitvijo podatkov bi banka avtocestnih podatkov dobila novo vrednost. Za ta namen sta IRF in Prometnotehniški inštitut (PTI) Fakultete za gradbeništvo in geodezijo v Ljubljani bazo dopolnila z geografskim informacijskim sistemom (GIS). Omrežje avtocest je bilo digitalizirano in razdeljeno na posamezne odseke v skladu s podatkovnim modelom. Za osnovno orodje prostorskega informacijskega sistema smo izbrali programski paket ARCVIEW. Za ostale prostorske informacije, ki rabijo kot ozadje, smo uporabili publikacijo Digital

SUMMARY

European Motorway Databank was established by the International Road Federation (IRF), Geneva, Switzerland. Beside the data, which exactly describe the motorway network geometry, different data like status of construction, number of lanes, traffic volumes, traffic safety data, management and financing data, etc. for present and future situation were collected for each motorway section. Motorway databank was implemented by the MS ACCESS. The presentation of the collected data was possible only as different reports, tables, charts, etc. In this way user can get large amount of exact data, but from which is very hard to get clear picture of the situation on the motorway network. With the graphical presentation of the motorway data the databank will get new value. For this reason the IRF and the Traffic Technical Institute, University of Ljubljana, Slovenia developed a GIS extension of the Motorway Databank. Motorway network was digitised and segmentation was done according to the database model. As a presentation tool we select ARCVIEW 2.0. For background information of space we use Digital Chart of the World. In this way we get very powerful, easy to use and nonexpensive tool to manage and to present the European motorway database. In the May of 1995 the pilot project for Austria and Slovenia was presented at the IRF meeting in Glasgow, Scotland where was decided to implement the next step of the project to cover whole Europe motorway network.

AVTOR:
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Chart of the World. Na ta način smo dobili zelo močno, enostavno in ne predrago orodje, ki pomaga pri upravljanju in predstavitvi baze podatkov evropskih avtocest. V maju 1995 je bil na srečanju IRF članov v Glasgowu na Škotskem predstavljen pilotski projekt za območje Avstrije in Slovenije. Projekt je bil zelo pozitivno ocenjen in je prejel vso podporo za razširitev na območje celotne Evrope.

UVOD

International Road Federation (IRF), Geneva, Switzerland je v nekaj zadnjih letih vzpostavila Banko podatkov evropskih avtocest. Najprej je bil razvit podatkovni model, kjer so se odločili za fiksne avtocestne odseke. S pomočjo lokalnih IRF organizacij v posameznih državah se avtocestno omrežje razdelili na odseke in vsakemu odseku določili enoličen identifikator, ki predstavlja ključ dostopa do podatkov za celotno bazo. Za vsak avtocestni odsek so poleg podatkov, ki natančno opisujejo lokacijo odseka, zbrani tudi podatki o status odseka, številu voznih pasov, povprečnem dnevnem prometu ločeno za osebna in tovorna vozila, vrsti vozne površine, podatki o prometni varnosti, upravljalcu ceste, prioriteti izgradnje načrtovanih odsekov, itd. Vsi podatki opisujejo trenutno stanje, prav tako pa je podana tudi napoved za leto 2010.

Banka podatkov evropskih avtocest je vzpostavljena na osebnem računalniku v okolju WINDOWS s programskim orodjem MS ACCESS. Podatki so razdeljeni glede na vsebino in shranjeni v različnih tabelah. Trenutno so v bazi podatki za prek 1700 avtocestnih odsekov, baza pa bo s priključevanjem novih območij še naraščala. Različnim uporabnikom so podatki na voljo v obliki različnih poročil, tabel, grafikonov in podobno. Na ta način uporabnik dobi ogromno natančnih podatkov o avtocestnih odsekih, vendar si iz teh podatkov le s težavo ustvari pravo sliko stanja na omrežju. Na primer: na podlagi tabelaričnih podatkov si uporabnik le s težavo ustvari sliko prometnih tokov v neki državi.

Z grafično predstavitvijo avtocestnih podatkov pridobimo tem podatkom novo uporabno vrednost. Za ta namen je bilo vzpostavljeno sodelovnaje med IRF in Prometnotehniškim inštitutom (PTI) Fakultete za gradbeništvo in geodezijo v Ljubljani. PTI s svojimi večletnimi izkušnjami na področju geografskih informacijskih sistemov, še posebno v prometu, je prevzel nadgranjo obstoječega sistema v sodoben prostorski informacijski sistem.

BANKA AVTOCESTNIH PODATKOV IN GIS

Cilji sistema

Osnovni cilj nadgradnje Banke avtocestnih podatkov z GIS je omogočiti uporabo in razumevanje zbranih podatkov vsem ljudem, ki jih to zanima, in jim dati natančne, hitre in jasne odgovore na zastavljena vprašanja. Sistem ponuja boljši pregled tabelaričnih podatkov s pomočjo grafične predstavitve in uporabniku ponuja kartografski pogled vseh ali pa le izbranih podatkov. Poleg tega sistem v veliki meri pomaga pri odpravljanju napak, tako pri samih definicijah avtocestnih odsekov kot pri opisnih podatkih vezanih za te odseke.

INTRODUCTION

In the last years European Motorway Databank was established by the International Road Federation (IRF), Geneva, Switzerland. First database model was developed and principle of fixed motorway sections was accepted. With the help of local IRF organization in each country motorway network was divided into the sections where each got unique identification number which is the key for the whole database. For each road section beside the data, which exactly describe the motorway section location, different data like status of construction, number of lanes, traffic volumes, traffic safety data, management and financing data, etc. for present (year 1994) and future (year 2010) situation were then collected.

Motorway databank is implemented on personal computer in WINDOWS environment by the MS ACCESS software. Data are stored in different tables according to the subject. Already more than 1700 motorway sections is described in the database and the database will grow with the time while new areas will be added. As the database output material for different users reports, tables, charts, etc. were produced mostly. In this way users can get exact data about the motorway system but because of the large amount of the data such a presentation is not so successful. For instance for user it is very hard to get impression of the traffic flows in some country only on the base of tabular data.

With the graphical presentation of the motorway data the databank gets new value. For this reason the cooperation between the IRF and the Traffic Technical Institute, University of Ljubljana, Slovenia as the Geographic Information System specialist was established.

MOTORWAY DATABANK AND GIS

System goals

The primary goal of the GIS extension of the Motorway Databank is to enable using and understanding of collected motorway data to all interested people and to give quick, clear, accurate and easy to understand answers to all questions related to the motorway network. The system offers more powerful view of the tabular database through a graphical presentation and gives the users an overall or selective cartographic view of the data collected in the motorway databank. Beside this the system helps to manage consistency and correctness of the data collected.

Implementacija sistema

Za transformacijo IRF Banke avtocestnih podatkov v GIS moramo najprej vključiti prostorske informacije. Zato potrebujemo lego in potek avtocestnega omrežja v digitalni obliki, poleg tega pa moramo vsakemu odseku določiti enolični identifikator po specifikaciji obstoječe Banke avtocestnih podatkov. S pomočjo te enolične identifikacije lahko nato priključimo poljubne podatke iz obstoječe baze.

Na podlagi naših izkušenj s podobnimi GIS projekti smo za osnovo izbrali ARC/INFO podatkovni format za prostorske podatke in ARCVIEW za WINDOWS kot prezentacijsko orodje. ARCVIEW smo izbrali, ker ponuja vse in celo več, kot končni uporabniki zahtevajo in pričakujejo od sistema, program je uporabniku prijazen in enostaven za uporabo, poleg tega pa teče v istem okolju, kot je že realizirana obstoječa Banka avtocestnih podatkov (MS WINDOWS – MS ACCESS). Prav tako imamo znotraj paketa ARCVIEW neposredni dostop do baze v MS ACCESS skozi SQL povezavo in tako lahko zgradimo učinkovit sistem brez najmanjše spremembe v obstoječi bazi.

Samo prostorska predstavitev avtocestnega omrežja nam ne da dovolj informacij, da bi si ustvarili pravo sliko o situaciji. Dodati moramo še nekaj informacij, ki rabijo kot pomoč pri orientaciji v prostoru. Za ta namen smo uporabili podatke iz publikacije Digital Chart of the World (DCW). V DCW so zbrani digitalni prostorski podatki za celoten svet v merilu 1:1000000 (1:milijon), kar je praktično idealno za potrebe projekta, ki pokriva večje območje, kot je na primer Evropa. V naš sistem smo vključili naslednje sloje iz DCW:

- meje držav
- območja večjih urbanih poselitev
- teren (plastnice)

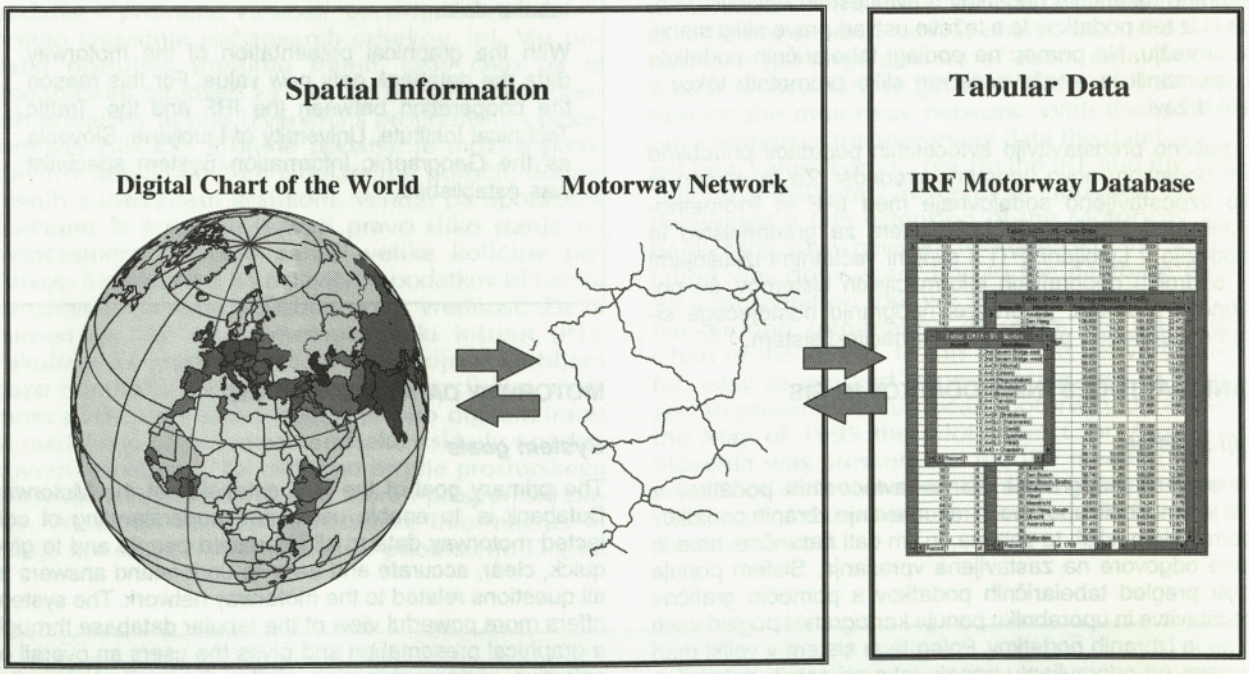
System implementation

To transform IRF Motorway Databank to an GIS first a spatial information must be added to the system. For this reason the motorway network must be prepared in digital format and section identificator associated with each motorway section. After that the content of the Motorway Databank is linked to the motorway network through the unique motorway section identificators.

On the base of our experience with GIS we select ARC/INFO data format for spatial data and ARCVIEW 2.0 for WINDOWS as the presentation tool. We select ARCVIEW 2.0 because it offers all and even more what the end users expect from the system, it is easy to use and runs in the same environment as existing Motorway Databank (MS WINDOWS - MS ACCESS). Also from the ARCVIEW we have direct access to MS ACCESS database through the SQL connection and we can build powerful system without any database transformation.

Only spatial presentation of the motorway network does not give enough information to end user to get clear picture of the situation. We must add some background spatial information and we use Digital Chart of the World (DCW) data for this purpose. The scale of the DCW data (1:1000000) is very appropriate for an overview project which cover all Europe. In the system we include the next layers from DCW:

- country boundaries
- boundaries of main urban areas
- elevation levels
- main rivers
- main railway lines
- main roads



Slika 1: Komponente podatkovne baze geografskega informacijskega sistema

Picture 1: Geographic information system database components

- vode (morje, glavne reke in jezera)
- glavne železniške linije
- glavne ceste
- večja pristanišča
- pomembnejše energetske vode

S tako kombinacijo programskega paketa ARCVIEW in DCW prostorskih podakov smo dobili učinkovito, vendar kljub temu poceni rešitev, ki nam omogoča prostorsko predstavitev Banke avtocestnih podatkov.

Z implementacijo sistema lahko uporabnik izrisuje, analizira in poizveduje po podatkih v bazi. Nekateri standardni pogledi in izrisi so v sistemu že v naprej pripravljeni:

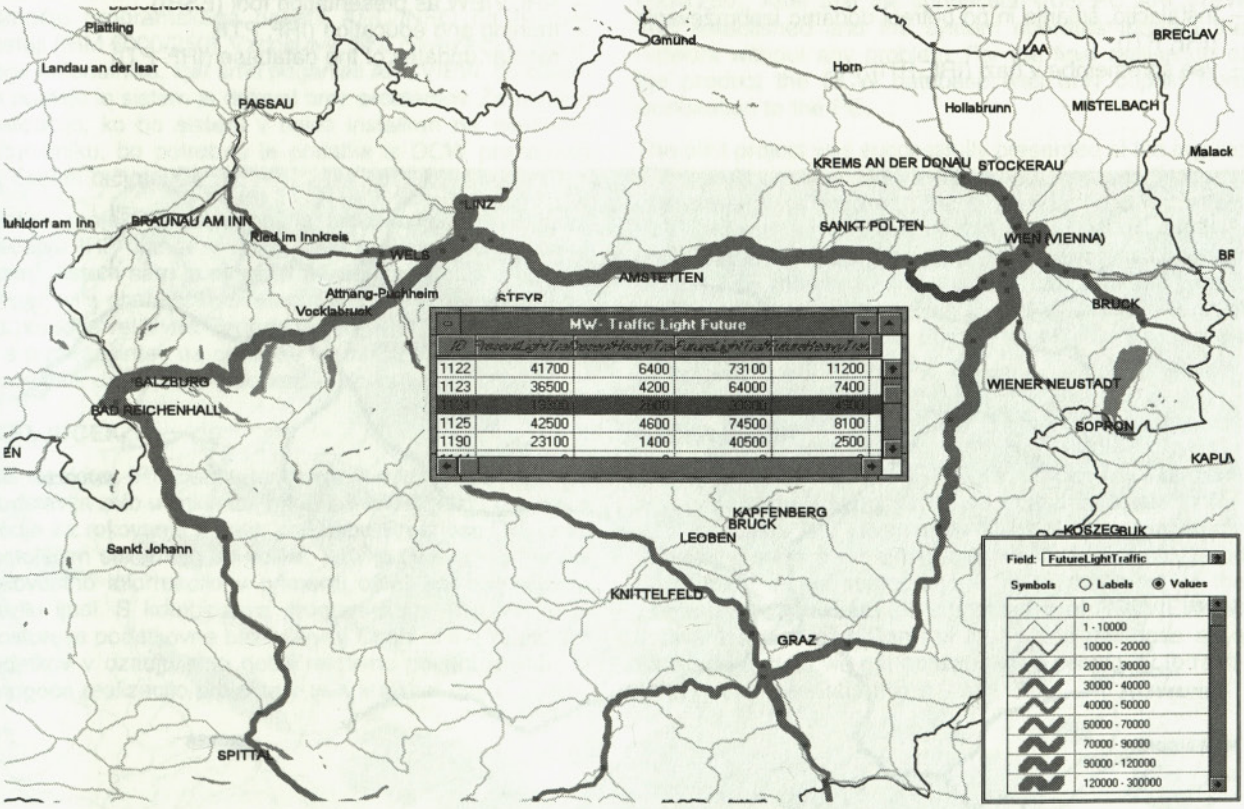
- mreža avtocestnih odsekov z vozlišči (z imeni večjih lokacij v soseščini)
- status izgrajenosti avtocestnih odsekov
- prometni volumni (obstoječi/planirani) na teh odsekih (proporcionalni pogled)
- vrsta obrabnega sloja
- število voznih pasov
- vrsta lastništva in vrsta pobiranja cestnine

- main harbours
- main utility lines

With the combination of the ARCVIEW software and Digital Chart of the World data we get a nonexpensive solution to present IRF Motorway Databank graphically.

With the implemented system users can display, query, analyse and plot the contents of the Motorway Databank. In the system some views and different layouts are prepared in advance, like:

- existing motorway sections and sections to be realised (differentiated by colour or typography according to realisation status)
- existing and future motorway nodes (with names of the most significant neighbouring localities)
- traffic levels (present/future) on these sections (proportional view)
- nature of pavement on these sections (colour view).
- number of lanes (present/future) on these sections (proportional view)
- nature of ownership and charging (present/future) on these sections (colour view).



Slika 2: Obstoječi volumen lahkega prometa za zahodni del Avstrije
2: Present light traffic volumes for the west part of Austria

Produkti sistema

Potencialni uporabniki sistema so predvsem vladne službe, transportne organizacije, svetovalne organizacije s področja prometa, itd. Z Banko avtocestnih podatkov v GIS

System Products

Potential users of the system products are mostly government offices, transportation organization, traffic consultants firms, etc. With the GIS of Europe Motorway Databank

lahko končnim uporabnikom ponudimo različne produkte. Najprej so to različne tabele v digitalnem formatu ali pa na papirju. Seveda je to možno že z obstoječim sistemom, brez GIS nadgradnje. Novi produkti so predvsem različni izrisi in pa celoten informacijski sistem kot celota za zahtevnejše uporabnike. Uporabniku lahko ponudimo različne izrise glede na:

- vsebino za obstoječe in načrtovano stanje (*stanje avtocestne mreže, število voznih pasov, vrsta obrabnega sloja, prometni volumni, itd.*)
- merilo in velikost izrisa
- območje (*Evropa, del Evrope, ena država*)
- informacije v ozadju (*državne meje, urbana območja, teren, vode, ceste, železnice,itd.*)
- posebne zahteve uporabnika

Uporabnikom, ki potrebujejo različne informacije bolj pogosto, lahko ponudimo tudi instalacijo kompletnega sistema. Sistem vključuje:

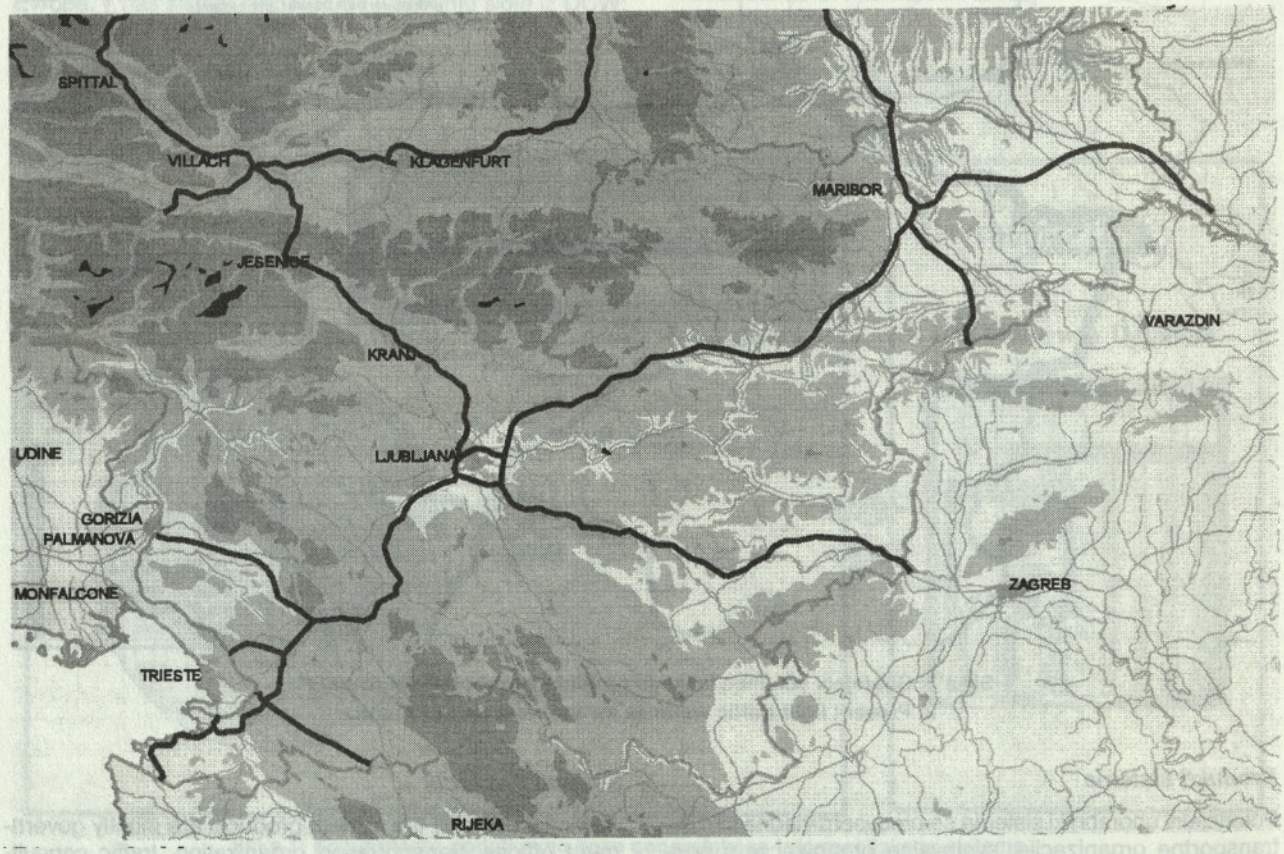
- IRF Banko avtocestnih podatkov (IRF)
- digitalno avtocestno omrežje (PTI)
- Digital Chart of the World (ESRI)
- ARCVIEW (ESRI)
- inštalacijo, šolanje in po potrebi dodatno izobraževanje (IRF, PTI)
- vse spremembe v bazi (IRF, PTI)

we can offer different products to the end users. The first are database tables in digital format or paper edition. Of course this can already be done without GIS capability with MS ACCESS. The new products are different plots and the complete system. With the system we can produce plots of different

- content for present and future situations (*motorway status, number of lanes, pavement type, traffic volumes, charging type, ownership, etc.*)
- map scale and paper size
- area (*Europe, part of Europe, single country*)
- background information (*state boundaries, urban areas, elevation data, roads, railways, rivers, etc.*)
- special user request

To the users which request different informations more frequently we can offer installation of the complete system composed of

- IRF Motorway Databank (IRF)
- digital motorway network (PTI)
- Digital Chart of the World (ESRI)
- ARCVIEW as presentation tool (ESRI)
- training and education (IRF, PTI)
- regular updates of the database (IRF, PTI)



Slika 3: Potek avtocesnega omrežja glede na teren v Sloveniji **Picture 3: Motorway network - terrain integration for Slovenia**

PILOTSKI PROJEKT

GIS projekt smo pričeli ob koncu leta 1994, ko je bila dokončana prva izdaja Banke avtocestnih podatkov. Na področju Slovenije in Avstrije smo najprej izvedli pilotski projekt, ki predstavlja osnovo za testiranje GIS razširitve obstoječe baze.

Avtocestno omrežje za Avstrijo in Slovenijo smo digitalizirali iz ustreznih topografskih kart. Segmentacija omrežja je bila izdelana v skladu s specifikacijo obstoječe Banke avtocestnih podatkov. Vse koordinate smo transformirali v tako imenovano "geografsko" projekcijo s fi-lambda vrednostmi. Na ta način smo omogočili, da uporabnik lahko kasneje s pomočjo paketa ARCVIEW sam izbere projekcijo, ki mu najbolj ustreza za posamezne poglede in izrise.

Za potrebe predstavitve smo v paketu ARCVIEW vse tabele iz Banke avtocestnih podatkov povezali z atributivno tabelo avtocestnega omrežja. Za vsako tabelo smo kreirali eno več tem v odvisnosti od vrste podatkov v tabeli. Na ta način smo določene poglede lahko pripravili v naprej (klasifikacija, simboli, barve, itd.).

Podatki iz DCW so bili naloženi in pripravljeni (knjižnice) s pomočjo programskega paketa ARC/INFO na delovni postaji (IBM 6000/250). Vzpostavili smo povezavo iz osebnega računalnika, kjer smo poganjali ARCVIEW, do delovne postaje in sistem je deloval brez problemov. Za končno realizacijo, ko bo sistem v celoti instaliran na osebnem računalniku, bo potrebno le podatke iz DCW prekopirati na osebni računalnik.

Pilotski projekt je bil uspešno predstavljen na rednem srečanju IRF članov v maju 1995 v Glasgowu na Škotskem. Sistem sam in njegova učinkovitost ter prednosti v primerjavi z obstoječim sitemom so na udeležence srečanja naredile velik vtis. Podprto je bilo nadaljevanje projekta in s tem razširitev na območje celotne Evrope. Tako smo predvideli, da bi projekt dokončali do konca leta 1995.

ZAKLJUČEK

GIS razširitev IRF Banke avtocestnih podatkov za Evropo predstavlja zelo učinkovito, hkrati pa enostavno in prijazno orodje za rokovanje z bazo podatkov. Prednosti GIS pred obstoječim sistemom so velike, kajti le GIS lahko ponudi kakovostno informacijo v primerni obliki kar največjemu številu ljudi. S kombinacijo programskega ARCVIEW in prostorske podatkovne baze Digital Chart of the World kot podatkov v ozadju smo dobili relativno poceni rešitev, ki omogoča realizacijo projekta v zelo kratkem času.

PILOT PROJECT

The GIS project started at the end of 1994 when first edition of Motorway Databank (MS ACCESS) was finished. In the first step the pilot project on 2 countries was implemented to provide a test basis for the GIS extension of the IRF Motorway Databank. The pilot project handles IRF motorway data for Austria and Slovenia.

The motorway network for Austria and Slovenia was digitised from topographic maps and segmentation was implemented according to the IRF Motorway Databank specification. Coordinates were transform to fi-lambda values. In this way we can later in ARCVIEW select the projection for data presentation what is most appropriate for wide area projects.

For presentation purpose for each Motorway Databank table copy of motorway network theme was done and the table was joined to the motorway network attributive table. In this way we can prepare some views of the data (classification, symbols, colors, etc.) in advance.

Data form Digital Chart of the Word was loaded and prepared (libraries) on workstation version of ARC/INFO (IBM 6000/250). After that the connection from PC ARCVIEW was established and the system operates through the network without any problem. For the final realisation of the product the DCW database was only copied from workstation to the PC.

The pilot project was successfully presented at the regular IRF meeting in May 1995 in Glasgow, Scotland. The great impression was done with the system possibilities, effectiveness and advantages of the presented products in comparison to existing products. The project got support by the IRF members and the next step in the project realisation was accepted. This should be the extension of the project on the whole Europe and it is planed to be realised until the end 1995.

CONCLUSION

The GIS extension of the IRF Europe Motorway Databank is very powerful and easy to use tool to manipulate motorway database. The advantages of the GIS in comparison to existing system are great and only GIS can offer good information in an appropriate form to the most of the interested people. With the combination of ARCVIEW 2.0 software and Digital Chart of the World database as a background data we get nonexpensive possibility to realise project in very short time.

PRESOJA VPLIVOV CESTE IN PROMETA NA OKOLJE TER IZBOR OPTIMALNE VARIANTE POTEKA TRASE

THE ROAD AND TRAFFIC ENVIRONMENTAL IMPACT ASSESSMENT AND OPTIMAL ROOM LAYOUT SELECTION

UDK: 656.13:504.05

MARIJAN ŽURA, PETER LIPAR*

V tem članku predstavljava računalniško aplikacijo za izdelavo ocene vplivov ceste in cestnega prometa na okolje. Ocena ranljivosti okolja temelji na informacijah o vegetaciji, živalskem svetu, vrsti tal, vodnih virih, klimatskih pogojih, naravni in kulturni dediščini, poselitvi itd. Ti podatki so shranjeni v t.i. vektorski obliki v posameznih informacijskih slojih podatkovne baze. Pri oceni ranljivosti moramo upoštevati tudi relativno pomembnost posameznih pojavov. To pomembnost določimo z utežmi znotraj posameznega sloja in med sloji. Za izračun ranljivosti moramo torej posamezne sloje topološko prekriti. Za določitev optimalnega koridorja trase moramo združen sloj pretvoriti iz vektorske v rastrsko obliko. Ranljivosti lahko prikažemo grafično z različnimi barvnimi odtenki in ta grafični prikaz lahko uporabimo kot eno od osnov za izdelavo različnih alternativ poteka trase. S prekrivanjem variant ter informacijskih slojev lahko analiziramo vplive vzdolž stacionaže.

In this paper we present ARC/INFO based application for assessment of the road and traffic impacts to the environment. The estimation of the environmental vulnerability is based on the information about fauna, flora, soil, water, air, climate, landscape, natural and cultural environment, urban areas, etc. and the importance of different phenomena. The importance is established by weighting inside and between the layers. The vulnerability of individual layers as well of the joint layer can be presented in different colour shades and can be used as one of the graphics bases for the optimal room layout selection. Joint layer can be converted into the grid and the least impact corridor between origin and destination can be calculated. This corridor can be used as another source of information for the optimal room layout selection. Several alignment alternatives can be overlaid above the joint environment layer and the cumulative impact can be assessed. Strip maps show the impacts on each alignment section.

UVOD

Presoja vplivov na okolje je postopek, v katerem identificiramo, opišemo in ocenimo neposredne in posredne vplive projekta na naslednje elemente: človek, živalstvo,

INTRODUCTION

The Environmental Impact Assessment is a procedure, where we identify, describe and assess the direct and indirect effects of the project on the following factors:

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vegetacija, tla, vodni viri, zrak, klimatske razmere, naravna in kulturna dediščina itd. Nekatere vplive lahko merimo z znanimi postopki (npr. kmetijstvo, gozdarstvo, vodni viri, hrup, emisije, vibracije) ali pa določimo s simulacijskimi modeli, medtem ko drugih ne moremo določiti drugače, kot z ekspertno oceno. Pri izdelavi ekspertne ocene se moramo v največji možni meri izogniti subjektivnosti strokovnjaka, zato moramo zagotoviti transparentnost postopka in ažurne podatke. Pri zbiranju in analizi podatkov si lahko zelo pomagamo z orodji, ki nam jih nudi tehnologija geografskih informacijskih sistemov (GIS).

METODOLOGIJA

Postavitev problema

Cilj presoje vplivov na okolje je poiskati koridor med dvema točkama, v katerem so vplivi projekta najmanjši. V tej začetni fazi definiramo študijsko območje in identificiramo sloje okolja, ki jih moramo upoštevati v analizi. Na podlagi izkušenj predlagamo, da študijsko območje zajema območje v oddaljenosti 400m od ravne črte med začetno in končno točko.

Vnos podatkov o prostoru

Po določitvi študijskega območja zberemo podatke o prostoru. Kot vedno predstavlja ta aktivnost najbolj časovno (in finančno) zahteven del projekta, vendar se situacija tudi na tem področju izboljšuje iz leta v leto. Trenutno je v Sloveniji na voljo že precej podatkov v digitalni obliki. Celotno območje države je pokrito s skeniranimi kartami od meril 1:250,000 do 1:5,000. Informacije so v precejšni meri ločene po slojih (topografija, izohipse, hidrografija, toponimi), kar olajšuje (pol)avtomatsko vektorizacijo. Veliko informacijskih slojev je bilo tudi že vektoriziranih. Kot referenčno ozadje in dodatno informacijo pa lahko uporabljamo tudi digitalne ortofoto posnetke.

Strokovnjaki za posamezna področja torej v tej fazi pripravijo podatke o posameznih slojih. Po vnosu podatkov izdelajo oceno ranljivosti elementa okolja na posameznih lokacijah študijskega območja. Ponavadi uporabljamo štiri različne stopnje:

1 - ni vpliva
2 - majhen vpliv
3 - velik vpliv
4 - nedopustno

Ranljivost posameznih lokacij lahko nato prikažemo grafično v obliki različnih barvnih odtenkov.

Model

V naslednjem koraku združimo posamezne sloje v t.i. združen sloj elementov okolja. Študijsko območje torej predstavimo s poligoni z znanimi ranljivostmi posameznih elementov prostora. Skupno ranljivost pa izračunamo kot vsoto ocen pomnoženih z utežjo sloja. Uteži sloja so predstavljene v odstotkih. Npr. hidrografija predstavlja 40% skupne ranljivosti, medtem ko tla, kmetijstvo in gozdarstvo vsak po 20%. To pomeni, da so na tem območju vodni viri dvakrat pomembnejši kot kvaliteta zemljišča. Seveda je določitev teh razmerij med posameznimi sloji zelo težaven

human beings, fauna, flora, soil, water, air, climate, landscape, material assets, cultural heritage and the interaction between the factors. Some impacts can be measured by known procedures (agriculture, forestry, water, noise, emissions, vibrations) because they have bounds determined by the legislation. Other impacts are evaluated on the basis of simulation models while some are based only on expert's perceptions. Here we must take into account the subjectivity of certain expertise. Therefore it is necessary to assure the transparency of the procedure.
While impact assessment is connected with extensive environment data collection and analysis, GIS technology represents the right tool for this task.

METHODOLOGY

Problem definition

The goal of the Environmental Impact Assessment is to find the least impact corridor and to select the best alignment alternative between two places. In this early stage, analyst should define the study area and identify environment layers that should be considered in the analysis. Considering the previous experiences we suggest 400 m wide corridor around straight line between the origin and destination.

Environment data input

After we determine the study, we have to collect and enter information about the environment. As always this task represents the most time (and money) consuming part of the project. But in these days digital information in suitable format is more and more available also in Slovenia. The whole area of the country is covered by scanned images from scales 1:250,000 up to 1:5,000. The information is separated into topography, contour lines, hidrography layer and annotations what makes (semi)automatic vectorisation much easier. Several information layers have already been vectorised. Digital orthophoto can also be used as a background information.

Different experts prepare the data bases on fauna, flora soil, water, climate, etc. When the data is entered, the estimation of area vulnerability is made, taking in consideration available information on the particular phenomena in that area. The vulnerability of individual environmental factor, which is prepared on its own layer, is shown in different colour shades.

Usually there are four different grades used for this estimation:

1 – no impact
2 – small impact
3 – large impact
4 – unacceptable impact

For example, grades from 1 to 4 are assigned to different soil types, according to the perception of the expert.

Model

After then, all these layers are joined into one layer which is later used in the analysis. Total vulnerability of each

proces. Zahteva timsko delo, multi-disciplinaren pristop in verjetno tudi uporabo specialnih metod, ki so bile razvite za t.i. "mehke sisteme".

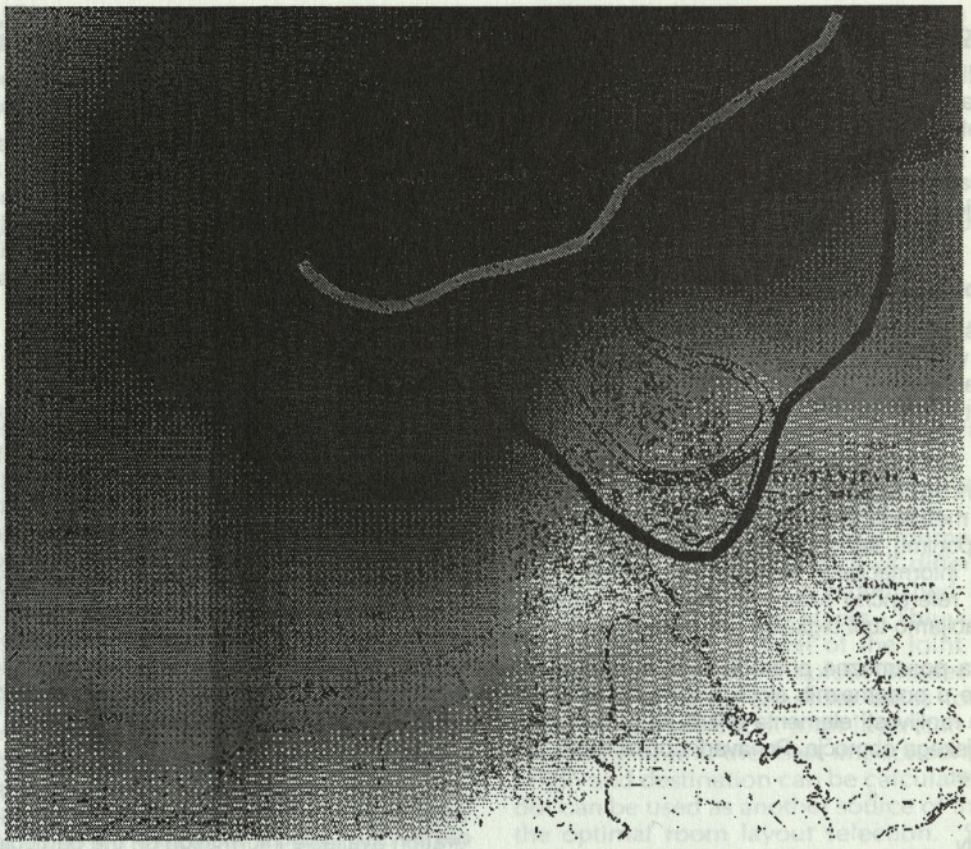
Optimalni koridor

Model prostora, izdelan v predhodnem koraku, uporabimo za določitev optimalnega koridorja poteka trase med začetno in končno točko. Za ta namen pretvorimo združeni poligonski sloj iz vektorske v rastrsko obliko in z uporabo posebnih funkcij določimo območje, po katerem naj bi šle variante trase. To območje lahko uporabimo v naslednjem koraku izdelave variant ter se s tem že na samem začetku izognemo konfliktom z okoljem.

polygon is calculated as a sum of grade multiplied by layer weight. Layer weights are represented as percents. For example, hydrology represents 40% of the total, while soils, agriculture and forestry 20% each. That means that water supplies are twice as much important as soils in this area. Of course, determination of this relative importance of each layer is very complicated task. It requires team work of different experts and probably application of some special methods developed for so called "soft systems".

Optimal corridor

The optimal workflow would be first to determine the best corridor and after then to develop some possible layouts



Slika 1: Optimalni koridor in variante trase

Figure 1: Minimum impact corridor and alignment alternatives

Variante trase

Za izdelavo variant trase lahko uporabimo specializirane programske pakete za projektiranje cest, kajti večina od njih omogoča izmenjavo podatkov z GIS paketi. V paket za projektiranje cest prenesemo podatke o terenu, zgradbah, rekah itd. po obdelavi pa vrnemo v podatkovno bazo GIS geometrijo trase z vsemi ukopi in nasipi.

Izbor optimalne variante

Analizo nadaljujemo z določitvijo vplivov posameznih alternativ. Sloj, v katerem je shranjena geometrija posameznih variant, prekrijemo z združenim slojem okolja. S tem določimo občutljivost okolja na posameznih odsekih

through this corridor. The joint polygon layer is converted to grid and with use of costdistance and corridor functions one can develop the corridor where all the layouts should go through. This corridor can be plotted and used as a base map for design of road alignments thus designer can avoid major conflicts with environment already at the beginning.

Layouts

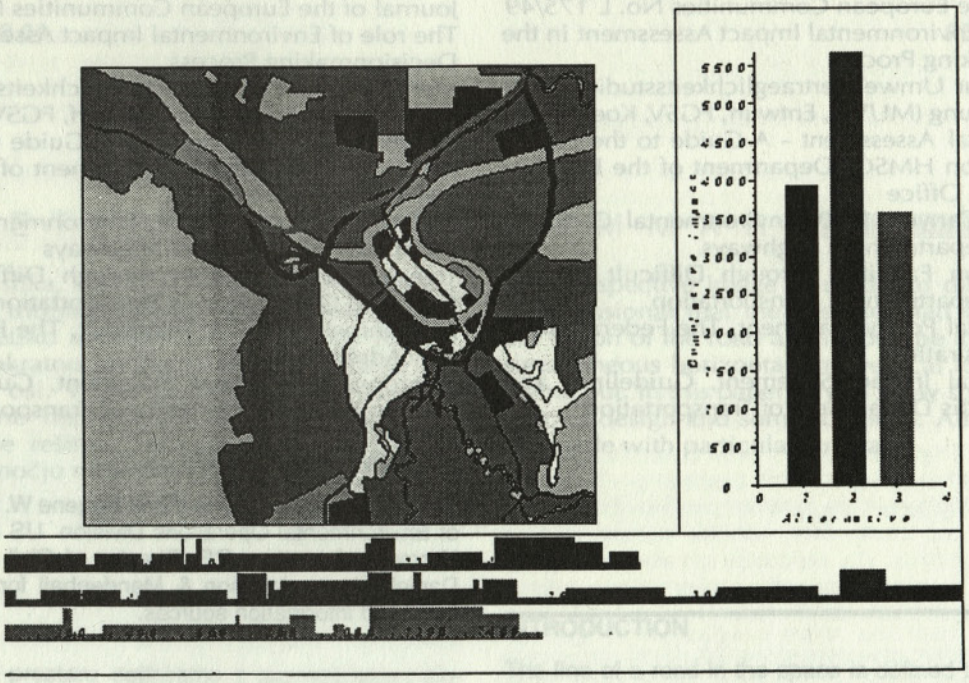
Specialised roadway design packages can be used for alignment development. Most of them support data interchange with GIS packages. Digital terrain model, buildings, rivers, etc. can be imported to the design package,

trase. Skupen vpliv variante določimo tako, da pomnožimo dolžino odseka z občutljivostjo prostora na tem odseku ter te zmnožke seštejemo. Rezultate lahko prikažemo v obliki tabel in histogramov s kumulativnim vplivom oz. vplivi vzdolž trase. Optimalna varianta je seveda tista, ki ima najmanjši kumulativni vpliv.

and road alignments with all cut and fills exported to the GIS database.

Selection of the best alternative

When the different road alternatives are set, the estimation can be done with overlaying the layers of area vulnerability and the road centrelines. In this way we can establish for each arc separate and total vulnerability of the underlying polygon. This vulnerability is multiplied by the length of the arc and cumulative value for each alternative is calculated. The results can be inspected as a tabular report and represented as a histogram. Stripmap of the vulnerability is also displayed.



Slika 2: Vplivi variant

Figure 2: Cumulative impact of each alternative

IZVEDBA

Aplikacija je razvita s paketom ArcInfo 6.1.1 na delovnih postajah HP z operacijskim sistemom HP-UX.

ZAKLJUČEK

Predstavljena aplikacija omogoča izdelavo ocene vplivov ceste in cestnega prometa na okolje. Planerji in načrtovalci cest jo lahko uporabljajo za določitev optimalnega koridorja ter za izbor najboljše variante. Seveda pa moramo program razumeti samo kot orodje za pomoč pri sprejemanju odločitev in ne kot odločujoč dejavnik. Omogoča nam hitro izvedbo analize z različnimi nabori uteži in s tem v precejšnji meri olajša najtežji del vrednotenja.

Trenutno aplikacija še ne upošteva razlik v vplivih glede na oddaljenost od ceste, zato načrtujemo njeno dopolnitev. Poleg cone neposredne fizične spremembe (cestno telo)

IMPLEMENTATION

The application is implemented as a set of AMLs and MENUs with extensive use of ArcTools. It was developed and tested under ArcInfo 6.1.1 on HP-UX.

CONCLUSIONS

Presented application enables assessment of road and traffic impacts to the environment. Road planners and designers can use it for development of least impact corridor and selection of the most suitable alignment alternative. The problem of ponders was touched and possible solution was suggested. When considered as if-then analysis tool it can be of great help to decision makers. The application was tested on several projects in Slovenia and showed satisfactory results.

As traffic impacts are not limited to the area of physical change (road body) the application should be enhanced

bomo vrednotili tudi območje posrednega fizičnega vpliva (do 100m od ceste) in območje vizualnega stika (približno 450m od ceste).

to take into account different zones of road environment impact: zone of direct physical modification (pavement), zone of direct modification (total land requirement-right of way), zone of indirect impact (area up to 100 meters from the road) and zone of visual contact (approximately 450 meters from the road).

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OPTIČNO VODENJE OSI IN GEOMETRIJSKO OBLIKOVANJE CEST

Optical leading of axis and geometrical forming of roads

UDK: 625.711.3.04

PETER LIPAR*

POVZETEK

Perspektivna slika, ki jo vidi voznik, je lahko precej drugačna od tridimmenzionalne predstave projektanta. Za estetsko spojitev ceste in krajine je zelo pomembno hkratno horizontalno in vertikalno vodenje cestne osi. V tem prispevku skušamo predstaviti različne nepravilnosti pri projektiranju in podati možne rešitve. Tridimenzionalni prikaz je narejen s pomočjo računalniške grafike.

SUMMARY

The perspective image of road can differ from the tridimensional that the designer had in mind. For the fusion of the road and landscape it is important simultaneous horizontal and vertical leading of the laying out. In this paper I try to show some mistakes in road design and some solutions. All 3D pictures are made with particular software.

UVOD

Potek ceste v prostoru definiramo z geometrijskimi elementi v tlorisnem in višinskem poteku trase. Zavedati se moramo, da vidi voznik samo perspektivno sliko ceste, ki pa je lahko drugačna od tiste, ki si jo je zamislil projektant. Zaradi tega moramo že v začetnih fazah projekta preverjati tridimenzionalno vodenje trase.

Pri projektiranju ceste in pri njeni spojitvi s krajino so pomembni funkcionalni in oblikovno estetski kriteriji:

- funkcionalni kriteriji so posledica vozno – dinamičnih analiz
- oblikovno – estetski kriteriji se postavijo na podlagi vizualnih predstav in doživljanja ceste z gledišča njihovega uporabnika – voznika in potnika; estetski kriterij je zelo pomemben zaradi "človeškega dejavnika" , ki vpliva na varnost prometa

INTRODUCTION

The line of a road in the space is defined by geometrical elements in the ground-plan and height flow of the laying out. One has to be aware that the driver sees only the perspective image of the road which can differ from the one that the design engineer had in mind. For this reason the three-dimensional leading of the laying out has to be checked already in the first stages of the project.

When designing a road and at its fusion with the landscape, functional as well as formative-aesthetic criteria are important:

- functional criteria are a consequence of the driving-dynamic analyses
- the formative-aesthetic criteria are set on the basis of visual concepts and ideas of the road from the side of its user - driver and passenger; the aesthetic criterion is of

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Drugi vidik je zaznavanje ceste iz okolice. Izpolnjevanje funkcionalnih ter oblikovno – estetskih kriterijev je potrebni pogoj za spojitev ceste in krajine, ni pa tudi zadosten. Za to je potrebno izpolniti tudi dodatne pogoje. Hkrati je pa razumljivo, da samo estetski kriteriji še ne zagotavljajo tudi ustreznih prometno tehničnih rešitev.

Projektant mora upoštevati vse kriterije – da je cesta varna in da se spaja s krajino. Za optimalno rešitev je potrebno angažiranje prometne psihologije, teorije informacij, računalniške perspektivne slike, krajinske arhitekture in tehnične kibernetike.

OPTIČNO VODENJE OSI CESTE

Za dobro optično vodenje trase so potrebni naslednji pogoji:

- prostorska slika ceste mora delovati "umirjeno"
- cesta mora imeti pregleden potek na večji dolžini
- potek ceste mora biti pravočasno in nedvoumno razumljivo dojet.

Geometrijsko oblikovanje

Smoter geometrijskega oblikovanja je skladnost sestavljanja projektnih elementov, tako da prostorska slika ceste učinkuje ugodno in pozitivno na vedenje voznika in mu vliva občutek varnosti.

Za to ni dovolj, da so vsi izbrani horizontalni in vertikalni elementi trase v mejah dopustnih vrednosti, ki so odvisne od računske hitrosti, ampak je potrebno vzpostaviti širšo medsebojno odvisnost projektnih parametrov. Tu gre za prostorsko predstavo, ki jo formirajo vodilne (strukturne) linije ceste – rob ceste, črte, odbojne ograje, ki so v vidnem polju voznika. Vtis zaporedja teh elementov je za voznika lahko popolnoma drugačen od predstave o cesti, ki jo dobimo iz projektne dokumentacije

V okviru dojemljive preglednosti na 25 do 30 sekundah, vožnje kar znaša pri hitrosti 120 km/h okoli 1000m, lahko oko voznika zazna več geometrijskih oblik – premo, krožni lok, prehodnico in vertikalne zaokrožitve. Dolžina vidnega polja je enaka približno štiri kratni razdalji hitrosti izražene v metrih. To pomeni, da so te vrednosti pri večjih hitrostih višje, le širina vidnega polja je manjša.

Najpogostejše napake in priporočila:

A Prema

Dolge preme učinkujejo monotono in utrujajoče na voznika. Težko je pravilno oceniti njeno dolžino. Zato naj bo prem čimmanj, njihove dolžine pa naj bi bile odvisne od računske hitrosti na predvideni cesti in naj ne bi presegale razdalje 20 x V_r, kar ustreza največji globini vidnega polja.

B Krožni lok

Krožni lok ima boljše oblikovne kakovosti kot prema. Minimalna dolžina loka mora biti takšna, da voznik dojame stopnjo zakrivljenosti. To praktično pomeni 2 – 5 sekund vožnje. Maksimalna dolžina pa je omejena z vizuro dojemljive preglednosti.

a great importance because of the "human factor" which influences the traffic safety

Another view is perceiving the road from the surrounding. Meeting the functional and formative-aesthetic criteria are necessary in order to achieve the fusion of the road and the landscape. But this does not suffice, some other additional conditions are to be met, too. At the same time it is understandable that only aesthetic criteria do not provide adequate traffic-technical solutions.

The design engineer has to consider all the criteria - that the road is safe and that it is fused with the landscape.

For an optimal solution the traffic psychology, theory of information, computer perspective images, landscape architecture and technical cybernetics are to be engaged.

OPTICAL LEADING OF THE ROAD AXIS

For a good optical leading of the laying out the following conditions are to be met:

- the space image of the road has to have a "soothing" effect
- the road has to have an easily surveyable line in a larger length
- the road line has to be perceivable duly and undoubtedly.

Geometrical design

The purpose of the geometrical design is conformity of putting together the project elements through which the space image of the road will have a pleasing and positive effect on the behaviour of the driver and will give them a sense of safety.

It is not enough, though, that all the chosen horizontal and vertical elements of the laying out are within the allowable values which depend on the computational speed, but also a wider interdependence of the project parameters has to be established. This is a matter of spatial image which is formed by the leading (structural) lines of the road - road border, lines, safety rails which are in the visual field of the driver. For the driver the impression of a sequence of these elements can be completely different from the image of the road that is obtained from the project documentation.

Within the perceivable surveyability at each 25 to 30 seconds of the driving, which amounts at the speed of 120 km/h to about 1000 m, the eye of the driver can sense several geometrical forms - straight, circular bend, crossings and vertical round-ups. This means that these values are higher at higher speed, only the width of the visual field is smaller.

Most common errors and recommendations:

A Straight

Long straight have a monotonous and tiresome effect on the driver. It is difficult to assess its length correctly. For this reason there should be as few straight as possible

C Prehodnica

Prehodnica daje najboljše optične učinke. Glede pravilne dolžine prehodnice obstaja več teorij. Najboljše oblikovne rešitve se dosegajo pri dolžinah,ki so približno enake dolžinam lokov in pri velikosti parametra R/3<A<R.

D Vzdolžni sklon

Nagib nivelete do 3% ne predstavlja nobenih negativnih optičnih učinkov. Pri vrednostih nad 4% pa lahko učinkuje zelo neprijetno, še posebno, če je trasa v premi in če je njena dolžina več sto metrov. Pojavi se lahko učinek zidu, kjer voznik izgubi občutek za realne dolžine. Ugodnejšo rešitev v tem primeru dobimo, če v horizontalnem poteku speljemo os ceste z večjimi radiji.

E Vertikalne zaokrožitve

Tudi vertikalne krivine učinkujejo prijetno, če so ustrezno dolge. Majhne vertikalne krivine lahko učinkujejo kot prelomi. Predlagani minimum je 3 – 4 kratna dolžina vizurne preglednosti.

Usklajevanje horizontalnih elementov

Enako smerni krivini in kratka vmesna prema učinkujejo kot poligonalna os. Posledica tega je, da voznik sam skuša najti ustreznejšo trajektorijo poti, kar pa je lahko nevarno. Boljša rešitev je uporaba ene same večje horizontalne krivine, ali pa košaraste krivine.

and their lengths shall depend on the computational speed at the foreseen road, and should not be larger than the distance of 20 x Vr, which corresponds to the larger depth of the visual field.

B Circular bend

Circular bend has better design qualities than straight. The minimal bend length has to enable the driver to perceive the level of bending. Practically, this means 2 - 5 seconds of driving. The maximum length is limited with the visure of the perceivable surveyability.

C Crossing

The crossing gives the best optical effects. According to the correct lengths of the crossings there are several theories. The best design solutions are achieved at the lengths which equal approximately the lengths of the bends, and at the parameter of the size R/3<A<R.

D Longitudinal profile

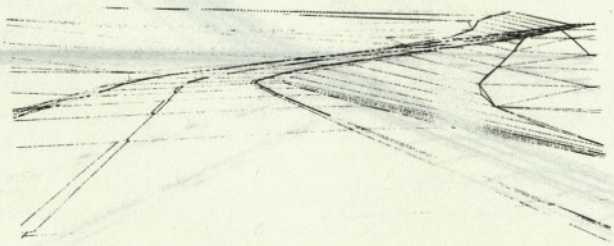
The incline of the levelling up to 3% does not present any negative optical effects. However, at the values above 4% it can have a rather unpleasant effect, especially if the laying out is in straight, and if its length is several hundred meters. Also the effect of the wall can appear, here the driver can lose the sense of real length. A more suitable solution in this case is to lead the axis of the road in the horizontal line with several radii.

E Vertical round-ups

Also vertical bends have a pleasant effect if they are long enough. Small vertical bends can effect as faults. The proposed minimum is 3 - 4 times the length of the visure surveyability.

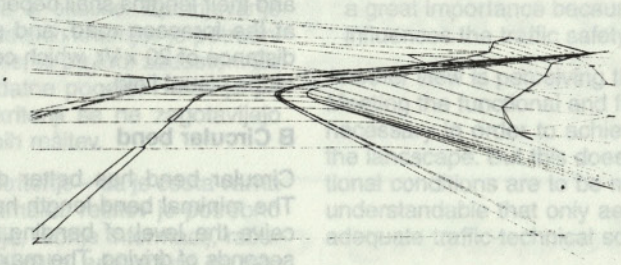
Adjustment of horizontal elements

Bendings of the same direction and short intermediary straight have the effect of a polygonal axis. As a consequence, the driver tries to find a more appropriate alignement of the road, which can be dangerous. A better

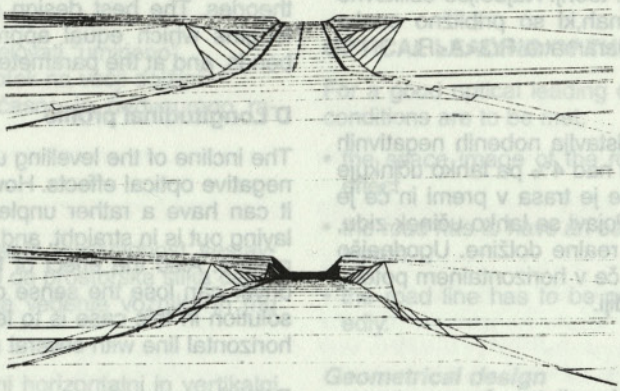


Prehod iz preme v krivino brez prehodnice

Transition from straight to bending without a crossing

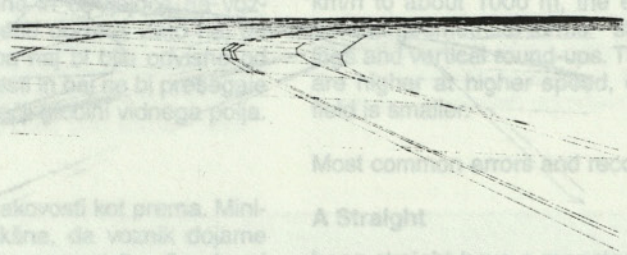


Prehod iz preme v krivino s prehodnico
Transition from straight to bending with a crossing



Pogled na traso s 7% in 3% vzpona
View to the laying out with a 7% and 3% incline

Ena krivina
One bending



Poligonalno vodenje osi
Polygonal leading of the axis

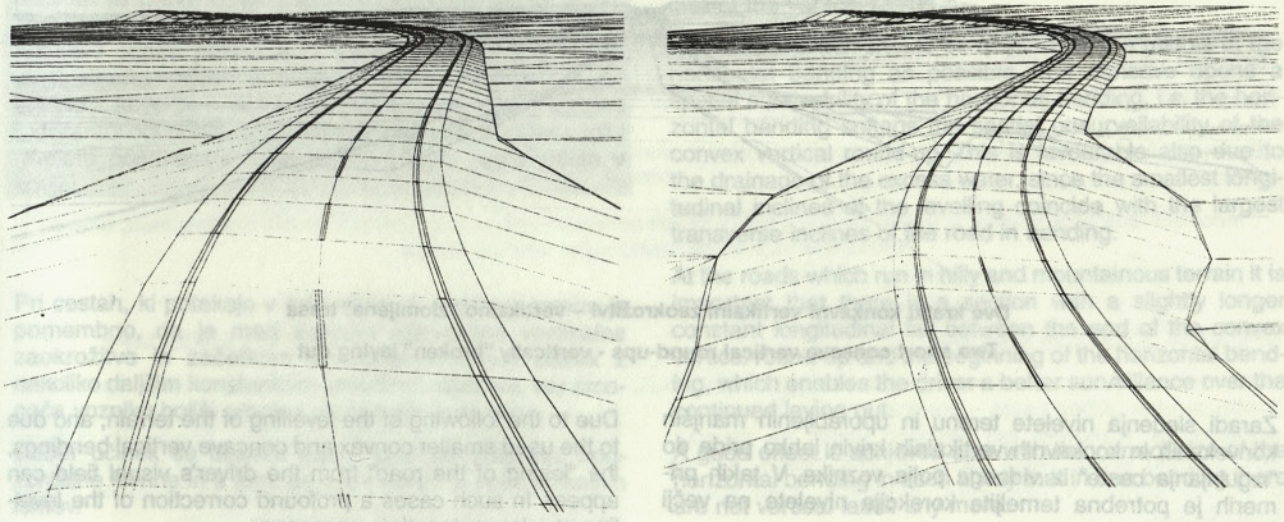
"S" krivina s kratko vmesno premo je prav tako optična slaba rešitev. Boljša je rešitev je s kontinuirano krivino z ustrezno vmesno prehodnico. če je uporaba preme nujna, moramo izbrati pravilno dolžino.

Zelo pomembno je zaporedje horizontalnih radijev, predvsem iz vidika prometne varnost in seveda tudi optičnega vodenja rase. Oblikovna in vozno dinamična občutljivost je največja pri radijih R<400 metrov. Priporoča se uporaba sosednjih radijev v razmerju $R_i<1,5\ R_{i+1}$.

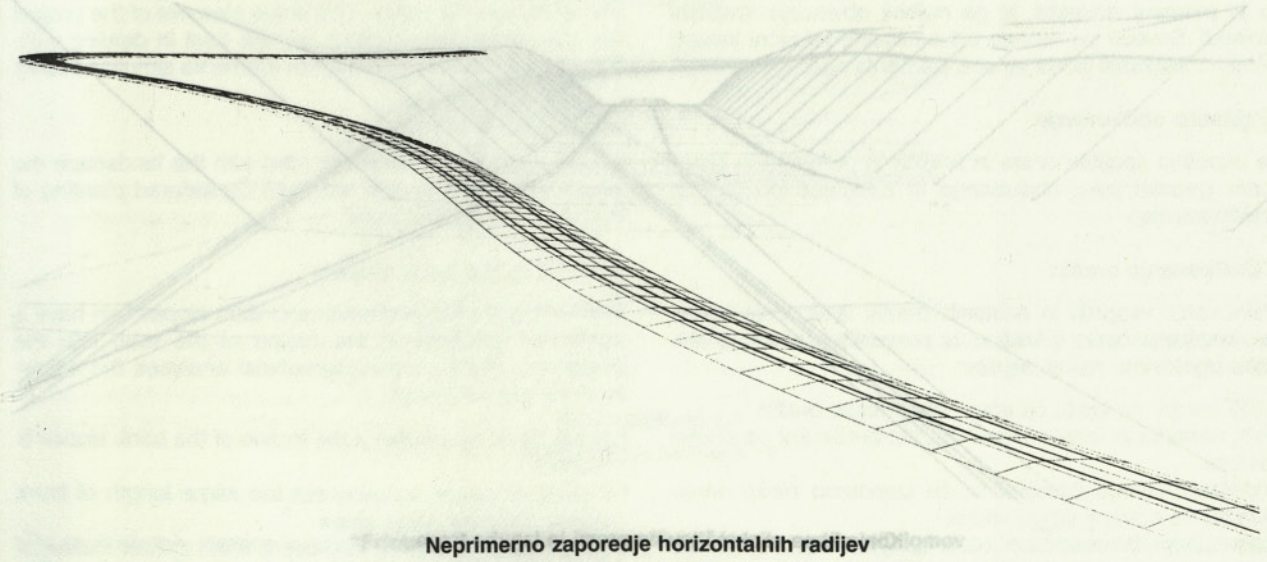
solution is to use one single larger horizontal bending, or combined bending.

Bending "S" with a short intermediary straight is also a bad solution from the optical point of view. A better solution is with a continual bending with adequate intermediary crossing. If the use of straight is necessary, attention has to be paid to its correct length.

The sequence of horizontal radii is very important, especially from the point of view of traffic safety, and, naturally, also from the point of view of optical leading of the laying out. The design and driving-dynamical safety is largest at the radii of R<400 meter. It is advisable to use the neighbouring radii in the ratio of $R_i<1.5<R_{i+1}$.



"S" krivina s kratko vmesno premo in kontinuirana krivina s prehodnico
Bending "S" with a short intermediary straight and continual bending with a crossing



Neprimerno zaporedje horizontalnih radijev
Inappropriate sequence of horizontal radii.

Usklajevanje vertikalnih elementov

Glavne napake pri vertikalnem vodenju trase se pojavljajo pri izbirah velikosti zaokrožitve in pri lokacijah loma nivelete.

V oblikovnem pogledu je konkavna vertikalna krivina občutljivejša od konveksne, zato ker je pregledna in tako odpira širši pogled na vodilne linije ceste. Kratko konkavo ali pa dve kratki konkavi in vmesno premo je bolje zamenjati z eno večjo krivino.

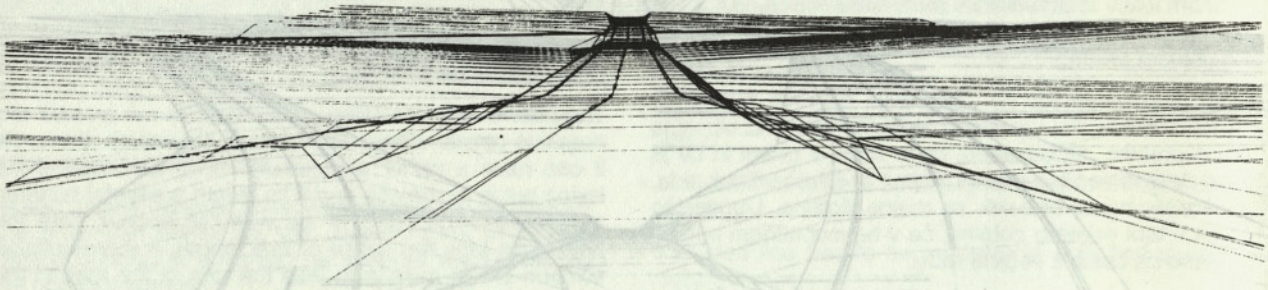
Pomembna je tudi izbira velikosti vertikalnih zaokrožitev, ko gre za zaporedje dveh konkavnih in enega vmesnega konveksnega radija. Najboljši rezultati se dosežejo, če sta konkavna radija večja od konveksnega.

Adjustment of vertical elements

The main errors at the vertical leading of the laying out appear at the selection of the size of rounding-up, and at the location of the levelling fault.

From the design point of view the concave vertical bending is more sensitive than the convex one, since it is surveyable and opens in this way a wider view to the leading lines of the road. Short concave or two short concaves and an intermediary straight should better be replaced with one larger bending.

Important is also the selection of the size of vertical radii, it is a case of a sequence of two concave and one intermediate convex radium. The best results are achieved if the concave radii are bigger than the convex one.

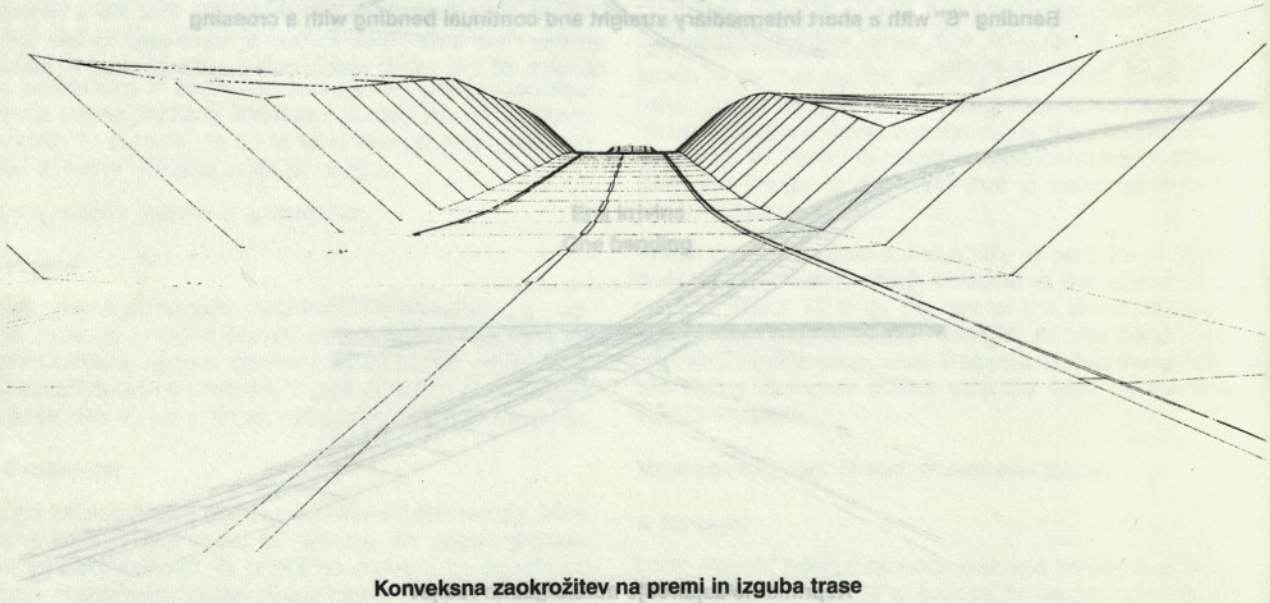


Dve kratki konkavni vertikalni zaokrožitvi – vertikalno "zlomljena" trasa

Two short concave vertical round-ups - vertically "broken" laying out

Zaradi sledenja nivelete terenu in uporabljenih manjših konveksnih in konkavnih vertikalnih krivin lahko pride do "izgubljanja ceste" iz vidnega polja voznika. V takih primerih je potrebna temeljita korekcija nivelete na večji dolžini.

Due to the following of the levelling of the terrain, and due to the used smaller convex and concave vertical bendings, the "losing of the road" from the driver's visual field can appear. In such cases a profound correction of the levelling at a larger length is necessary.



Konveksna zaokrožitev na premi in izguba trase

Convex round-up at straight and losing the laying out

Prostorsko usklajevanje projekcij ceste

Prostorsko sliko ceste kreirajo naslednje projekcije ceste:

- situacija
- vzdolžni profil
- prečni profili

Za zagotovitev harmonične slike ceste v prostoru, morajo biti elementi znotraj posameznih projekcij usklajeni. To pa ni dovolj. Potrebna je tudi usklajenost med posameznimi projekcijami, kar pomeni hkratno horizontalno in vertikalno vodenje trase.

Največji vpliv pri kreiranju prostorske slike imajo pravilno uporabljene vertikalne krivine – pravilna pozicija loma nivelete in pravilno izbrana velikost vertikalnega radija. Lom nivelete naj bo čim bližje sredini horizontalne krivine. Konkava odpira prostorsko preglednost horizontalne krivine oziroma horizontalna krivina ublaži prostorsko nepreglednost koveksne vertikalne zaokrožitve. To je ugodno tudi zaradi odvodnjevanja, ker se najmanjši vzdolžni nagibi nivelete pokrivajo z največjimi prečnimi nagibi ceste v krivini.

Pri cestah, ki potekajo v hribovitem in gorskem terenu je pomembno, da je med koncem konveksne vertikalne zaokrožitve in začetkom horizonalne krivine odsek z nekoliko daljšim konstantnim vzdolžnim padcem, kar omogoča vozniku boljši pregled na nadaljevanje trase.

Dober učinek se doseže tudi s pravilno velikostjo horizontalne krivine in s tem, da v eni krivini ni več vertikalnih lomov.

Spatial harmonisation of the road projections

The spatial image of the road is created by the following road projections:

- situation
- longitudinal profile
- transverse profiles

In order to provide harmonic views of the road in the space, the elements within individual projections need to be harmonised. However, this is not enough, the harmonisation between individual projections is also necessary, which means simultaneous horizontal and vertical leading of the laying out.

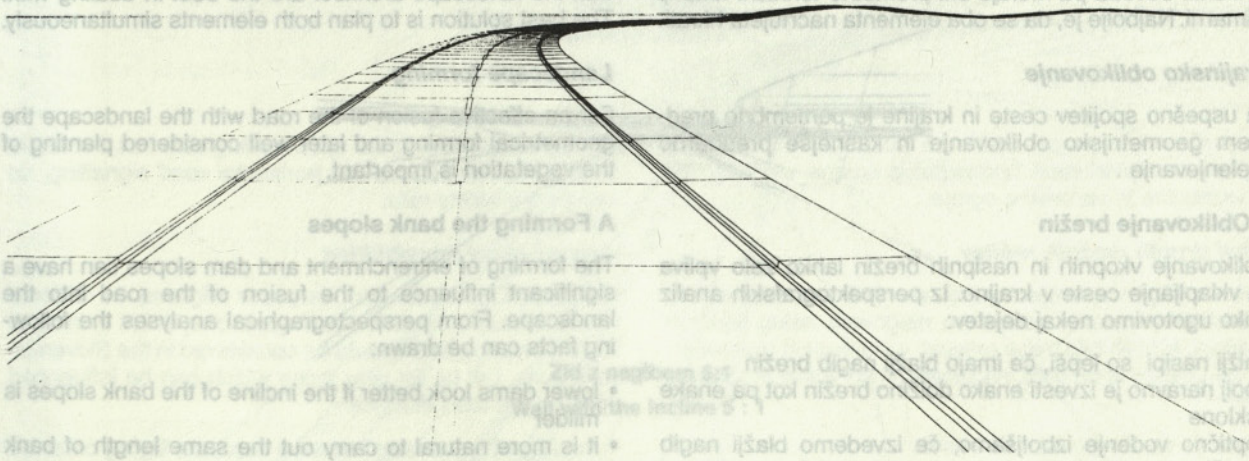
The largest influence at the design of the spatial image have correctly used vertical bendings

- correct position of the levelling fault and correctly chosen size of the vertical radius

The levelling fault should be as close to the middle of the horizontal bending as possible. The concave opens a spatial survivability of the horizontal bending, i.e. the horizontal bending softens the spatial unsurveilability of the convex vertical round-up. This is favourable also due to the drainage of the excess water, since the smallest longitudinal inclines of the levelling coincide with the largest transverse inclines of the road in bending.

At the roads which run in hilly and mountainous terrain it is important that there is a section with a slightly longer constant longitudinal fall between the end of the convex vertical round-up and the beginning of the horizontal bending, which enables the driver a better surveillance over the continued laying out.

A good effect is achieved also with the correct size of the horizontal bending in such a way that in one bending there are not vertical faults any more.

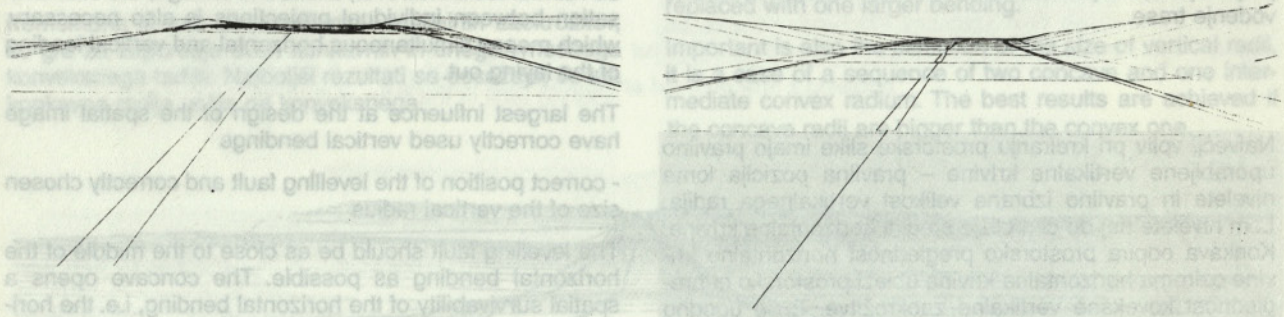


"Frfotanje" ceste zaradi prevelikega števila vertikalnih lomov

The "fluttering" of the road due to too large number of vertical faults

Lom nivelete v premi je lahko zelo kočljiv – posebno konveksni, ker popolnoma zakrije kasnejšo zakrivljenost trase. Upoštevati je treba pogoj, da sta konec vertikalne zaokrožitve in začetek horizontalne krivine na razdalji 2 x P_z (dvakratna dolžina vizure zaustavne preglednosti). Pri konkavnih zaokrožitvah se zaokrožitev ne sme potegniti v prehodnico.

The levelling fault in the straight can be very tricky - especially the convex one, since it covers completely the later bending of the laying out. The condition that the end of the vertical round-up and the beginning of the horizontal bending are at a distance of 2 x Lp (twice the length of the vizure of surveyability) has to be considered. At concave round-ups the round-up should not be drawn into the crossing.



Nepravilni lom (ne ve se, kam se bo cesta nadaljevala) in pravilni položaj loma nivelete, kjer je že nakazan nadaljnji potek trase

Incorrect fault (it is unclear in which direction the road will continue) and correct position of the levelling fault, where the further line of the laying out is already marked

SPOJITEV CESTE IN KRAJINE

Voznik pri velikih hitrostih lahko registrira kvečjemu vsebino iz neposredne bližine ceste – brežine, objekti, linija ceste, signalizacija. Kakovost teh sestavin vpliva na njegovo emocionalno stanje (lepa cesta, zoprna cesta), kar se posredno odraža v njegovem obnašanju med vožnjo (psihologija).

Na cesto pa gledajo tudi tisti iz okolice (stanovalci iz bližine, potniki, izletniki..), ki njene oblikovne vrednosti doživljajo kot sestavni del svojega življenjskega prostora. To je element projekta, ki ga najbolj obvladajo krajinski arhitekti. Seveda pa morajo biti prometno tehnični kriteriji primarni. Najbolje je, da se oba elementa načrtujeta hkrati.

Krajinsko oblikovanje

Za uspešno spojitev ceste in krajine je pomembno predvsem geometrijsko oblikovanje in kasnejše preudarno ozelenjevanje .

A Oblikovanje brežin

Oblikovanje vkopnih in nasipnih brežin lahko zelo vpliva na vklapljanje ceste v krajino. Iz perspektografskih analiz lahko ugotovimo nekaj dejstev:

- nižji nasipi so lepši, če imajo blažji nagib brežin
- bolj naravno je izvesti enako dolžino brežin kot pa enake sklone
- optično vodenje izboljšamo, če izvedemo blažji nagib brežin na notranji strani ukopa
- plitvi ukopi in nasipi se lepše spojijo s krajino, če se planum ceste podaljša do naravnega nagiba terena

FUSION OF THE ROAD AND THE LANDSCAPE

In the best case the driver can register at high speed only the contents from the direct vicinity of the road - bank slope, complexes, road line, signalling. The quality of these elements influences the driver's emotional state (pleasant road, unpleasant road), which is directly displayed in their behaviour during the driving (psychology).

The road has a visual effect also on those from its surrounding (inhabitants from the vicinity, passengers, travellers,...) who perceive its design values as a composite part of their living space. This is the element of the project that the landscape architect are the best in dealing with. The best solution is to plan both elements simultaneously.

Landscape forming

For an effective fusion of the road with the landscape the geometrical forming and later well considered planting of the vegetation is important.

A Forming the bank slopes

The forming of entrenchment and dam slopes can have a significant influence to the fusion of the road into the landscape. From perspectographical analyses the following facts can be drawn:

- lower dams look better if the incline of the bank slopes is milder
- it is more natural to carry out the same length of bank slopes than the same slope
- optical leading can be improved, if the milder incline of the slopes is carried out inside the entrenchment

B Ozelenjevanje

Z ozelenjevanjem lahko ponovno vzpostavimo fizično in oblikovno ravnotežje, ki je bilo podrto s konstrukcijo nove ceste. S tem lahko izboljšamo oblikovno predstavo o prostoru in tudi geotehnično stabilnost nasipnih in ukopnih brežin.

S pravilno razporeditvijo visokega zelenja lahko ugodno vplivamo na optično vodenje osi ceste.

Zasaditev nam lahko rabi tudi kot naravna ovira pri zaslepilnih učinkih nasproti vozečih vozil, za ublaževanje vetra in za zmanjševanje razširjanja hrupa.

Oblikovanje objektov

Poleg svoje osnovne vloge mostovi, podporni zidovi in druga prometna oprema sodelujejo tudi pri formiranju prostorske slike ceste. Zato je potrebno njihovo smotrno in pazljivo oblikovanje.

Podporni zidovi kljub temu, da predstavljajo grd tujek v naravi, lahko s pravilno izbranim nagibom in obdelano površino rabijo tudi optičnemu vodenju.

- shallow entrenchments and dams fuse more pleasantly with the landscape, if the road formation level is extended to the natural incline of the terrain

B Planting the vegetation

Planting can re-establish the physical and visual balance that was ruined with the construction of the new road. In this manner the formational image of the space as well as the geotechnical stability of the entrenchment and dam slopes can be improved.

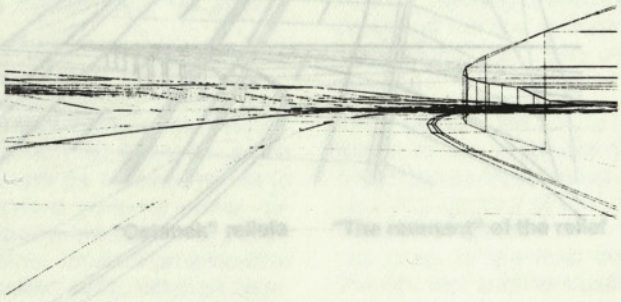
Correct distribution of high vegetation can influence positively the optical leading of the road axis.

Planting can serve also as a natural barrier with blinding effects to the vehicles driving in the opposite direction, to soften the wind and to prevent the spreading of noise.

Forming of objects

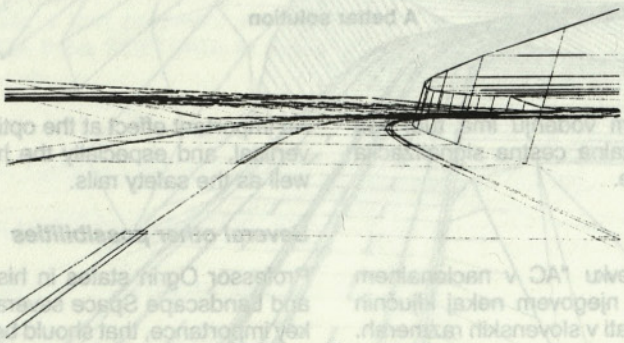
Beside its basic role, bridges, supportive walls and other traffic equipment cooperate also at forming the spatial image of the road. For this reason, their reasonable and careful design are unavoidable.

Supportive walls can serve with a correctly chosen incline and cultivated surface also in optical leading, although they present an unpleasant oddity in the nature.



Vertikalni zid

Vertical wall



Zid z nagibom 5:1

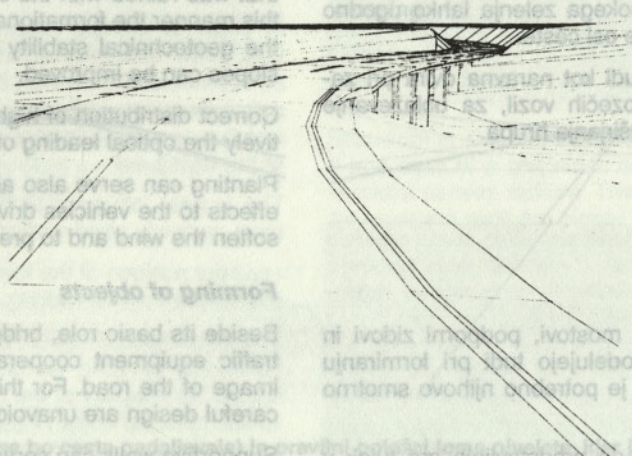
Wall with the incline 5 : 1

Pri projektiranju mostov imamo na voljo veliko več oblikovnih možnosti. Tu je seveda najpomembnejša vloga obliko-

When designing bridges, there are several design possibilities at disposal. The most important role, however, is

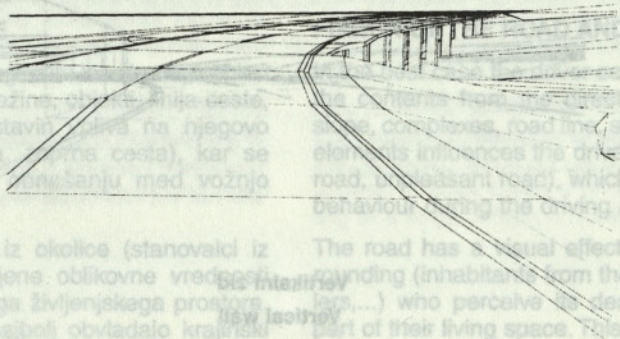
valca arhitekta, projektant ceste pa lahko s pravilno izbiro vertikalnega in horizontalnega poteka ceste v območju mostu znatno prispeva k pravilni umestitvi v okolje. Tako most ne bo le ovira, ki od voznika zahteva še posebno opreznost.

the role of the design architect, whereas the road designer can, with the adequate choice of the vertical and horizontal line of the road in the area of the bridge, contribute significantly to the correct location in the environment. In this way bridge will not b only an obstacle which demands of the driver a special attention.



Zlomljena niveleta in učinek "deske"

Broken levelling and the "board" effect



Boljša rešitev

A better solution

Pomemben učinek pri optičnem vodenju ima tudi vsa vertikalna in predvsem horizontalna cestna signalizacija ter varnostne in varovalne ograje.

An important effect at the optic leading also has the whole vertical, and especially the horizontal road signalling, as well as the safety rails.

Nekaj drugih možnih rešitev

Profesor Ogrin v svojem prispevku "AC v nacionalnem krajinskem prostoru" navaja po njegovem nekaj ključnih vprašanj, ki bi jih bilo treba reševati v slovenskih razmerah. Naj se omejim le na tiste, na katere lahko vpliva projektant ceste:

- vodenje vozišč po ločenih trasah
- oblikovanje ločilnega pasu
- obravnavanje manjših ostankov reliefa v ukopih
- značaj objektov, ki spremljajo cesto

Several other possibilities

Professor Ogrin states in his paper Highway in National and Landscape Space several questions, in his opinion of key importance, that should be considered in the Slovenian conditions. Let us list only those which can be influenced upon by the road designer:

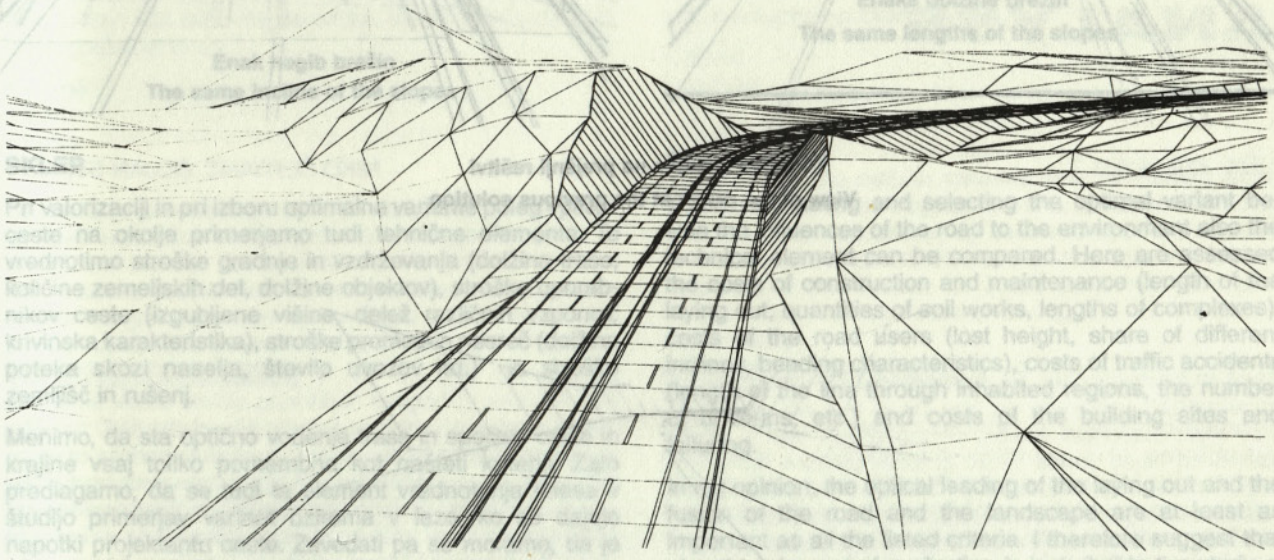
- leading of the driving lanes on separate laying outs
- forming a separating lane
- considering smaller remnants of the relief in the entrenchments

- nadomestitev nasipov z objekti
- signalizacija in oprema ceste
- protihrupna zaščita

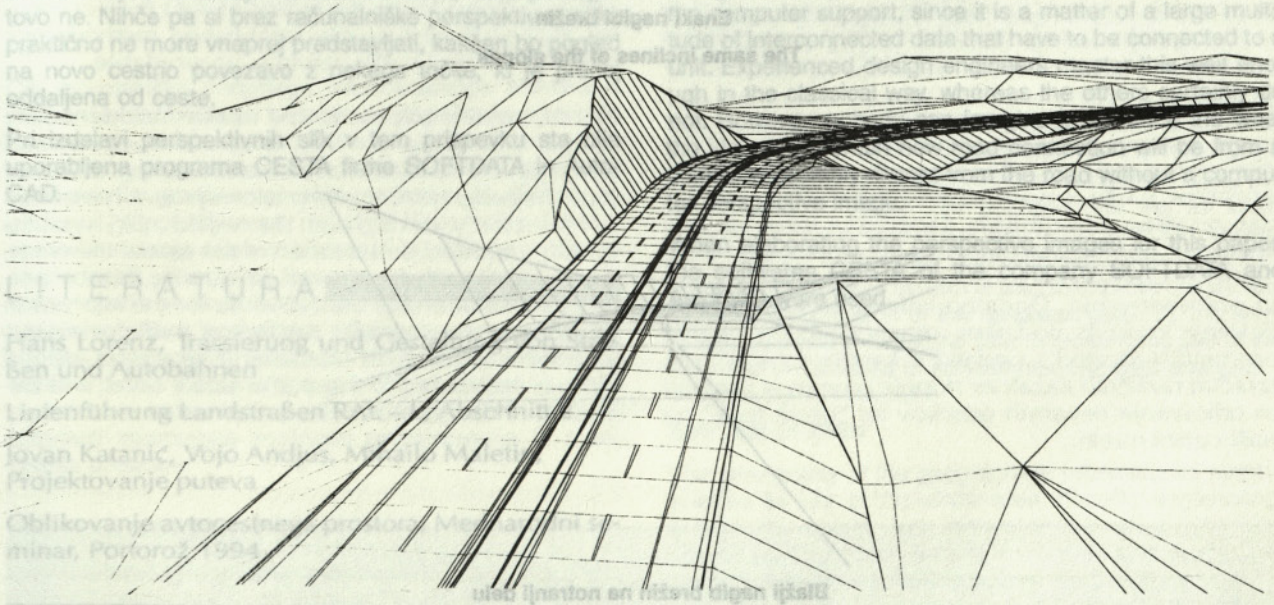
Profesor Ogrin v svojem prispevku ugotavlja, da je cesta omejeno prilagodljiv tehniški organizem s strogimi funkcionalno – strukturnimi zakonitostmi in zato v navzkrižju s pestro naravno in kulturno krajino, ki je za posege zelo ranljiva in težko sprejema gradbene vložke večjih meril. To je vsekakor res, vendar ima iznajdljivi projektant cest na voljo veliko rešitev, ki lahko ta strogo funkcionalni organizem preoblikuje za največjo možno spojitev s krajino.

- character of the complexes by the road side
- signalling and road equipment
- anti-noise protection

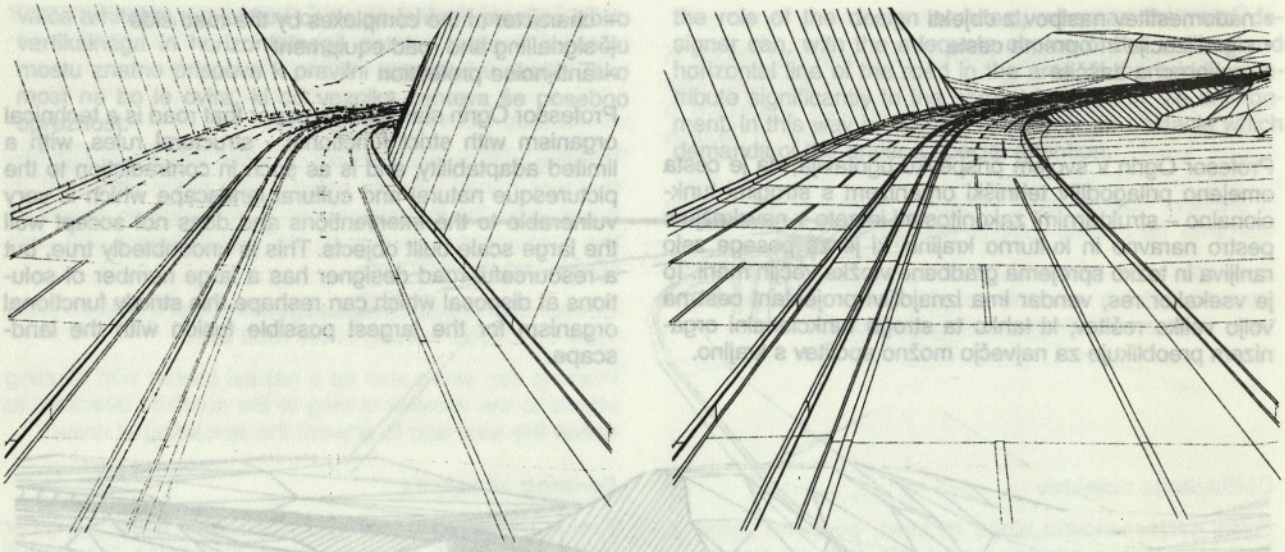
Professor Ogrin states in his paper that road is a technical organism with strict functional - structural rules, with a limited adaptability, and is as such in contradiction to the picturesque natural and cultural landscape which is very vulnerable to the interventions and does not accept well the large scale built objects. This is undoubtedly true, but a resourceful road designer has a large number of solutions at disposal which can reshape this strictly functional organism for the largest possible fusion with the landscape.



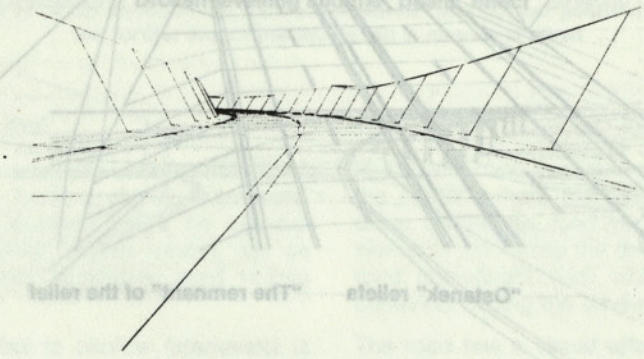
"Ostanek" reliefa **"The remnant" of the relief**



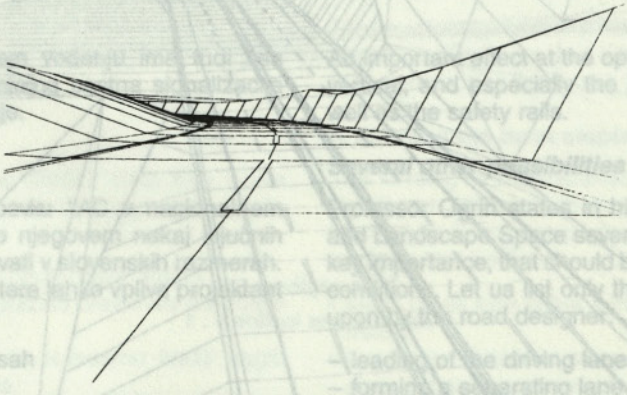
Boljša rešitev **A better solution**



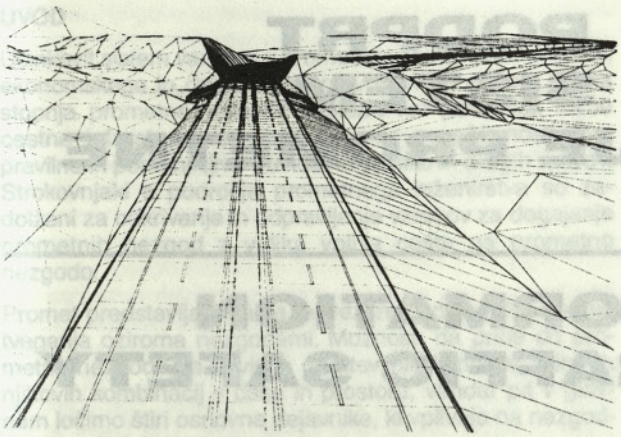
Pogled voznika na prejšnji rešitvi
View of the driver at the previous solution



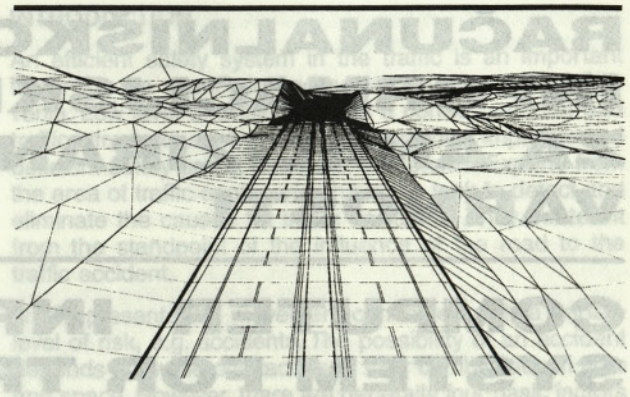
Enaki nagibi brežin
The same inclines of the slopes



Blažji nagib brežin na notranji delu
Milder incline in the inside part



Enak nagib brežin
The same incline of the slopes



Enake dolžine brežin
The same lengths of the slopes

SKLEP

Pri valorizaciji in pri izboru optimalne variante poleg vplivov ceste na okolje primerjamo tudi tehnične elemente. Tu vrednotimo stroške gradnje in vzdrževanja (dolžina trase, količine zemeljskih del, dolžine objektov), stroške uporabnikov ceste (izgubljene višine, delež različnih vzponov, krivinska karakteristika), stroške prometnih nesreč (dolžina poteka skozi naselja, število uvozov itd.) in stroške zemljišč in rušenj.

Menimo, da sta optično vodenje trase in spojitev ceste in krajine vsaj toliko pomembna kot našteti kriteriji. Zato predlagamo, da se tudi ta element vrednotenja vnese v študijo primerjav variant oziroma v fazo, ko se dajejo napotki projektantu ceste. Zavedati pa se moramo, da je tako vrednotenje brez računalniške podpore skoraj nemogoče, saj gre za veliko množico prepletajočih se podatkov, ki jih je treba povezati v celoto. Izkušeni projektanti to še zadovoljivo obvladajo na klasičen način, ostali pa zagotovo ne. Nihče pa si brez računalniške perspektivne slike praktično ne more vnaprej predstavljati, kakšen bo pogled na novo cestno povezavo z nekega točke, ki je precej oddaljena od ceste.

Pri izdelavi perspektivnih slik v tem prispevku sta bila uporabljena programa CESTA firme SOFTDATA in AutoCAD.

CONCLUSION

When valorisating and selecting the optimal variant beside the influences of the road to the environment also the technical element can be compared. Here are assessed the costs of construction and maintenance (length of the laying out, quantities of soil works, lengths of complexes), costs of the road users (lost height, share of different inclines, bending characteristics), costs of traffic accidents (length of the line through inhabited regions, the number of drive-ins, etc.) and costs of the building sites and failuring.

In my opinion, the optical leading of the laying out and the fusion of the road and the landscape are at least as important as all the listed criteria. I therefore suggest that also this element of evaluation is included in the study of variant comparison, or in the stage when the instructions are given to the road designer. One has to be aware, though, that such evaluation is almost impossible without the computer support, since it is a matter of a large multitude of interconnected data that have to be connected to a unit. Experienced design engineers master this well enough in the classical way, whereas the others certainly do not. However, nobody can imagine in advance the what the view to a certain new road connection will be from a point considerably distant from the road without a computer perspective image.

When elaborating the perspective images for this paper, the softwares CESTA of the company SOFTDATA and AutoCAD were used.

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RAČUNALNIŠKO PODPRT INFORMACIJSKI SISTEM ZA ANALIZIRANJE PROMETNE VARNOSTI

COMPUTER INFORMATION SYSTEM FOR TRAFFIC SAFETY ANALYSE

UDK: 656.08:681.3

NIKO ČERTANC, BOJAN STRAH*

POVZETEK

Prometno varnost v odnosu "cesta–voznik" lahko izboljšamo le v primeru, da odkrijemo natančno prostorsko lokacijo nevarnih mest na cestni mreži, ugotovimo dejanske vzroke za nezgodna dogajanja na teh mestih in nato ustrezno ukrepamo. Za odkrivanje in analiziranje nevarnih mest pa je potrebna pravilno zasnovana, točna in vzdrževana baza podatkov o prometnih nezgodah, prometu, prometnotehničnih in voznih karakteristikah cest ter drugih prostorskih informacijah. Glede na obseg podatkov je nujna njihova računalniška obdelava na podlagi uveljavljenih metodologij s področja prometne varnosti.

Ceste, cestna oprema in prometne nezgode so elementi prostora podani s prostorsko lokacijo in opisnimi informacijami. Za obvladovanje prostorskih podatkov pa se v svetu in v zadnjem času tudi pri nas uspešno uporabljajo geografski informacijski sistemi. Z njimi lahko elemente prostora kakovostno grafično predstavimo, izvajamo prostorske analize in poizvedovanja. Dodatno izdelan modul za analiziranje opisnih podatkov omogoča povezovanje prometnih nezgod s podatki o karakteristikah cest, izračun različnih kazalcev stopnje prometne varnosti in odkrivanje nevarnih odsekov ter "črnih točk" na naši cestni mreži.

SUMMARY

Traffic safety in the relation "road-driver" can be improved only if the exact spatial location of dangerous spots in the road net is discovered, and if the actual reasons for the accidents in these spots are established and adequate measures are taken. In order to determine and analyse dangerous spots also the correctly designed, precise and maintained database on traffic accidents, traffic and driving characteristics of roads and other spatial information are needed. Considering the extent of data their computer analysis based on the established methodology from the field of traffic safety is unavoidable.

Roads, road equipment and traffic accidents are spatial entities, given by the spatial location and descriptive information. For the mastering of spatial data the geographical information systems have been used recently throughout the world. GIS enables quality graphical presentation of the spatial elements, and spatial analyses as well as queries can be performed. Additionally built module for the analysis of descriptive data enables the link of traffic accidents with the data on road characteristics, calculation of various indicators of the traffic safety level and detection of dangerous sections Slovenian road net.

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UVOD

Učinkovit sistem varnosti v prometu je pomemben dejavnik ekonomskega in družbenega razvoja naše dežele. Nizka stopnja prometne varnosti nastopa kot posledica slabe cestne infrastrukture, nizke stopnje osveščenosti, nepravilne in pomanjkljive varnostne politike in drugih vplivov. Strokovnjaki s področja prometnega inženirstva so zadolženi za odkrivanje in odpravljanje vzrokov za dogajanje prometnih nezgod z vidika vpliva ceste na prometno nezgodo.

Promet predstavlja gibanje, povezano z določeno stopnjo tveganja oziroma nezgodami. Možnost, da pride do prometne nezgode, je odvisna od številnih faktorjev oziroma njihovih kombinacij v času in prostoru, vendar pa v glavnem ločimo štiri osnovne dejavnike, ki vplivajo na nezgodne dogodke, in to so :

- voznik
- vozilo
- cesta
- okolje

Do sedaj je prevladovalo mnenje, da je človeški dejavnik botroval nastanku večine prometnih nezgod in jih je le manjši del nastalo kot posledica pomanjkljivosti vozil ali neustreznosti ceste. Tako so se raziskave vzrokov prometnih nezgod v glavnem opravljale za potrebe sodišč, ne pa tudi za izboljšanje prometne varnosti.

Glede na veliko število prometnih nezgod (v zadnjem letu prek 40.000) in obsežno bazo podatkov o cestah je bilo potrebno izbrati ustrezno orodje, s katerim bi lahko na podlagi analiz nad temi podatki v kratkem času in pravilno ugotovili obstoječe stanje prometne varnosti. Ker so ceste, oprema in prometne nezgode podatki vezani na prostor, smo se na podlagi, izkušenj in znanih prednosti geografskih informacijskih sistemov (GIS) odločili za implementacijo te tehnologije tudi na področje prometne varnosti.

CILJI

Cilj računalniško podprtega informacijskega sistema je podpora odločitvam pri ukrepih za izboljšanje prometne varnosti na naših cestah. Pri tem naj ne bi zahajali v področje vzgoje in preventive, temveč bi se omejili na prometno in gradbenotehnično področje, ki nam je po strokovni usposobljenosti najbližje. S pomočjo sistema ugotovimo stanje prometne varnosti in nevarna mesta na cestni mreži, enostavna uporaba pa zagotavlja, da kot strokovnjaki s področja cest in prometa in ne računalništva kar največ časa posvetimo odkrivanju vzrokov za nezgodna dogajanja in ukrepanju. Namen predstavljenega sistema je tudi v optimalni meri izboljšati nadzor in izrabo podatkovne baze, ki jo nudi tehnologija GIS in hkrati izkoristiti neomejene možnosti pregledovanja in analiziranja podatkov.

ZASNOVA SISTEMA

Univerzalnost geografskih informacijskih sistemov omogoča njihovo uporabo na celotnem področju prometnega inženirstva. Posamezni programi so povezani prek sistema

INTRODUCTION

An efficient safety system in the traffic is an important factor for the economic and social development of Slovenia. Low level of traffic safety is a consequence of bad traffic infrastructure, low level of conscience, improper and deficient safety policy, and other influences. Experts from the area of traffic engineering have the task to detect and eliminate the causes for traffic accidents. They treated it from the standpoint of the influence of the road to the traffic accident.

Traffic presents the movement connected with a certain level of risk, e.g. accidents. The possibility of an accident depends on numerous factors or their combination in time and space. However, there are generally four basic factors which influence accident events:

- driver
- vehicle
- road
- environment

Until recently the opinion prevailed that the human factor was the cause of the majority of traffic accidents, and only a smaller part was caused by deficiencies of the vehicles or inadequate road conditions. For this reason, the researches of the causes for traffic accidents were performed mainly for the needs of courts, and not to improve traffic safety.

According to a large number of traffic accidents (over 40,000 in the last year) and an extensive database on roads, it was necessary to choose adequate tools with which the existing state of traffic safety could be established quickly and correctly. Our decision, based on experience and known advantages of geographical information systems (GIS), was to implement these technologies also to the field of traffic safety.

GOALS

The goal of the computer information system is to support the decisions at the measures for the improvement of traffic safety on our roads. Here, we should not interfere with the area of education and preventive measures, but should focus on the traffic and constructional area which is closest to our expert qualification. By the help of the system the state of traffic safety and dangerous spots are established. Its simple use provides that we, as traffic experts, dedicate most of the time to the search of causes for accidents, and to take adequate measures. The intention of the presented system is also to improve the surveillance and application of the database given by the technology GIS and in the same time to make good use of the unlimited possibilities of surveillance and data analyses.

SYSTEM DESIGN

The universality of the geographical informational system enables its use in the whole area of traffic engineering. Individual programs are connected through a system of interfaces. Their task is transfer of data and analysis of results among the following areas:

- traffic planning

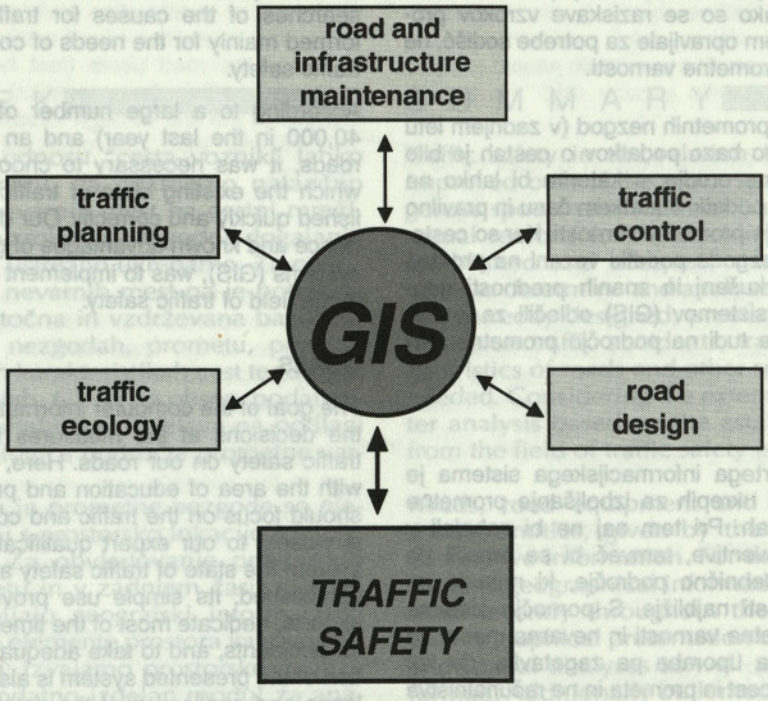
vmesnikov. Njihova naloga je prenos podatkov in rezultatov obdelav med naslednjimi področji:

- prometno planiranje
- projektiranje cest
- vodenje in optimizacija prometa
- simulacija prometa
- prometna ekologija
- vzdrževanje prometne infrastrukture
- **prometna varnost**

Osnova informacijskega sistema za analiziranje prometne varnosti je baza podatkov, ki je vsebinsko razdeljena na opisne in geografske podatke. V tematskih skupinah so tabele z opisnimi podatki o prometnih nezgodah, prometu, cestah, cestni opremi in signalizaciji. Uporabljamo jih v grafičnem in atributivnem modulu informacijskega sistema. Grafični del baze so vektorski in rastrski podatki, pripravljeni v formatu, kot ga zahteva grafični modul. Osnovna je cestno omrežje Slovenije v vektorski obliki, na katero se s stacionažo in šifro odseka navezujejo in prikazujejo prometne nezgode in ostali prostorski elementi. Ostali grafični podatki rabijo kot dodatne informacije in pomoč pri orientaciji v prostoru.

- traffic planning
- road design
- leading and optimisation of traffic
- traffic simulation
- traffic ecology
- maintenance of traffic infrastructure
- **traffic safety**

The basis of the system is database which is divided into descriptive and geographical data. In the thematic groups there are tables with descriptive data on traffic accidents, traffic, roads, road equipment and signalling. They can be used in graphical and attributive modules. The graphical base contains vector and raster data. The basis is the Slovenian road net in the vector shape. Traffic accidents and other spatial elements are connected to road net with the mailage and section code. Other graphical data serve as additional information and help at the spatial orientation.



Slika 1: Zasnova GIS sistema v prometnem inženirstvu

Figure 1: Design of GIS system in the traffic engineering

V sklopu sistema se ne predvideva zbiranje in priprava geografskih podatkov, temveč le njihova uporaba. To pomeni, da je ARC/INFO kot standardno orodje za izdelavo GIS glede na potrebe neizkoriščen. Enostavna rešitev izbora programske opreme se je ponudila s prihodom produkta ARCVIEW 2.0 na tržišče kot nadgradnja ARC/

Within the system the data acquisition and preparation of geographical data are not foreseen, only their use is. This means that ARC/INFO as standard tools for the elaboration of GIS is according to the needs not adequately used. A simple software solution was ARC/INFO upgrade named Arcview 2.0. Its basic qualities are simple and effective

INFO–a. Njegove osnovne kakovosti so enostavno in učinkovito prikazovanje geografskih in pregledovanje atributivnih podatkov, delovanje v okolju Windows, povezava z različnimi bazami podatkov prek SQL, itd.

Atributivni modul je izdelan v okolju programskega paketa Microsoft Access 2.0 za obdelavo baz podatkov. Osnovne funkcije so upravljanje s podatki o prometnih nezgodah, povezovanje z ostalimi podatki, izračun meril prometne varnosti, itd. Integriran je v strokovni informacijski sistem cestnega gospodarstva in tako povezan z ostalimi strokovnimi področji. Vsi rezultati analiz in obdelav opisnih podatkov so dostopni grafičnemu delu sistema za prikazovanje in nadaljnje analiziranje.

Sicer pa smo delo na sistemu razdelili na dve fazi. V prvi, ki jo predstavljamo v tem prispevku, so obdelani:

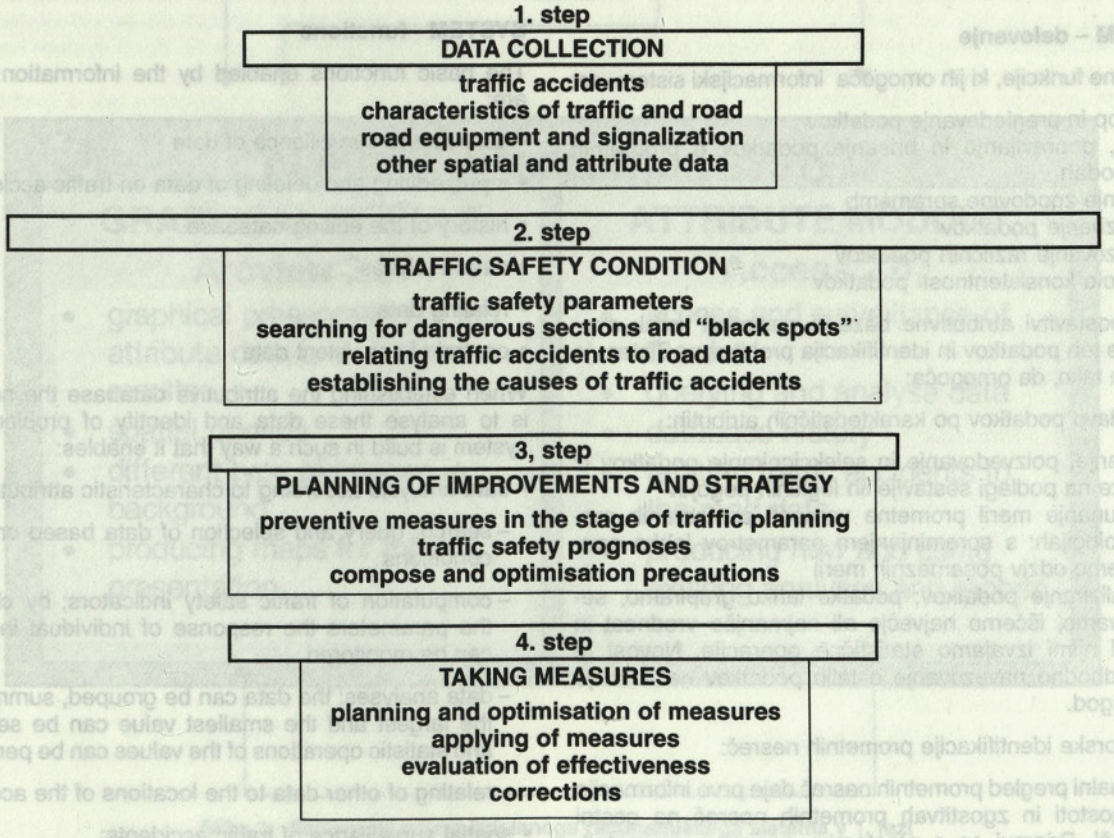
- zbiranje in organizacija podatkov
- metodologije in modeli za ugotavljanje stanja prometne varnosti

presentation of geographical and inspection of attributive data, functioning in the Windows environment, connection to different data bases through SQL, etc.

The attributive module is built in the environment of the program package Microsoft Access 2.0. The basic functions are managing data on traffic accidents, link with other data, calculation of traffic safety indicators, etc. It is integrated into the professional information system of road management, and thus connected to other expert fields. All the analysis results and the descriptive data are available in the graphical part of the system for the presentation and further analysis.

The work at the system was divided into two stages. In the first stage, presented in this paper, analyses:

- data acquisition and organisation
- methodologies and models for determining the traffic safety state



Slika 2: Koncept analiziranja prometne varnosti.

Figure 2: Steps for the traffic safety improvements.

Druga faza predvideva načrtovanje in vrednotenje ukrepov za povečanje prometne varnosti.

The second stage foresees the planning and evaluating of taking measures.

PODATKOVNI MODEL

Model podatkov je privzet v skladu z organizacijo podatkov

DATA MODEL

The data model is adopted according to the organisation

o prometnih nesrečah, ki jo vodi Ministrstvo za notranje zadeve in v skladu z organizacijo podatkov o cestah, prometu, prometni opremi in signalizaciji, ki jo vodi Direkcija za ceste Republike Slovenije. Podatki so ločeni tematsko in vsebinsko na atributivne in grafične podatke. Shranjeni so v centralni bazi tako, da je dostop hiter in enostaven, hkrati pa je zagotovljena uporaba ažurnih podatkov na perifernih računalnikih.

Podatkovni model o prometnih nezgodah obsega samo tiste podatke, ki jih lahko smiselno povezujemo s cesto in cestno opremo. Prometna nezgoda je definirana kot točkovna entiteta in je podana s stacionažo na odseku, ključ za navezavo na cestno mrežo pa sta odsek in stacionaža.

Podatkovni model za ceste (Banka Cestnih Podatkov, BCP) obsega podatke o cestah in pripadajoči infrastrukturi. Točkovni elementi (npr. prometni znak) so podani s stacionažo in šifro odseka, linijski pa s stacionažo začetka in konca ter šifro odseka. Vsi elementi pa vsebujejo tudi pripadajoče opisne podatke.

SISTEM – delovanje

Osnovne funkcije, ki jih omogoča informacijski sistem, so:

- dostop in pregledovanje podatkov
- vnos, popravljanje in brisanje podatkov o prometnih nezgodah
- vodenje zgodovine sprememb
- analiziranje podatkov
- povezovanje različnih podatkov
- kontrolo konsistentnosti podatkov

Po vzpostavitvi atributivne baze je naslednji korak analiziranje teh podatkov in identifikacija problemov. Sistem je zgrajen tako, da omogoča:

- obdelavo podatkov po karakterističnih atributih:
  - iskanje, poizvedovanje in selekcioniranje podatkov iz baze na podlagi sestavljenih logičnih pogojev
  - računanje meril prometne varnosti po izbranih metodologijah; s spreminjanjem parametrov lahko opazujemo odziv posameznih meril
  - analiziranje podatkov; podatke lahko grupiramo, seštevamo, iščemo največjo ali najmanjšo vrednost in nad njimi izvajamo statistične operacije. Novost je predhodno navezovanje ostalih podatkov na lokacije nezgod.
- prostorske identifikacije prometnih nesreč:
  - vizualni pregled prometnih nesreč daje prvo informacijo o gostoti in zgostitvah prometnih nesreč na cestni mreži. Pripravi se s prostorsko navezavo prometnih nezgod na ceste z dinamično segmentacijo. Natančnost vidnega zaznavanja problemov je odvisna od merila pregledovanja, ki ga lahko poljubno spreminjamo. Grafična podloga so podatki o cesti, opremi, okolju, itd..
  - vrednosti atributov na izbranih lokacijah elementov poleg prostorske lokacije dajejo celotno informacijo o izbranem elementu. Z vertikalnim prebodom skozi podatkovne plasti dobimo vse podatke na izbrani lokaciji

of the data on traffic accidents managed by the Ministry of the Interior. The data organisation on roads, traffic equipment and signalling are directed by the Direction for Roads of the Republic of Slovenia. The data are divided to the attributive and graphical data. They are stored in the central base in such a way that the access is quick and simple. At the same time the use of the updated data at peripheral computers is provided.

The data model on traffic accidents comprises only those data that can be logically connected with the road and road equipment. Traffic accident is defined as point entity and is given with a mailage in the section. Key for the connection to the road net are the section code and the mailage.

The data model for roads (Bank of Road Data, BCP) contains data on roads and road infrastructure. Point entities (e.g. stop sign) are given by mailage in section code. Line entities are given by start and end mailage and section code. All entities also contain the descriptive information.

SYSTEM - functions

The basic functions enabled by the information system are:

- access and surveillance of data
- input, editing and deleting of data on traffic accidents
- history of the editing database
- data analyses
- relating data
- control of consistent data

When establishing the attributive database the next step is to analyse these data and identify of problems. The system is build in such a way that it enables:

- data analysis according to characteristic attributes
  - search, query and selection of data based on logical conditions
  - computation of traffic safety indicators; by changing the parameters the response of individual indicators can be monitored
  - data analyses; the data can be grouped, summarised, the largest and the smallest value can be searched, and statistic operations of the values can be performed.
  - relating of other data to the locations of the accidents.
- spatial surveillance of traffic accidents:
  - visual surveillance of traffic accidents gives the first information on the density and condensing of traffic accidents in the road net. It is prepared with the spatial connection of traffic accidents to the roads with dynamic segmentation.
  - the values of attributes at the selected locations of the entity give beside the spatial location also descriptive information. With the vertical penetration through the data layers all the data at the chosen location are obtained.

– iskanje lokacije elementov, katerih atributi zadoščajo izbranemu pogoju, nam omogoča prostorsko selekcioniranje podatkov in s tem kakovostnejše opazovanje in identificiranje morebitnih problemov.

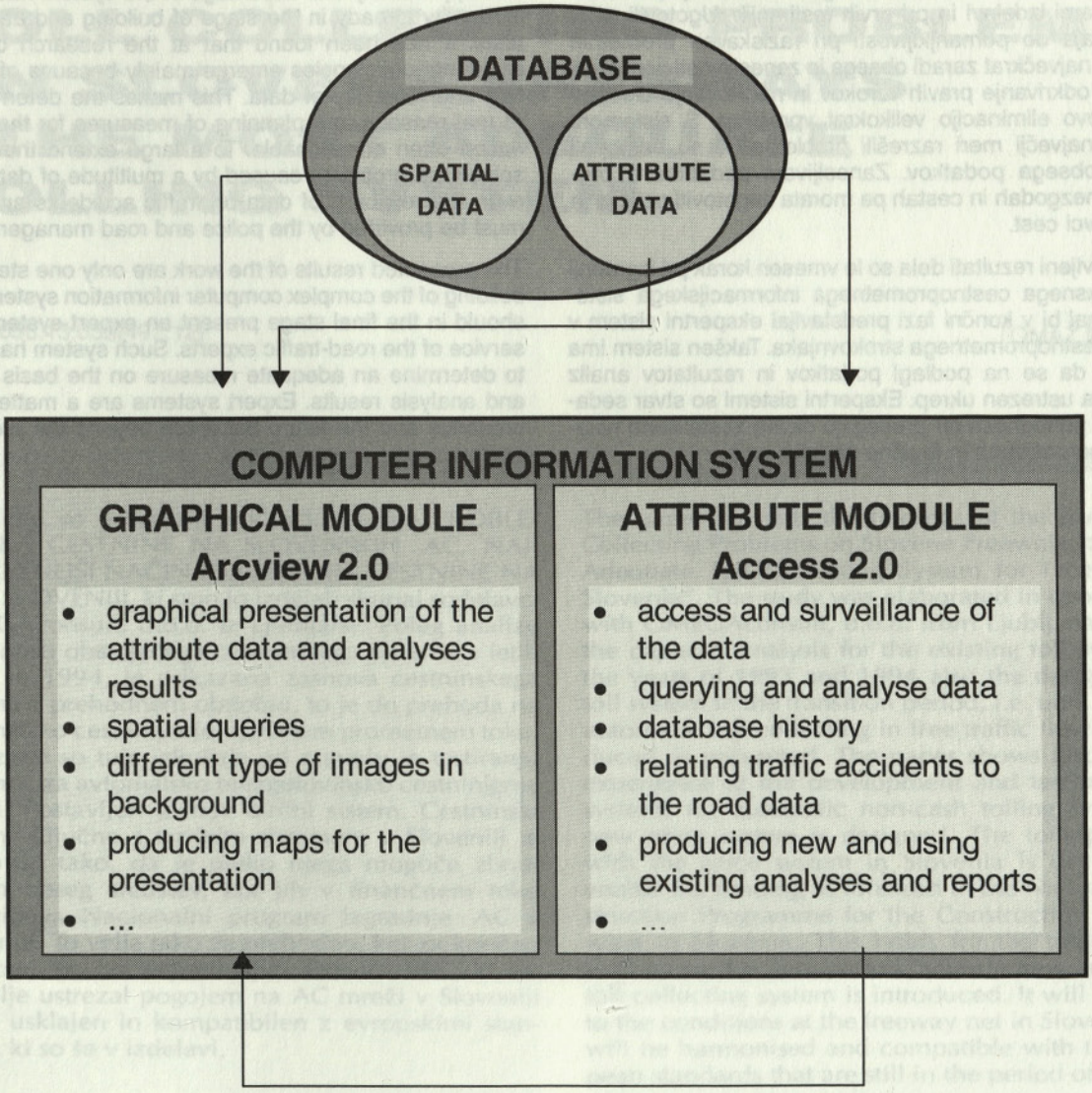
• grafične prikaze:

– nezgodne karte
– izrise rezultatov analiz

– search for the element location the attributes of which suffice the chosen condition enables higher quality monitoring and identifying of any possible problems

• graphic presentations:

– accident maps
– print-outs of analyses results



Slika 3: Shematski prikaz izdelanega računalniškega sistema v 1. fazi

Figure 3: Schematic presentation of stage 1 of the system

SKLEP

Cestni promet in prometno dogajanje sta sestavni del našega življenja, povezana z določeno stopnjo tveganja oziroma z nesrečami. Možnost, da pride do prometnih nesreč, je odvisna od številnih dejavnikov oziroma njihovih

CONCLUSION

Road traffic and road activity are part of our life, and are connected to a certain level or risk, e.g. accidents. A possibility of a traffic accident depends on numerous factors or their combination in time and space. The role of the

kombinacij v času in prostoru. Človek v tem sistemu ne nastopa le v vlogi voznika, to je uporabnika vozila in ceste, ampak tudi v vlogi kreatorja in izdelovalca vozil, ter načrtovalca, graditelja in vzdrževalca cest. Za poseganje v nezgodna dogajanja z regulativnimi in gradbenotehničnimi ukrepi je potrebno predhodno ugotoviti, kateri cestni odseki so nevarni in kje so nevarna mesta oz. t.i. črne točke. Zaradi številčnosti podatkov pa se lahko delo opravi kakovostno in hitro le s pomočjo računalniške podpore.

Uporabnost in prednost izdelanega sistema se je pokazala že pri sami izdelavi in pri prvih testiranjih. Ugotovili smo, da prihaja do pomanjkljivosti pri raziskavah prometnih nezgod največkrat zaradi obsega in zanesljivosti podatkov. Tako je odkrivanje pravih vzrokov in načrtovanje ukrepov za njihovo eliminacijo velikokrat vprašljivo. S sistemom smo v največji meri razrešili probleme, ki so nastopali zaradi obsega podatkov. Zanesljivost podatkov o prometnih nezgodah in cestah pa morata zagotoviti policija in upravljavci cest.

Predstavljeni rezultati dela so le vmesen korak pri izgradnji kompleksnega cestnoprometnega informacijskega sistema, ki naj bi v končni fazi predstavljal ekspertni sistem v službi cestnoprometnega strokovnjaka. Takšen sistem ima nalogo, da se na podlagi podatkov in rezultatov analiz odloči za ustrezen ukrep. Ekspertni sistemi so stvar sedanjosti in prihodnosti ter presegajo okvire zastavljene naloge, so pa potrebno in logično nadaljevanje.

human being is in this system not only the role of a driver, i.e. road or vehicle user, but also the role of designer and manufacturer of vehicles, planner, constructor and roads maintaining engineer. In order to intervene into the accident events with regulative and constructional-technical measures, it has to be previously established which road sections are dangerous. However, due to the large number of data the work can be performed with high quality and quickly only by the computer support.

The applicability and advantage of the system has proven its quality already in the stage of building and at the first tests. It has been found that at the research of traffic accidents deficiencies emerge mainly because of the extent and reliability of data. This makes the determination of real reasons and planning of measures for their elimination often questionable. To a large extend the system solved the problems caused by a multitude of data. However, the reliability of data on traffic accidents and roads must be provided by the police and road managers.

The presented results of the work are only one step to the building of the complex computer information system which should in the final stage present an expert system in the service of the road-traffic experts. Such system has a task to determine an adequate measure on the basis of data and analysis results. Expert systems are a matter of the presence and the future but reach beyond the presented system.

PROBLEMATIKA CESTNINE NA SLOVENSKIH AVTO CESTAH NAJUSTREZNEJŠI NAČIN PLAČEVANJA

TOLL COLLECTING PROBLEMS ON SLOVENE FREEWAYS - THE MOST ADEQUATE TOLLING SYSTEM

UDK: 656.13.035(497.12)

TOMAŽ MAHER*

P O V Z E T E K

V članku so prikazani zaključki študije PROBLEMATIKA CESTNINE NA SLOVENSKIH AC, NAJUSTREZNEJŠI NAČIN PLAČEVANJA CESTNINE NA AC V SLOVENIJI, ki smo jo izdelali skupaj sodelavci OMEGAconsult, d.o.o. iz Ljubljane. Poleg analize uspešnosti obstoječega cestninskega sistema v letih 1993 in 1994, je prikazana zasnova cestninskega sistema v prehodnem obdobju, to je do prehoda na avtomatsko cestninjenje v prostem prometnem toku. Prikazane so tuje izkušnje pri razvoju in testiranju sistemov za avtomatsko brezgotovinsko cestninjenje (ABC). Postavljen je nov tarifni sistem. Cestninski sistem vključno s tarifnim sistemom v Sloveniji je zasnovan tako, da je preko njega mogoče zbrati takšen obseg sredstev, kot jih v finančnem toku predvideva Nacionalni program izgradnje AC v Sloveniji. To velja tako za prehodno, kot za končno obdobje, ko bo vzpostavljen sistem ABC, ki bo najbolje ustrezal pogojem na AC mreži v Sloveniji in bo usklajen in kompatibilen z evropskimi standardi, ki so še v izdelavi.

S U M M A R Y

The paper presents the findings of the study "Toll Collecting Problems on Slovene Freeways, the Most Adequate Toll Collecting System for Freeways in Slovenia". The study was elaborated in cooperation with OMEGAconsult, d.o.o. from Ljubljana. Beside the capacity analysis for the existing toll system in the years of 1993 and 1994 also the design of the toll system in the transition period, i.e. until the new automatic toll collecting in free traffic flow is introduced, is presented. The paper shows also foreign experience at the development and testing of the systems for automatic non-cash tolling system. A new price system is designed. The tolling system with the price system in Slovenia is designed to enable the funding as foreseen in the National Construction Programme for the Construction of Freeways in Slovenia. This holds for the transition as well as for the final period, when a new automatic toll collecting system is introduced. It will suit best to the conditions at the freeway net in Slovenia and will be harmonised and compatible with the European standards that are still in the period of.

UVOD

Do sedaj je cestnina predstavljala denarno nadomestilo, ki ga je uporabnik AC plačal za koristi, ki jih je imel z

INTRODUCTION

So far tolling has presented a cash compensation that the user of freeways paid for the benefits of driving on a

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vožnjo po avtocesti v primerjavi z necestninsko povezavo. Cestnina je veljala kot pravično in namensko nadomestilo za višji standard prometnih uslug. V svetu pa se vse bolj uveljavlja načelo, da naj uporabnik v prometu plača čim večji delež stroškov, ki jih povzroči s transportom ljudi in blaga. Pri t.i. pojmu "Road pricing" cestnina ne bi bila le instrument financiranja, temveč tudi sredstvo za preusmerjanje prometa (cesta, železnica, drugo).

V Evropi je odločitev o uvedbi cestnine na avto cestah predvsem prometnopolitični cilj. Prav zaradi naraščajoče mobilnosti je treba zmanjšati negativne učinke prometa. Zaradi naraščajočega povpraševanja po prometni infrastrukturi in zaradi povečanih zahtev (okolje, prometna varnost, ipd.) so vse večje potrebe po finančnih sredstvih, ki jih ni več mogoče izpolniti z obstoječimi viri in instrumenti financiranja. Nobena vrsta transporta ne pokrije v celoti vseh stroškov, ki jih povzroči (pri tem pa ne mislimo samo na stroške gradnje in vzdrževanja AC, stroške pobiranja ipd), temveč tudi vse druge stroške, ki jih prevzema družba z uvajanjem posameznih novih prometnih površin (okolje, izraba površin). Posodobitev tehnologije pobiranja sta zato tudi širom po Evropi pospešila trend za uvedbo cestnine. Uvajanje plačevanja cestnine ne bo samo na medmestnih cestah z visokim standardom - AC, ampak naj bi se kasneje uveljavilo tudi na preobremenjenih urbanih cestnih mrežah. Sistemi za avtomatsko cestninjenje, ki jih bomo uporabili v Sloveniji, morajo zmanjšati negativne vplive (ustavljanje na cestninskih postajah, zamude vozil, prekomerna poraba površin za CP) in omogočati cestninjenje vozil ob popolni anonimnost uporabnikov, varnosti denarnih transakcij in nadzoru nad zlorabami.

IZHODIŠČA

Kot izhodišča navajamo naslednje:

Sklep DZ na 12. seji 1.10.1993, da "se s 1. 7. 1994 v Sloveniji preneha z neposrednim pobiranjem cestnine". Realizacija navedenega sklepa v predlaganem roku ni mogoča.

V Nacionalnem programu izgradnje AC v Sloveniji natančno ovrednotena sredstva cestnine v strukturi investicijskih sredstev

Mnenje MPZ, da se v Sloveniji v prihodnje uvede plačilo cestnine brez ustavljanja (in ne pavšalna cestnina). Pripravi se na postavitev pilotskega projekta za avtomatsko cestninjenje. Na posameznih stezah je treba za zmanjšanje števila ustavljanj uvesti prehodni sistem, ki bo v končni fazi prešel v popolnoma avtomatski sistem, usklajen z evropskimi standardi.

Mnenje MOP, ki se strinja, da je za uporabo AC v Republiki Sloveniji treba pobirati cestnino. Do prehoda na avtomatski sistem cestninjenja (brez ustavljanja) naj se na že zgrajenih AC odsekih uporablja obstoječ način (odprt ali zaprt sistem), na novo zgrajenih odsekih pa je treba predvideti izključno t.i. odprte sisteme. Pri zasnovah tarifnega sistema je treba zagotoviti omejevanje tranzitnega mednarodnega tovornega prometa in spodbujanje regionalnega in medregionalnega prometa.

Stališče ES, ki ima odklonilno stališče do t.i. pavšalne

freeway, as compared to the non-tolling connection. Tolling has been considered a rightful and purposeful compensation for higher standard of traffic services. In the rest of the world another principle is geining importance, i.e. that the users in the traffic pays as large share of costs that they cause with the transport of people and goods as possible. At the so called term "road pricing" the toll collection should not be only an instrument of financing, but also a means for the redirection of traffic (road, railway, others).

In Europe the decision on introducing the tolling on freeways is in the first place a traffic-political goal. Increasing mobility is the main reason why negative influences of traffic should be decreased. Owing to an increase at the demand for traffic infrastructure and due to higher criteria (environment, traffic safety, etc.) the needs for financial means are increasing. They cannot be filled any more with the existing resources and instruments of financing. No branch of transport can cover the whole costs that it causes. Here not only the costs of freeway construction and maintenance, collecting etc. are included, but also all other costs that society is taking over with the introduction of new traffic surfaces (environment, land use). For this reason the trend to introduce toll collecting with modernisation of technology is gaining importance. Toll collecting should not be introduced only to inter-city roads with high standard - freeways, but later on also to highly loaded urban road nets. The system for automatic tolling that will be used in Slovenia has to reduce negative influences (stopping at toll plazas, delays of vehicles, too large consumption of surfaces for toll plazas) and enable toll collection with complete anonymity of the users, safety of monetary transactions and prevention of abuses.

FOUNDATIONS

I quote:

Decree of the Parliament at its 12th session held on 1 October 1993 that "with 1 July 1994 there is no more direct collection of toll in Slovenia". The quoted decree is impossible to realise within the proposed time period.

The National Freeways Construction Programme in Slovenia evaluates in detail the funds for the tolls in the structure of investment funds.

Opinion of the Ministry for Transport and Connections that Slovenia will in future introduce tolling without stopping (and not lump toll). The introduction of pilot project for automatic tolling is to be prepared. On individual lanes a transition system has to be introduced in order to decrease the number of stoppings. In the final stage it will be replaced with a completely automatic system that will agree to the European standards.

Opinion of the Ministry for Environment which agrees with the toll collecting for the use of freeways in the Republic of Slovenia. Until automatic system of tolling is introduced (without stopping), the existing tolling system is to be used in the already built freeway sections (open or closed system), whereas at the newly built sections the so called open systems are to be planned. At the design of

cestnine. Cestnina mora biti v čimvečji meri odvisna od dejanske prevožene razdalje.

CESTNINSKI SISTEM

Obstoječe stanje

Kot je znano, je obstoječ sistem pobiranja cestnine ročen (gotovinski in brezgotovinski). Do konca leta 1994 je bilo zgrajenih 196,73 km AC, vključno s 64,68 km priključnih cest. Cestnina se ne plačuje za celotno dolžino AC. V območju večjih mest so cestnine prosti odseki. Cestninski sistem na odseku Ljubljana-Razdrto in Arja vas-Maribor je zaprt, na Torovem in Hrušici (na gorenjski AC) pa odprt. V letu 1993 je bilo s cestnino zbranih skupaj 2.989596.387,00 SIT. Delež pobrane cestnine po AC bazah je bil naslednji: Postojna 53.7%, Sl. Konjice 20.4%, Hrušica 14.8% in Ljubljana 11.2%. Stroški pobiranja so znašali skupaj 365.000.000,00 SIT (12%), stroški rednega vzdrževanja AC pa 652.612.000,00 SIT (21%). V letu 1994 so s cestnino zbrana sredstva narasla na 4.371.070.341 SIT in indeks porasta 146. V tem času se je promet na območju AC baze Postojna povečal za 17%, na Hrušici za 30%, na območju AC baze Ljubljana (Torovo) za 22 % in na območju AC Slovenske Konjice za 10%. Stroški pobiranja cestnine so padli pod 10 % pobrane cestnine.

Na vseh novih AC odsekih, ki bodo zgrajeni v prihodnosti, smo predvideli odprte cestninske sisteme, ki omogočajo necestninsko uporabo AC za regionalni promet (tudi okoli večjih regionalnih središč (Ljubljana, Maribor, Celje, Novo mesto, Koper, Nova gorica). Sistem je postavljen tako, da v čim večji meri zajame tranzitni promet skozi Slovenijo. Cestninske postaje so dimenzionirane na leto 1999, upoštevaje obstoječo prepustnost stez (do 160 vozil/uro v konici). Prepustnost stez se bo z uvedbo avtomatskih sistemov povečevala, zato se bo njihovo število kasneje ustrezno zmanjševalo. Predvidena je uvedba t.i. hitrih, ločenih stez za negotovinsko plačevanje.

Predlagan cestninski sistem

Za celotni slovenski AC sistem je bilo preverjenih več variant cestninskega sistema. Zavedamo se, da na izbiro cestninskega sistema poleg prostorsko-prometno tehničnih in ekonomskih pogojev vplivajo tudi politični. Teh ni lahko vrednotiti. Končno odločitev o izbranem cestninskem sistemu na AC sistemu v Sloveniji bo treba poiskati v konsenzu s prizadetimi občinami, prek katerih potekajo AC, potrditi pa ga bo moral tudi državni zbor.

Obdelane so bile štiri variante cestninskega sistema. Te se razlikujejo glede na kombinacijo zaprti oz. odprti sistem in glede na lokacijo cestninskih postaj. Ločeno od teh variant smo na primorskem kraku dodatno preverili smiselnost vzpostavitve odprtega sistema, vendar je ekonomska primerjava pokazala, da bi prihodek pri odprtem sistemu zaradi velikega odliva prometa znašal le 71% dohodka, ki ga ustvari pravičnejši obstoječi zaprti sistem. Odpiranje sistema bo potrebno ponovno preveriti ob vzpostavitvi sistemov za avtomatsko cestninjenje.

Za vse variante oz. avtocestne odseke je bila izdelana

the payment system the limitations of international goods transport have to be considered, whereas regional as well as inter-regional traffic has to be stimulated.

The standpoint of the EC referring to the so called lump toll is negative. The toll has to depend as much as possible on the actually covered distance.

TOLLING SYSTEM

The existing state

As known, the existing tolling system is manual (cash and cash-free). By the end of 1994 196.73 km of freeways had been built, including the 64.68 km of connecting roads. The toll is not paid for the whole length of freeways. In the area of larger towns there are toll-free sections. The tolling system at the section Ljubljana-Razdrto and Arja vas-Maribor is closed, whereas at Torovo and Hrušica (the Gorenjsko freeway) it is open. In the year 1993 2,989,596,387 SIT were collected with the toll. The share of collected toll in the freeway stations was as follows: Postojna 53.7%, Slovenjske Konjice 20.4%, Hrušica 14.8% and Ljubljana 11.2%. The costs of toll collection amounted to 365,000,000 SIT (12%), and the costs of regular freeway maintenance amounted to 652,612,000 SIT (21%). In 1994 the funds collected with toll increased to 4,371,070,341 SIT, and the index of growth to 146. In this period the traffic in the area of freeway section Postojna increased by 17%, in Hrušica by 30%, in the area of freeway section Ljubljana (Torovo) by 22%, and in the area of Slovenjske Konjice by 10%. The costs for toll collecting decreased under 10% of the collected toll.

In all new freeway sections that will be constructed in the future open tolling systems are foreseen. This enables non-toll use of freeways for regional traffic (also around larger regional centres, such as Ljubljana, Maribor, Celje, Novo mesto, Koper, Nova Gorica). The system is designed in such a way that it includes the transit traffic through Slovenia in the highest possible degree. The toll plazas are foreseen for the year 1999, taking into account the existing lane permeability (up to 160 vehicles/hour in rush hours). The lane permeability will increase with the introduction of automatic system, which will later on result in fewer lanes. The so called fast lanes, separate lanes for non-cash payment are also planned.

The proposed tolling system

For the whole Slovene freeway system several variants of tolling system were tested. We are aware that the selection of tolling system is influenced besides by spatial-traffic technical and economic conditions, also by political conditions. However, the latter are difficult to evaluate. The final decision on the selected tolling system on the freeway system in Slovenia will have to be reached in consensus with the affected municipalities where the freeways run. It will also have to be confirmed by the Parliament.

Four tolling system variants were considered. They differ according to the combination closed or open system, and according to the location of the toll plazas. Separate of these variants the suitableness of introducing open sys-

ocena obsega prometa in prognoza prometa za naslednjih 25 let. Stopnje rasti za posamezne vrste prometa smo privzeli iz predloga Nacionalnega programa. V nalogi so prikazane prometne obremenitve za obdobje 1993 - 2018 ločeno za osebna domača vozila, za osebna tuja vozila, za avtobuse in za tovornjake.

Za posamezne variante so bili izračunani stroški izgradnje in vzdrževanja avtocestnega sistema, stroški postavitve cestninskega sistema ter stroški pobiranja cestnine. Iz predloga Nacionalnega programa izgradnje cest v Sloveniji so privzeti stroški novih investicij, financiranja investicijskega vzdrževanja in tekočega vzdrževanja po letih.

Stroški postavitve cestninskega sistema so bili izračunani na podlagi cene postavitve ene steze, ki znaša 65.000 US$ (brez opreme za avtomatsko cestninjenje).

Stroški postavitve sistema za izbrano varianto, ki ima 87 stez, od tega 15 začasnih, znašajo 5,655 mio US$.

Stroški pobiranja cestnine so bili izračunani na podlagi letnih stroškov obratovanja na eno stezo, ki znašajo v povprečju 40.000 US$ letno. Stroški naraščajo z vključevanjem novih cestnih odsekov v cestninski sistem do končne izgradnje sistema leta 2006, ko se bodo ustalili.

Ocena prihodka od pobrane cestnine je bila narejena na osnovi predvidene rasti prometa v naslednjih petindvajsetih letih. Upoštevani so bili prometni tokovi po tarifnih razredih za vsako cestninsko postajo posebej. Pri tem je bilo za vsako C.P. upoštevano tako leto izgradnje kot tudi dolžina odseka, za katerega se cestnina zajema. Upoštevan je bil tarifni razred za osebna vozila 0,06 US$/km, za osebna vozila s prikolicami in kombije 0,09 US$/km, za avtobuse 3-krat višja kot za osebna vozila in za tovorna vozila 6-krat višja kot za osebna vozila (tarifna varianta A).

Za vsako varianto cestninskega sistema je bil izdelan tok prihodkov in tok stroškov za obdobje petindvajsetih let. Donosnost posamezne variante izkazuje obrestna mera, pri kateri se diskontirani tok prihodkov izenači z diskontiranim tokom naložbe v analiziranem obdobju. Primerjava stopenj donosnosti izkazuje, da je izbrana varianta cestninskega sistema, gledano iz vidika gospodarnosti, najprimernejša. Zato predlagamo, da se, kolikor ni drugih zadržkov, izbrana varianta realizira (glej nadaljevanje).

Za izbrano varianto cestninskega sistema sta bili poleg tarifnega razmerja po varianti A (0.06 US$ za osnovno kategorijo in razmerje 1:6 med kategorijami), preverjeni še dve različni tarifni razmerji med kategorijami, in sicer:

Varianta B (sedanje stanje):

I. razred:	osebna vozila	0.0310 USA$/km
II. razred:	osebna vozila s prik.	0.0465 USA$/km ali 1.5 x I.raz.
III. razred:	avtobusi in tovor. do 3 osi	0.0930 USA$/km ali 3.0 x I.raz.
IV. razred:	tovornjaki s 4 osmi in več	0.1860 USA$/km ali 6.0 x I.raz.

tem was tested at the Primorska section, but economic comparison showed that the income at the open system will amount only to 71% of the income that would be obtained from the more rightful closed system. The opening of the system has to be re-evaluated when the system of automatic tolling is to be introduced.

For all variants or freeway sections the estimation of traffic extent and traffic forecast for the next 25 years was elaborated. The growth levels for individual types of traffic were assumed from the Proposal of National Programme. The paper presents the traffic loads for the period of 1993 - 2018, separately for personal vehicles, foreign personal vehicles, buses and trucks.

For individual variants the construction costs and the costs of maintaining the tolling system, the costs of introducing the tolling system as well as the costs of collecting toll were calculated. The costs of new investments, financing the investment maintenance and current maintenance in years are assumed from the Proposal of the National Freeway Construction Programme in Slovenia.

The costs of introducing the tolling system were calculated according to the price of setting up one lane, which amounts to 65,000 US$ (without equipment for automatic tolling).

The costs of setting up the system for the selected variant with 87 lanes, 15 of which are temporary, are 5,655 million US$.

The costs of toll collecting were calculated according to the yearly operation costs which amount on average to 40,000 US$ annually. The costs increase with the inclusion of new freeway sections and tolling system, until the finalisation of the system in 2006, when they are fixed.

The estimation of the income from the collected toll was made on the basis of the foreseen growth of traffic in the next twenty-five years. Traffic flows according to the payment classes were considered for each toll plaza individually. For each toll plaza the year of construction as well as the section length that the toll includes were taken into account. The following payment classes were considered: for personal vehicles 0.06 US$/km, for personal vehicles with trailers and for vans 0.09 US$, for buses 3 times higher than for personal vehicles, and for trucks 6 times higher than for personal vehicles (payment variant A).

For each variant of the tolling system a flow of income and costs for the period of 25 years was elaborated. The profitability of each individual variant is presented by the interest rate where the discounted flow of income is equalled with the discounted flow of investment in the analysed period. The comparison of profitability levels shows that the chosen variant of the tolling system is from the standpoint of economy the most adequate. Therefore we propose that, if there are no other obstacles, the selected variant is realised (see the sequel).

For the selected variant of the tolling system beside the payment ratio according to variant A (0.06US$ for the first category and ratio 1:6 between categories) two more different payment ratios were checked, i.e.:

Varianta C (sedanje stanje za tovorna vozila in zmanjšanje ostalih razredov na razmerje 1:4)

I. razred:	osebna vozila	0.0465 USA$/km
II. razred:	osebna vozila s prik.	0.0698 USA$/km ali 1.5 x I.raz.
III. razred:	avtobusi in tovor. do 3 osi	0.1395 USA$/km ali 3.0 x I.raz.
IV. razred:	tovornjaki s 4 osmi in več	0.1860 USA$/km ali 4.0 x I.raz.

Pregled stopenj donosnosti kaže, da sedanja višina in razmerje tarif ne ustvari zadostnega priliva, ki bi pokril naložbena sredstva, niti pri nični diskontni stopnji. Modificirana sedanja tarifa pa izkazuje pozitivno vrednost stopnje donosnosti v višini 2,99%. Tarifni razred A bi zagotavljal 10.1% donosnost naložb v sistem avtocest in cestninski sistem v Sloveniji, vendar so pri teh tarifah možni večji odlivi prometa. Zato smo pri t.i. "naložbeni tarifi" preverjali le gospodarsko učinkovitost posameznih vrst cestninskega sistema. Odločitev za tarifni razred B pomeni, da pobrana cestnina tudi na daljši rok ne bo zagotavljala sredstev, ki bodo potrebna za izgradnjo in vzdrževanje sistema avtocest in cestninskega sistema v Sloveniji. Pri tarifah C pa je pričakovati zadostne prilive za pokritje vseh stroškov, vendar le pri 3% donosnosti kapitala.

Predlagani cestninski sistem je naslednji:

Primorska:	zaprt sistem med Ljubljano, Razdrtim, Danami in Kozino;
	odprt in cestnine prost sistem v Vipavski dolini
	odprt in cestnine prost sistem med Kozino in Srminom;
CP:	vse obstoječe CP na priključkih, obstoječa CP Razdrto kot začasna na obstoječi lokaciji do dograditve AC do Kozine in CP Kozina, nova CP Razdrto na kraku proti Vipavski dolini po dograditvi CP Kozina, CP Kozina (v priključku Kozina) CP Senožeče, CP Dane, CP Matavun, CP Vogrsko
Gorenjska:	odprt sistem med Ljubljano in predorom Karavanke,
CP:	CP Torovo, CP Hrušica
Dolenjska:	odprt sistem med Ljubljano in Obrežjem
CP:	CP Višnja gora, začasna do dograditve CP Bič, CP Brežice (v priključku Brežice)
Štajerska:	odprt sistem med Ljubljano in Mariborom
	odprt sistem med Mariborom in Šentiljem

Variant B (present state):

I. class:	personal vehicles	0.0310 US$/km
II. class:	personal vehicles with trailers	0.0465 US$/km or 1.5 x I.cl.
III. class:	buses or trucks up to 3 axes	0.0930 US$/km or 3.0 x I.cl.
IV. class:	trucks with 4 axes or more	0.1860 US$/km or 6.0 x I.cl.

Variant C (present state for goods vehicles and lowering of other classes to the ratio 4:1)

I. class:	personal vehicles	0.0465 US$/km
II. class:	personal vehicles with trailers	0.0698 US$/km or 1.5 x I.cl.
III. class:	buses or trucks up to 3 axes	0.1395 US$/km or 3.0 x I.cl.
IV. class:	trucks with 4 axes or more	0.1860 US$/km or 4.0 x I.cl.

The examination of the profitability levels shows that the present height and ratio of payments do not bring enough inflow to cover the investment funds, not even at the zero discount level. However, the modified present payment system shows positive value of the profitability level in the height of 2.99%. Payment class A would provide 10.1% profitability of investments into the freeway and tolling systems in Slovenia, but with these payment classes larger outflows of traffic are possible. For this reason only the economic efficiency of individual kinds of tolling system was checked at the so called "investment payment". The decision for the payment class B means that the collected toll will not provide funds necessary for the construction and maintenance of the freeway and tolling system in Slovenia, not even for longer period of time. However, at payment variant C sufficient inflows to cover all costs are to be expected, though only at the 3% profitability of the capital.

The proposed tolling system is as follows:

Primorska (Littoral):	closed system between Ljubljana, Razdrto, Dane and Kozina;
	open and toll-free system in Vipavska dolina
	open and toll-free system between Kozina and Srmin;
toll plazas (TP):	all the existing TP at the connections, the existing TP as temporary at the existing location until the freeway to Kozina has been finished, and TP Kozina, new TP Razdrto at the section towards Vipavska dolina after the TP Kozina has been finished (in the interchange Kozina), TP Senožeče, TP Dane, TP Matavun, TP Vogrsko
Gorenjska:	open system between Ljubljana and the tunnel Karavanke
TP:	TP Torovo, TP Hrušica
Dolenjska:	open system between Ljubljana and Obrežje
TP:	TP Višnja Gora, temporary until the TP Bič, TP Brežice (in the interchange Brežice) have been

AVTOMATSKO BREZGOTOVINSKO CESTNINJENJE

Prehodno obdobje

V prehodnem obdobju predlagamo avtomatsko enostezno cestninjenje v delno oviranem prometnem toku (hitrost vozil do 40 km/h, praktično brez ustavljanja). Sistem mora omogočati dvosmerno komunikacijo (read/write) prek mikrovalovne povezave vozilo-obcestna oprema. Vozilo mora imeti elektronsko tablico s sposobnostjo branja in pisanja informacij. Na začetku bo takšno avtomatsko cestninjenje omejeno le na eno kategorijo (omejitve svetlega profila) in brez sistema za klasifikacijo in identifikacijo kršiteljev (kaznovanje vozil brez potrebne opreme in/ali kredita). Kasneje bi se postopoma vzpostavila tudi oba omenjena sistema. Predlagani avtomatski sistem cestninjenja bo vzpostavljen na že zgrajenih stezah na CP in ne bo zahteval nobenih bistvenih gradbenih posegov. Glede na število uporabnikov se bodo lahko ukinjale steze na CP. Sistem bo pokrival tako zaprte kot odprte cestninske sisteme. V zaprtih so bo na elektronsko tablico zapisala koda vstopne postaje, na izhodu pa bo vozilo ocestninjeno z ustrezno tarifo (matrika vstopno izstopnih postaj). V odprtih sistemih se na elektronsko tablico zapiše vstopna postaja, na čelni CP se vozilo o cestnini z ustreno "polno tarifo". V primeru, da vozilo zapusti AC nekje pred koncem ocestninjenega odseka, se vozilu povrne ustrezni del že ocestninjene tarife. Posebni zapis 10 zadnjih transakcij poskrbi za preprečevanje zlorabe te funkcije. Elektronska tablica z možnostjo branja in pisanja omogoča predvsem popolno anonimnost uporabnikov. Informacija o vozilu/vozniku se ne prenaša v centralni računalniški sistem. Možna je uporaba predplačila v obliki t.i. elektronskega denarja ali točk in časovna omejitev uporabe (mesečni najem). Pomanjkljivost je le ta, da voznik nima direktnega vpogleda o opravljeni transakciji in o stanju predplačila (to možnost omogoča uporaba t.i. smart kartice in čitalca z zaslonom v vozilu, kar bo omenjeno v nadaljevanju), kar pa je mogoče eliminirati prek posebnega zaslona na CP, ki pokaže plačan znesek in stanje po opravljeni transakciji cestninjenja. Uporaba takšnega sistema za avtomatsko cestninjenje poveča kapaciteto steze na 500 vozil/uro.

Končno obdobje

V končnem obdobju predlagamo uvedbo sitema za avtomatsko večpasovno cestninjenje v prostem prometnem toku. Cestninjenje deluje na principu izmenjave podatkov in informacij med t.i. opremo v vozilu, ki jo sestavlja radijskim transponder, LCD zaslon, tipkovnica in čipkartica ("On-Board-Unit", okrajš. OBU), in radijsko komunikacijsko napravo, pritrjeno ob in/ali nad voznim pasom. Nosilec denarne vrednosti je vrednostna čip kartica, ki se nahaja v OBU (t.i. "Smart-Card") z lastnim procesorjem in strukturiranim spominom. Obcestna oprema pod določenim kotom oddaja v smeri ceste mikrovalovni signal z najmanj eno mikrovalovno anteno za vsak vozni pas. Ta signal v omejenem področju (t.i. "komunikacijskem pasu") spodbudi vsa v tem področju nahajajoča se vozila, ki imajo OBU k odgovoru. Odgovor OBU je znak za začetek obojestranskega pogovora med OBU in obcestno opremo,

finished

Štajerska: open system between Ljubljana and Maribor
open system between Maribor and Šentilj

AUTOMATIC CASH-FREE TOLLING

Transition period

In the transition period the automatic one-lane tolling in partially obstructed traffic flow is proposed (vehicle speed up to 50 km/h, practically without stopping). The system has to enable a two-way communication (read/write) through a microwave connection between a vehicle and roadside equipment. The vehicle must have an electronic tag with the ability to read or write information. In the beginning such automatic tolling will be limited only to one category (limits of clearange) and without the system for classification and identification of violators (fining of the vehicles without the necessary equipment and/or credit). Later on gradually both mentioned systems would be introduced. The proposed automatic tolling system will be introduced at the already finished lanes of TP and it will not demand any essential constructional interventions. Considering the number of users some lanes at TP will be gradually abolished. The system will cover closed as well as open tolling systems. In the closed ones the code of the entry station will be written to the electronic tag, and at the exit TP the vehicle is tolled with the adequate "full payment". In case if the vehicle leaves the freeway before the tolled section, the vehicle is recompensed the already tolled payment. A special notification of 10 last transactions prevents abuses of these functions. The electronic tag with a possibility to read and write enables in the first place complete anonymity of users. The information on the vehicle/driver is not transferred into the central computer system. Possible is also payment in advance in the form of the so called electronic money or points, and temporary limitation of its use (hired monthly). The only disadvantage is that the driver does not have a direct insight into the performed transaction and on the balance of the payment in advance (this possibility is given by the so called smart cards and reader with a screen inside the vehicle, more about it in the sequel). This can be eliminated thorough a special screen at the TP which shows the paid amount and the balance after the performed tolling transaction. The use of such system for automatic tolling improves the lane capacity to 500 vehicles/hour.

Final period

In the final period we suggest to introduce the system for automatic multi-lane tolling in free traffic flow. The tolling operates according to the principle of data and information exchange between the so called equipment in the vehicle which consists of radio transporter, LCD screen, keyboard and chip-card ("On-Board-Unit", OBU), and radio communication device fixed by the side or above the driving lane. The bearer of money value is value chip-card which is beside the OBU (the so called "Smart-Card") and has its own processor and structural memory. The roadside equipment emits under a certain angle in the direc-

ki se praviloma konča s popolnim ocestninjenjem vozečega vozila in "izdanim" potrdilom o opravljeni transakciji, ki se zapiše na čip kartico. Če je v komunikacijskem pasu več vozil, je treba poskrbeti za ustrezne komunikacijske protokole, ki skrbijo za jasnost pogovora med posamezno OBU in postajo. Uspešno končan cestninski postopek je treba shraniti tako na čip kartico kot na računalnik, ki je priključen na obcestno opremo ("knjižni računalnik"). Tehnično je lahko obcestna oprema (postaja) sestavljena iz največ dveh, v smeri vožnje zaporedno postavljenih radijskih naprav. Poleg tega pa je treba postajo opremiti še z napravo za avtomatsko kategorizacijo vozil, ki je neodvisna od informacij v OBU, zapisanih na čip kartico. Vzpostaviti je potrebno video nadzor, ki bo vozila, ki bi kakorkoli kršila pravila avtomatskega cestninjenja fotografirala od spredaj oz. od spredaj in od zadaj. Slike, posnete z video napravami, bo treba shraniti in ovrednotiti registrsko tablico (OCR), tako da bo mogoče preveriti veljavnost čip kartice, ki je vezana na določeno kategorijo. Testirati bo potrebno avtomatsko zasledovanje ("Video-Enforcement") v odprtem cestninskem sistemu. Sistem mora biti operativen pri hitrosti prek 140 km/h kakor tudi pri t.i. "stop and go" režimu vožnje. Vozila, ki zaradi kakršnegakoli vzroka ne bi bila avtomatsko ocestninjena, je potrebno s spremenljivimi znaki voditi na posebeno stezo za ročno obračunavanje cestnine. Kapaciteta takšnega sistema je teoretično do 2000 vozil na uro. Cena takšnega sitema je ocenjena na 10 : 1 v primerjavi s predlaganim sistemom v prehodnem obdobju.

SKLEP

Vzpostavitev sistema za avtomatsko cestninjenje na slovenskih AC je nujnost. Razumljivo je, da je vzpostavitev nemogoče opraviti "prek noči", kot si nekateri preprosto zamišljajo. Prehod iz ročnega sistema gotovinskega in negotovinskega cestninjenja prek uporabe posebnih t.i. hitrih stez za negotovinsko cestninjenje (možna uporaba čip kartice, mesečne karte, blanketi, ipd.) je mogoč. Minimalni čas čakanja in atraktivne tarife bi pozitivno delovale na naraščajoče število uporabnikov (predplačnikov). Tak sistem lahko začnemo uvajati takoj.

Predlagani prehodni sistem je treba preveriti najprej na testnem območju. Za to predlagamo CP Torovo, ki nudi možnosti za preizkus vseh naštetih funkcij sistema. Sedanje uporabnike mesečnih kart lahko opremimo z elektronskimi tablicami. Z atraktivno tarifno politiko bo zanimanje za uporabo sistema nedvomno veliko. Izkušnje pridobljene na testnem poligonu (v realnem času in prostoru) bodo uporabljene pri širitvi sistema na ostale CP. Sistem je

tion of the road a microwave signal with at least one microwave antenna for each driving lane. This microwave signal triggers all vehicles in this area with OBU to respond. The response of OBU is the sign to start the interaction between OBU and the road-side equipment which finishes as a rule with a complete tolling of the driving vehicle and with the receipt on the performed transaction which is written on the chip-card. If there are several vehicles in the communication belt, adequate communication protocols have to be taken care of. They maintain clarity of the dialogue between individual OBU and the station. Successfully finished tolling procedure has to be stored to the chip-card as well as to the computer which is connected to the road-side equipment ("booking computer"). From the technical point of view the road-side equipment (station) consists of at the most two successively installed radio devices. The station has to be equipped also with a device for automatic categorisation of vehicles which does not depend on the information stored to the chip-card in OBU. Video surveillance has to be established. Thus photos of the vehicles which will in any way breach the rules of automatic tolling will be taken from the front or from the back and the front. The photos taken with video devices will have to be stored and the car number plate will have to be evaluated, which will enable to check the validity of the chip-card which is related to a certain category. The automatic tracking ("Video-Enforcement") will have to be tested in an open tolling system. The system has to be operative at the speed above 140 km/h, as well as at the so called "stop and go" driving regime. The vehicles that would from any reason not be tolled have to be lead with changing signs to a special lane for manual tolling. The capacity of such system is theoretically up to 2000 vehicles per hour. The price of such system is estimated to be 10 : 1 as compared to the proposed system in the transition period.

CONCLUSION

The establishment of systems for automatic tolling on Slovene freeways is a necessity. It is understandable that they can not be introduced "overnight" as some might think. As a transition from manual cash system and non-cash system to this system the use of special so called fast lanes for non-cash tolling (possible use of magnetic cards of chip-cards, monthly cards, forms, etc.) could be introduced. Minimal waiting times and attractive payment have positive influence to the growing number of users (payers in advance). We can start with the introduction of such system immediately.

The proposed transition system has to be checked first at a test area. Our proposal for a test area is TP Torovo which offers a possibility to test all the mentioned functions of the system. The present users of monthly cards can be equipped with electronic number plates. With attractive payment policy the interest to use the system will undoubtedly be large. The experience obtained in the test area (in real time and space) will be used when the system expands to other TP. The system can be introduced in the shortest possible time. It can also function until the transition to the final system (4 to 5 years), when it will

možno vzpostaviti v najkrajšem času in lahko deluje do prehoda na končni sitem (4 do 5 let), ko deluje vzporedno z njim ali pa ga je mogoče uporabiti v druge namene ("bus priority" v mestih, parkirne hiše ipd.)

Predlagani končni sistem je do sedaj še v razvoju. Obstojajo določeni testni poligoni (Göteborg (Š), Solun (GR), odsek AC A555 med Kölnom in Bonnom, Turska AC v Avstriji, v ZDA, idr.), kjer testirajo tako opremo kot programsko opremo, vendar sistem ni še nikjer v komercialni uporabi, kar to tudi ni za pričakovati pred letom 1998. V pripravi so tudi še evropski standardi, ki bodo unificirali tako strojno kot programsko opremo in komunikacijske protokole. Preoptimistično in neracionalno bi bilo, če bi bili v Sloveniji prvi, ki bi vzpostavili sistem za popolno avtomatsko cestninjenje v prostem toku, lahko pa se mnogo naučimo iz izkušenj sosednji dežel. Zagovarjamo postopni prehod na končni sistem. Kompatibilnost cestninskega sistema mora biti v prvi vrsti vzpostavljena s sistemi sosednjih dežel. Predvsem pomembne bodo avstrijske izkušnje na Turski AC, ki se prek Karavanškega predora neposredno navezuje na sistem slovenskih AC.

operate parallelly to it, or it can be used for other purposes (bus priority in towns, parking houses, etc.).

The proposed final system is still being developed. There are certain test polygons (Goteborg, Sweden; Tessaloniki, Greece; section of the freeway A555 between Cologne and Bonn, Germany; Tauern freeway in Austria; in the USA, etc.) where such equipment is tested as software, although the system has not been in commercial use yet, and it is not expected to be until 1998. European standards are being prepared. They will unify hardware as well as software equipment and communication protocols. It would be too optimistic and irrational if Slovenia would be the first introduce the system for completely automatic tolling in free flow, but we could learn a lot from the experience of our neighbouring countries. We stand for gradual transition to the final system. The compatibility of the tolling system has to be harmonised first with the systems of our neighbouring countries. Especially important will be the Austrian experiences of the Tauern freeway which is connected through the tunnel Karavanke directly to the system of Slovene freeways.

STROKOVNI IZPITI ZA GRADBENIŠTVO IN ARHITEKTURO TER PRIPRAVLJALNI SEMINARJI ZA STROKOVNE IZPITE V LETU 1996

			A.	B.	
Rok	Leto	Mesec	SEMINAR	IZPIT	
				pisni	ustni
I.	1996	Januar	15.–19. januar	20. januar	1.–7. februar
II.	1996	Februar	19.–23. februar	17. februar	4.–8. marec
III.	1996	Marec	18.–22. marec	23. marec	8.–12. april
IV.	1996	April	15.–19. april	20. april	6.–10. maj
V.	1996	Maj	20.–24. maj	25. maj	10.–14. junij
VI.	1996	September	16.–20. september	19. oktober	4.–8. november
VII.	1996	Oktober	14.–18. oktober	16. november	2.–6. december
VIII.	1996	November	18.–22. november		
IX.	1996	December	16.–20. december		

A. Pripravljalni seminar za strokovne izpite organizira **ZVEZA DRUŠTEV GRADBENIH INŽENIRJEV IN TEHNIKOV SLOVENIJE, LJUBLJANA, KARLOVŠKA 3, telefon (061) 221-587.** Prijavo, v obliki dopisa, pošlje organizatorju plačnik seminarja za prijavljeno osebo. Če je plačnik seminarja podjetje (pravna oseba), priobči v prijavi izjavo, kdo je plačnik. Samoplačnik pošlje organizatorju prijavo v obliki dopisa, skupaj s kopijo dokazila o plačilu seminarja. Cena seminarja za eno osebo znaša 50.400,00 SIT (znesku je že prištet 5% prometni davek). Številka žiro računa je 50101-678-47602. Prijave za seminar v določenem roku je potrebno poslati najmanj 14 dni prej.

B. Strokovni izpit organizira **GRADBENI INŠTITUT ZRMK, Dimičeva 12, Ljubljana, Gradbeni center (Dimičeva 9),** telefon (061) 342-671. Prijave, v obliki obrazca, z vsemi prilogami, ki so razvidne iz obrazca, sprejema organizator 20 dni pred pisnim delom izpita. Obrazce je mogoče dobiti pri organizatorju, vse informacije pri inž. Jakobu Grošlju od 8.00 do 12.00 ure.

GRADBENI VESTNIK

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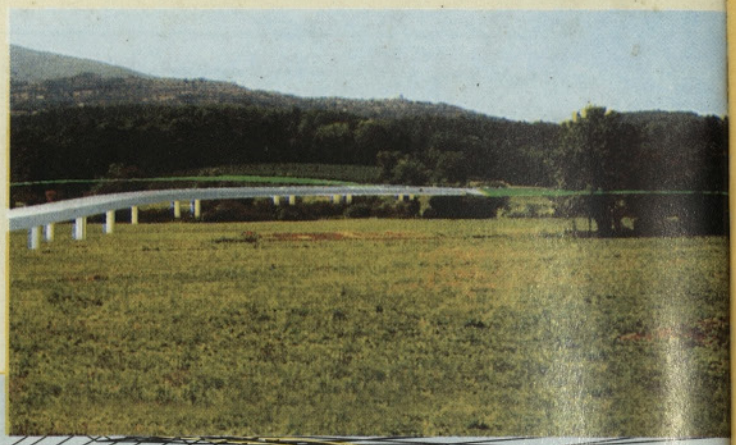

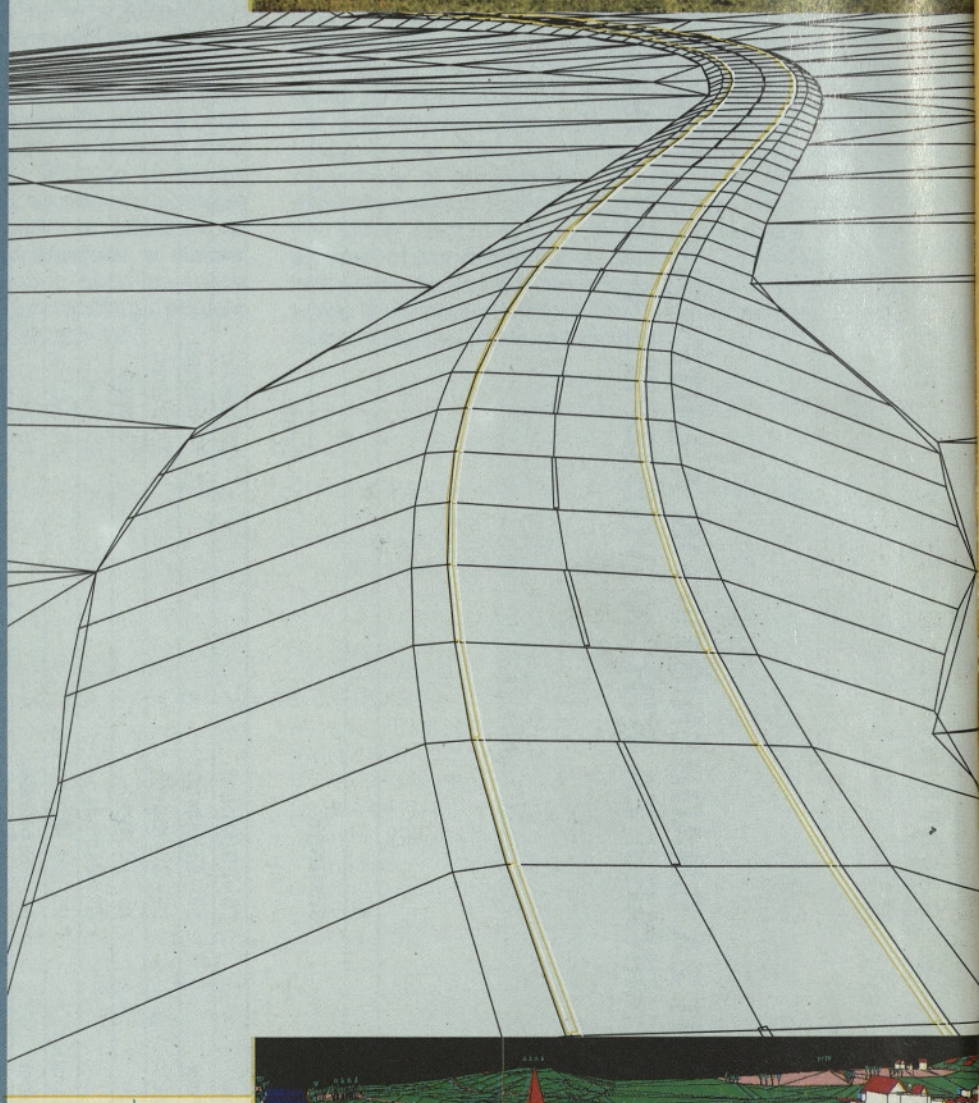

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