DYNAMIC VISUALIZATION IN TRANSPORT DOMAIN

DYNAMICKÁ VIZUALIZACE V OBLASTI DOPRAVY

Lucie HRUBÁ

Dipl. Eng., Institute of Geoinformatics, Faculty of Mining and Geology, VSB – Technical University of Ostrava
17.listopadu 15, Ostrava-Poruba, tel. (+420) 59 732 5597
e-mail: lucie.hruba@vsb.cz

Abstract

Cartography as a discipline with a rich history, analogously to other sciences, went during last years through a tremendous development, namely especially due to rapid advances in technologies. The digital technologies cause changes virtually in all scientific disciplines, not excepting cartography. In the field of cartography they bring new methods of data processing and new ways of presentation as well. Therewith a different view of map and reader's relation to map is related. However, such changes open quite new possibilities of phenomenon representations on maps. One of the possibilities is the utilization of dynamic visualization in computer cartography, namely not only for expressing phenomenon dynamics, but also for attracting attention of the user to significant phenomena or objects. Methods being used for paper maps can be adapted and extended by advanced expression means of computer cartography to interpret dynamics of spatial phenomena.

In introduction the contribution deals briefly with trends in up-to-date computer cartography. In its further part it then deals with a concept of dynamic visualization and methods of dynamic representation below demonstrated on examples of applications in the transport domain. Transport as a spatial and time-variable phenomenon is a perfect application field for the utilization of computer cartography methods and especially for the utilization of dynamic visualization. We might provide a whole series of examples and suggestions for its utilization, however the contribution does not set the aim of introducing their detailed overview. The contribution is focused on creating a brief overview of techniques of dynamic representation being used for visualization with illustrative examples in the transport domain.

Abstrakt

Kartografie, jako věda s bohatou historií, podobně jako jiné vědy, prošla během minulých let obrovským vývojem, a to především v důsledku rozvoje technologií. Digitální technologie způsobují změny prakticky ve všech vědních oborech, kartografii nevyjímaje. V oblasti kartografie přináší nové metody zpracování dat i nové způsoby prezentace. S tímto je pak spojen odlišný pohled na mapu a vztah čtenáře k této mapě. Tyto změny však otevírají zcela nové možnosti znázornění jevů na mapách. Jednou z těchto možností je využití dynamické vizualizace v počítačové kartografii, a to nejen pro vyjádření dynamiky jevu, ale také pro upoutání pozornosti uživatele k významným jevům či objektům. Metody použité u map v tištěné podobě je možné přizpůsobit a rozšířit o moderní vyjadřovací prostředky počítačové kartografie k vyjádření dynamiky prostorového jevu.

Příspěvek se v úvodu stručně zabývá trendy v současné počítačové kartografii. V další části se pak zabývá pojmem dynamické vizualizace a způsoby dynamické reprezentace, které jsou dále demonstrovány na příkladech aplikací z oblasti dopravy. Doprava jako prostorový a v čase proměnný jev je ideální aplikační oblastí pro využití metod počítačové kartografie a zvláště pro využití dynamické vizualizace. Příkladů a námětů pro její využití může být poskytnuta celá řada, avšak tento příspěvek si neklade za cíl uvést jejich vyčerpávající přehled. Příspěvek je zaměřen na vytvoření stručného přehledu používaných technik dynamické reprezentace pro vizualizaci s ilustračními příklady z oblasti dopravy.

Key words: cartography, animation, dynamic visualization, map, transport, traffic.

1 INTRODUCTION

Map is one of the most significant media for transmitting spatial data and is ever important in various areas. Paper maps utilize static symbols and graphics to transmit spatial information, however in the present Information Age the standard static maps could not satisfy the user's demand. Current advances in computer and related technologies raise wide utilization of multimedia digital maps that use dynamic representations, therefore they have more advantages than maps in paper form. [adapted according to 9]

The computer technologies initially having been used in cartography rather within research, today they virtually have gained control of cartographic production. After the digital methods of map production had been introduced to the practice by default in the middle nineties, at the beginning of the new century the Internet

onsets as an ideal medium for the data presentation. Present technological possibilities offer more than a mere map representation. The cartographic data can be shared on different servers and it is possible to work with the data interactively directly in the Internet environment. [2]

New forms of spatial data presentation occur such as electronic atlases and digital maps, animated and interactive maps utilizing multimedia elements in combination with map. Multimedia (multimedia elements) are defined in this case as interactive integrations of sound, animation, text, image or video. So the possibilities brought by digital cartography and web environment extend conventional cartographic variables.

The traditional static, analogue map is able to reflect a certain moment in geographic space [9]. In the paper maps the dynamic development of individual mapped objects and phenomena in space are hardly to capture, although limited possibilities of representation exist. In the digital maps the possibilities are much more wider. The creators of maps use the term 'dynamic visualization' to describe representations coherently changing, no matter whether under the user's control or not [9]. The dynamic visualization is then applicable to quite a number of domains and phenomena, especially where time factor and capturing the dynamics of development (e.g. in space) is indispensable.

2 DYNAMIC VISUALIZATION

According to [5] we distinguish 3 methods of the cartographic visualization to capture development.

- Single static map - here a development is captured by means of graphic-variable symbols
- Series of static maps - a series as a whole represents the development of event
- Animated map

In sixties the animation was used in cartography at the experimental level for representing some phenomena. Technological advances of eighties allowed further development in this area. The third wave is in progress just now and is significantly boosted by possibilities of the current GIS (geoinformation systems) technologies [adapted according to 5 and 8]. Animations can be useful for explaining trends and processes, as well for clarifying or recognizing spatial interrelations. We classify cartographic animations to time-related (or temporal) and time-unrelated (or non-temporal) ones. For the first named a direct relation exists between animation time and world time, in other words, the animation represents real-time changes. An example is a yesterday's weather animation, motion of aircrafts over the USA on a certain day or changes in the Dutch coast line from Roman Era up to this day. In the non-temporal animations on the contrary animation time is not linked with world time, the animation dynamics is in this case applied to representing spatial relations and specifying geometric attribute characteristics of spatial phenomenon (an example is the animation of generation of digital terrain model (DTM)). [adapted according to 5]

Animations may be also divided to animations with a fixed sequence (or let us say fixed animations) and interactive ones [8]. In case of the fixed animations the user has nearly no chance to affect or set their behaviour. The animations allow mostly just to pause or perhaps adjust the playback speed. It concerns especially such animations produced in graphic programs by compiling a series of maps into an animation representation. These are then distributed in the form of animated GIF image or AVI clip. A typical illustration may be the animation of the development of meteorological conditions during 24-hour interval or the below mentioned animation of air traffic over the USA. It is convenient to apply the fixed animations where no interactions with the user are expected. On the contrary the interactive animations provide the user with much more extensive options. The user can for instance influence the selection of phenomena being represented, adapt animations to his/her needs and preferences, affect the animation stream. Te interactive animations may be built on the Java programming language.

In the dynamic map content representation and visualization not only animations may be applied, but also another techniques and multimedia elements. These involve:

- Sound
- Dynamic symbol
- Image
- Video
- Virtual reality
- Text

Combining the multimedia elements with maps aims at allowing the user to gain a better overview on the phenomenon being mapped as a whole, highlight some elements and last but not least make the map more attractive to the user. It is necessary to say that there is no need maps to contain dynamic, changing-in-time phenomena for the reason some of the mentioned elements to be used.

In further text the individual above mentioned multimedia elements will be described in more detail.

Sound is generally used for multimedia digital maps by several reasons - in order to achieve a pleasant atmosphere a music plays in background representing the space-related information (playing national anthem of

a selected nation, playing language of a selected country), it can be used for increasing the perception of a phenomenon of the real world (noise of a frequented intersection, sounds from a given place).

Dynamic symbols can represent real-world phenomena and are divided to point, line, area, flash symbols [9][5]. The next parameters of dynamic symbols to express properties of entities are frequencies of change in shape, colour, size, direction, position, rotation or flashing. These parameters should especially draw attention and make objects more attractive, but they can also imply a change in space and time. For instance, a dynamic point symbol can represent a moving vehicle [9].

Transferring the cartographic production into the digital environment brought along first of all the chance of a relatively fast change of the map appearance. The idea of the dynamic visualization then surpassed in many directions the limits given by the media formerly used (prompt query-induced change in map field contents and design). Considering the generated map represents always just the substantial in a given situation, it is possible to use a cartographic symbol in all complexity of its graphic properties without any apprehension before losing the transparency and readability of the map. The work with a map has however its regularities, whether it concerns both the paper map or digital one. The point is in the identification of objects in map via a symbol key, recognition of spatial interrelations of the objects identified and pursuant to such perception of situation drawing conclusions. Nevertheless the dynamic visualization changes this deep-rooted manner. Map to a certain extent stops functioning according to the regularities as they are defined in semiotics. Relationships vary. Objects in a given situation vital for the user come to the fore to the exclusion of projecting general signs. In the dynamic visualization the tendency to visualize the information effectively should prevail over the pursuit to view its maximum quantity. [3]

Images, animations, videos in connection with a map are able to offer another view of reality. For instance, we can see a photo of a monitored transport means (e.g. a vessel), a video projecting intensity of traffic in certain hours in a given location and others.

Texts are used relatively frequently, particularly in the form of floating texts projected over a map or element. When clicking on an object more detailed information is displayed, an example can be the current delay of a given train, information on size and velocity of a vessel and others. Very often also hypertext links are used. Some of electronic atlases have all kinds of the encyclopedic information interconnected with the map as a whole or with an individual map element.

Virtual reality is a rather rarely utilized, but very attractive and interesting element.

These possibilities of visualization can be combined in products of the computer cartography such as digital maps or atlases described below.

As noted above, the term dynamic visualization is used to describe representations that coherently change, namely with or without the user's control [9]. The essence of the dynamic visualization is then to project the substantial for a given situation and this requirement is applied to both the background and especially its thematic component [3].

2.1 Digital Maps

We can meet with maps very often in the Internet environment, although the Internet is not a sole medium for transmitting maps. In general, we can define the digital map as a map being based on the visualization of a cartographic (spatial) database and saved on a storage medium in the digital form. The digital maps combine several technologies involving GIS, digital cartography and mentioned above multimedia. A special type of the digital map is a web map.

Most of authors divides them to static and dynamic maps, followed by maps intended just for representing, and maps interactive.

The digital (electronic) maps differ from the conventional paper ones particularly in the possibility of faster updates, possibility to capture a phenomenon in a higher detail, frequently also in a simpler availability (for example web maps), extensibility and also in the noted above dynamism.

The electronic maps have a number of advantages over the paper maps resulting from their nature.

- Relatively easy to update their contents
- Easy portability
- Option to change or adapt the map projection
- Option to change interactively the map scale and cut
- Option to use zooming (zoom in, zoom out)
- Option to create individually the map contents (projecting layers and their properties)
- Option to measure distances etc.
- Option to use dynamic symbols such as flashing, moving or rotating objects etc.
- Support of multimedia

2.2 Electronic Atlases

We have known the conventional paper atlases in the form of books since school desks. The phenomenon of last period are however atlases electronic or digital. These atlases are mostly distributed on CDs or DVDs that contain both the geoinformation database and then also the software to display it. In a very simplified way we may say that it concerns the interconnection of functionality of GIS and the digital maps, however according to [5] this domain involves also products without any GIS functionality.

According to [5] we distinguish 3 different types of the electronic atlases:

- View-only atlases - an electronic version of the paper atlas without any further special functionality; the main reasons for this atlas representation is its simpler output and distribution, but mainly lower manufacturing costs
- Interactive atlases - are intended for the deeper computer-educated users, they allow handling with their contents (e.g. option to change the map appearance, change of colour scheme, classification methods and others)
- Analytical electronic atlases - these use the full potential of the electronic atlas, the user for instance does not need to be limited just to topics chosen for the atlas by a cartographer, but is able to combine data sets in a different way and adjust outputs to his/her preferences; in this case the GIS functionality is used built-in the electronic atlas

Some authors consider the last named type a real representative of the electronic atlas.

Advantages of the electronic atlases consist in the possibility of their adaptation to the user, analogously to the digital maps. Benefits of these maps then project themselves to the electronic atlases.

3 APPLICATIONS OF DYNAMIC VISUALIZATION IN TRAFFIC

Movement is one of an important part of the world, however it is relatively rarely represented on maps. Traffic is the movement of persons and goods and as such it is one of two main methods of overcoming physical distances - the other way are telecommunications. Traffic connects people at the personal, social, cultural and economic levels, e.g. it transfers goods from a location, where available, to a place, where needed for some purposes. The traffic system is a means allowing the required movement. It involves infrastructure, equipment, vehicles, employees, management system and each of us in the position of its user. [1]

Traffic in general is without doubts a time-variable, spatially-oriented phenomenon, some its phenomena are only hardly to capture on maps in paper form. These maps offer only reduced possibilities for illustrating the phenomenon dynamics that just in traffic plays a significant role. Means of the classical cartography involve for instance ribbon graphs, direction line symbols, line-bound cartograms. A limiting factor is however the projection of a phenomenon change in time, what means, for other period of time there is a need to create a new map. [4] Much more wider scale for capturing the phenomena related to traffic are offered by the digital cartography and especially then by the mentioned above representations of map contents.

Represented phenomena from the traffic domain involve:

- Motion of objects and their condition
- Traffic complications - roadblocks, closures, diversions, congestions
- Traffic information - trafficability, state of the weather, deployment of radars, beacons, control stations
- Traffic intensity
- Phenomena related to traffic - noisiness, dustiness

Lots of applications focus on public transport, however also applications exist focusing on personal transport. In the following subchapters examples of different types of applications are presented for road, railway, air and water transport.

3.1 Road Transport

An interesting and useful application in this domain is the Traffic Info system (available on http://www.dopravniinfo.cz/default.aspx that occurred within the realization of the Uniform Traffic Information System in CR. Its operator is the Road and Motorway Directorate of the Czech Republic. The purpose of the application is to publish the actual traffic information provided by the National Traffic Information and Control Centre. The application is at present in a testing operation.

The traffic information is projected over the background map of the road network of the Czech Republic generated from the data administered by the firm Central European Data Agency, a.s. (CEDA), the animations of traffic volumes were produced by the firm CTECH s.r.o.

The application is the demonstration of a map server and the utilization of digital interactive web-map representing the traffic information. Fig. 1 illustrates an example of a dynamic interactive symbol utilized for the

visualization of a shot from the camera on the motorway D1, restoring periodically. The application involves also the demonstration of the utilization of animations and dynamic symbols for representation of the road transport intensity on selected traffic junctions and roads (Fig. 2).

The providers of the official information are, as follows:

- National Traffic Information and Control Centre operators
- Police of the Czech Republic
- Road and Motorway Directorate of the Czech Republic
- Fire Rescue Service of the Czech Republic
- Emergency Medical Service of the Czech Republic
- Road Administration
- Traffic Centres of big towns (e.g. TSK Prague, Brněnské komunikace, a.s. ...)
- Road Administrators
- Municipal Police
- Parking field operators, cameras on roads, meteorological posts on roads etd.

The traffic information is in this application divided to several groups: [11]

Traffic events - it means accidents, roadblocks and restrictions (current and planned ones) and traffic situations induced by various events on roads. The information on traffic events is received by operators of the National Traffic Information and Control Centre (NTICC) inspected and possibly updated, and consequently by the system of NTICC published in several ways (including RDS TMC broadcasting). The traffic events are also classified according to urgency - 1: standard, 2: urgent, 3: very urgent.

Degrees of traffic load - it means the traffic intensity being assessed on continuously tracked road elements. The data is available in the largest towns and on chosen segments of motorways. Values in five degrees are viewed: 1 - continuous traffic, 2 - thickening traffic, 3 - dense traffic, 4 - queue formation, 5 - traffic collapse. The visibility of the traffic load information depends on the map scale.

State of trafficability in areas - road administrators are provided with information on the state of trafficability on roads in the area where they are responsible for trafficability. It concerns a prevailing state on given road classes.

State of the weather in areas - it is provided by road administrators simultaneously when reporting state of trafficability.

Shots from cameras on roads - static shots are viewed from cameras owned by the Road and Motorway Directorate.

Warnings from meteo-stations on roads - from the information automatically transmitted by meteo-stations (meteo-posts) located at roads states of the weather and trafficability are evaluated within the NTICC system. Should the state is adverse for traffic, the appropriate reports are viewed. The information relates to immediate surroundings of a given meteo-station.

Information boards on roads - the current information is viewed published on variable information boards and traffic facilities owned by the Road and Motorway Directorate.

Fig. 1 Preview of the Traffic Info application with a shot from a camera on D1 [source 11].

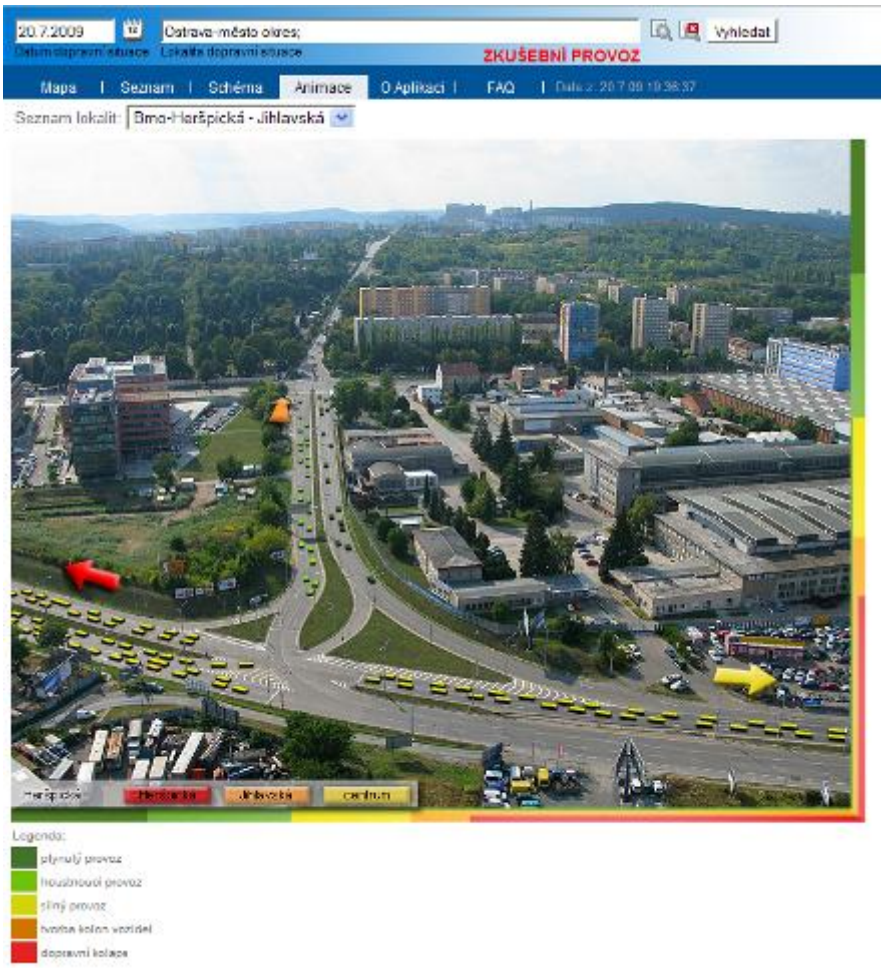

Fig. 2 Preview of the Traffic Info application - an animation of traffic intensity [source 11].

This application is not definitely the only one, further applications, this time from abroad, can be found on http://www.trafficengland.com .

3.2 Railway Transport

The application utilizing elements of the dynamic representation is the Current Train Position accessible on website http://kam.mff.cuni.cz/~babilon/zpmapa#mapa, whose author is Mgr. Robert Babilon from the Department of Applied Mathematics at the Faculty of Mathematics and Physics of the Charles University. České dráhy a.s. and the Institute of Theoretical Informatics cooperate on operation of the websites. On the digital map it is possible to track the current position of trains in the territory of the Czech Republic according to their types, acquire the information on current delay, learn on closures and roadblocks of lines (Fig. 3). In this case the dynamic symbols are used changing their positions and so representing the train position, the changes of symbol colour then indicate the train delay in a certain interval of values. The interactive floating text provides more detailed information on train that is represented by a relevant symbol. Although it concerns an interesting application, from the cartography point of view it has several errors, especially in the symbology used.

Fig. 3 Preview of the application Current Train Position in the territory of the Czech Republic [source 10].

Analogous applications may be found for the territories of many countries, for example Slovakia http://poloha.vlaku.sk/cs/mapa/uzly/ or Denmark http://poloha.vlaku.sk/cs/mapa/uzly/).

3.3 Air Transport

A representative of the presented above electronic atlases is the Animated Atlas – Air Traffic over North America (Fig. 4).

The maps in the electronic atlas represent by means of animations air traffic over the area of North America. All animations show traffic during 24-hour period. These were recorded during the period from March 2003 till September 2005. The localization of aircrafts was mapped using the program called FlyteTrax (Fig. 5) by the firm FlyteComm (available on http://www.flytecomm.com/). The program updates positions of flights every minute and enables to select flights according to aircrafts, airline companies or departure or arrival airports. [6] Pursuant to the data acquired via the program the above mentioned atlas of air traffic was compiled.

The atlas on DVD involves over 70 individual animations that can be played back at three speeds. Over 100 000 individual maps were used for generating the animations. The book describing management system of air traffic over North America and further links create enclosures to DVD. [7]

This atlas is the demonstration of the utilization of fixed sequence animations. On the contrary the desktop program FlyteTrax allows interactive animations. In both cases the dynamic symbols are used to demonstrate the movement of aircrafts over the USA.

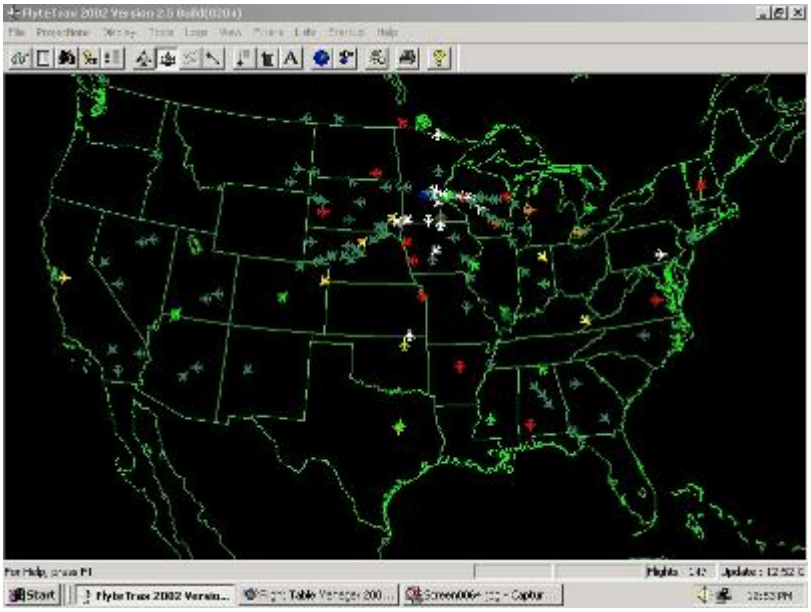

Fig. 4 Preview from the Animated Atlas - Air Traffic over North America [source 7].

Fig. 5 Preview of FlyteTrax III – projecting the movement of aircrafts over the USA with details of one of flights

3.4 Water Transport

Also in the water transport domain applications exist utilizing the dynamic visualization. An example is MarineTraffic.com (accessible on http://www.marinetraffic.com), developed and administered by the Department of Product and System Design Engineering at the University of the Aegean in Greece.

The application represents in a dynamic way positions of various types of vessels from tankers over tugs, yachts to cruisers. Except for the moving objects it views also beacons and further navigation systems. Photographs and further text information (vessel size, actual speed, port of destination, etc.) are attached to individual vessels. The application utilize just several options of the dynamic representation from dynamic symbols to multimedia utilization. Objects on the map are interconnected with further text information, photographs, hypertext, at some of them with video viewing the vessel. This added information is projected after making the selection of an object on the map. It is possible to change the types of viewed real world objects, thus the thematic component, but also the background. The interactive map of marine traffic may be treated as very successful in terms of the utilization of dynamic visualization.

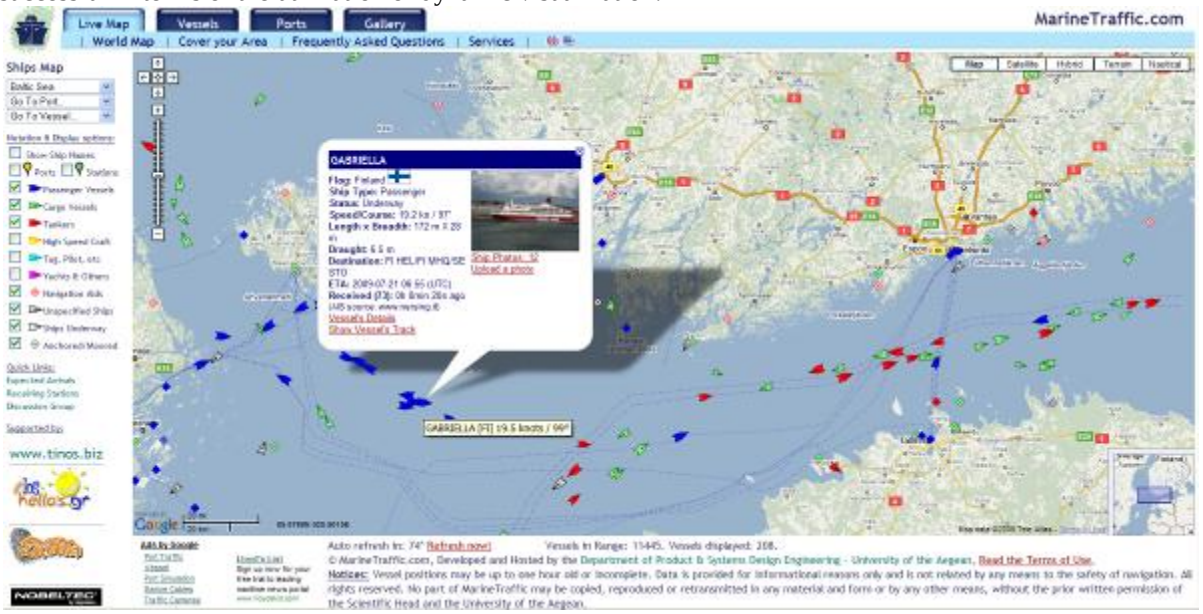

Fig. 6 Demonstration of the Marine Traffic application - representation of the information and photograph of a selected vessel [source 12].

4 CONCLUSIONS

The utilization of animations and dynamic visualization as a whole has in perspective a tremendous potential. As compared with paper maps the digital maps utilizing the dynamic methods of map content representations are able to bring more information on a minor area. In addition, the nature of some phenomena, traffic is an evidence of it, call straight for processing through the use of these means of expression.

This contribution does not involve by far an exhaustive overview of all possibilities and realizations in the traffic domain. Its goal was to create an overview of the used techniques of dynamic representations and possibilities of the dynamic visualization in connection with some outputs of the computer cartography and demonstrate them on examples of practical applications. The traffic domain has been chosen from many reasons discussed above. It is possible to illustrate different methods of visualization just on this domain.

In future one may expect that with further advances of the information technologies also possibilities of dynamic visualization will develop, means of expression of maps will be improved. Just now it is possible to see a number of successful, even less successful, practical applications from different areas not only from the traffic domain. Unfortunately, many of them occurred without an experienced cartographer, what reveals itself on their quality. The successful ones on the contrary involve some electronic historical atlases that utilize a full scale of techniques of dynamic representations, animations and virtual reality. One may then expect that also the quality of other applications will increase, especially if they will be a result of the cooperation of cartographers, information specialists and further experts.

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RESUMÉ

Dynamické vyjádření jevů pomocí počítačové kartografie je poměrně nová, rychle se rozvíjející oblast. Zatímco statická mapa dokáže reflektovat jen určitý moment geografického prostoru, dynamická mapa nebo mapa animovaná dokáže zachytit i vývoj v čase, či vývoj jevu v prostoru.

Příspěvek je orientován na vytvoření obecného přehledu v trendech počítačové kartografie ve vztahu k dynamické vizualizaci s příklady z oblasti vizualizace dopravy a dopravních jevů. V úvodní kapitole jsou stručně nastíněny trendy současné počítačové kartografie. Pojem dynamické vizualizace je rozveden v samostatné

kapitole, která popisuje především využívané techniky dynamické reprezentace. Pozornost je věnována také srovnání klasických analogových map s digitálními mapami a elektronickými atlasy.

Protože doprava je obecně časově proměnný, prostorově založený jev, byla právě tato oblast zvolena pro demonstraci možností dynamické vizualizace. Pro jednotlivé typy dopravy, dopravní jevy a problémy byly vybrány příklady zastupující různé typy digitálních map, elektronických atlasů a mapových serverů, používající zmiňované techniky dynamické reprezentace.