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BEZBEDNOST U ZDRAVSTVU: EVAKUACIJA DELIMIČNO POKRETNIH I NEPOKRETNIH OSOBA STARIJIH OD 70 GODINA IZ GERONTOLOŠKIH USTANOVA

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SAŽETAK

Uvod/Cilj: Gerontološke ustanove predstavljaju objekte sa prisustvom velikog broja delimično pokretnih i nepokretnih starih lica. U uslovima hitnosti, njihova evakuacija iz navedenih razloga može trajati duže, tako da je cilj istraživanja bio da se predstavi nekoliko načina za evakuaciju delimično pokretnih i nepokretnih lica starijih od 70 godina iz gerontoloških ustanova i da se proceni neophodno vreme evakuacije.
Metode: U okviru ovog istraživanja korišćen je kompjuterski softver *Pathfinder 2020* za izračunavanje vremena evakuacije i predviđanje potencijalnih situacija prilikom evakuacije lica iz gerontološke ustanove. Gerontološka ustanova, kao korišćeni model, predstavlja objekat koji ima prizemlje i četiri sprata. Svi spratovi imaju 16 soba, a u svakoj sobi su po dva pacijenta. Spratovi su povezani glavnim stepeništem, požarnim stepenicama i sa četiri lifta (dva teretna za 12 osoba i dva maloteretna za 6 osoba). Ukupan broj medicinskog i administrativnog osoblja je 44, a osoba korisnika usluga gerontološke ustanove 128. Simulacija evakuacije iz gerontološke ustanove prikazana je za četiri različita scenarija: I svi liftovi rade i sve stepenice su dostupne; II nijedan lift ne radi ali stepenište funkcioniše; III funkcioniše samo požarne stepenice; IV funkcionišu samo glavno stepenište. Svaki scenario ima četiri različite situacije koje zavise od procenjene brzine kretanja pacijenata.
Rezultati: Vreme evakuacije kada je moguće koristiti sve liftove i glavno i požarno stepenište je od 895 (14,9 minuta) (kada se osobe najbrže kreću - prva situacija) do 958 sekundi (16 minuta) (kada se osobe najsporije kreću - četvrta situacija), kada se koristi glavno i požarno stepenište od 984 do 1111,1 sekunde (16,4-18,5 minuta), samo požarno stepenište od 1997,6 do 2765,3 sekunde (33,3-46,1 minuta), a kada se koriste samo glavno stepenište od 1365 do 2342 sekundi (22,8-39,0 minuta).
Zaključak: Korišćenje kompjuterskog softvera *Pathfinder 2020* za simulaciju evakuacije predstavlja veoma važan, bezbedan i jeftin način predviđanja načina i brzine evakuacije, što može doprineti unapređenju nacionalne strategije za vanredne situacije.

Ključne reči: evakauacija, simulacija, gerontološki objekat, vanredne situacije

Uvod

Zdravstveni objekti predstavljaju veoma važne objekte za zdravlje ljudi, lečenje, rehabilitaciju i druge aktivnosti. Ovi objekti podrazumevaju prisustvo velikog broja ljudi i veoma važnu, složenu, sofisticiranu i skupu medicinsku i drugu opremu. Zdravstveni objekti, u zavisnosti od njihove namene, mogu da uključuju različite objekte poput klinika, sanatorijuma, operacionih sala, laboratorija, objekata za rehabilitaciju, gerontoloških ustanova i mnogo drugih objekata. Bez obzira na njihovu namenu, zdravstveni objekti podrazumevaju prisustvo velikog broja ljudi, od kojih jedan deo čine pacijenti, drugi medicinsko osoblje, a treći ljudi koji su se slučajno tu zatekli ili su tu iz nekog drugog razloga. Pacijenti u zdravstvenim objektima mogu da budu stacionirani u sobama u standardnim ili pokretnim medicinskim krevetima. Oni mogu da se kreću nezavisno ili uz nečiju pomoć. Na primer, neki pacijenti mogu sami da se kreću u kolicima ili uz pomoć jedne osobe, drugi su vezani za krevet i neohodna im je pomoć od dva do četiri zdravstvena radnika, a treći se kreću uz pomoć različitih medicinskih pomagala, poput štaka itd. (1-5).

Na osnovu navedenog, očigledno je da je evakuacija iz zdravstvenih objekata veoma težak, složen i odgovoran zadatak. Iako se zdravstveni objekti grade prema standardima koji obično uključuju jednu osnovnu rutu komunikacije koja pov-

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SAFETY IN HEALTH - THE EVACUATION OF IMMOBILE PERSONS FROM GERONTOLOGY INSTITUTION

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SUMMARY

Introduction/Aim: Gerontology institutions present objects with the presence of a great number of partly mobile or immobile persons. In emergency conditions, their evacuation because of noted reasons can take longer, so the aim of the research was to present several ways for the evacuation of partly mobile and immobile persons older than 70, from gerontology institutions, and to evaluate necessary evacuation time.
Methods: For this research, the software *Pathfinder 2020* was used for the calculation of evacuation times and predicting of potential situations during evacuation. The gerontology institution, as a used model, presents an object with a basement and four floors. All floors have 16 rooms with two patients in every room. Floors are connected with main stairs, emergency stairs and with four elevators (two cargo elevators for 12 persons per elevator, and two passenger elevators for 6 persons per elevator). The total number of medical and administrative staff is 44, and the number of users of gerontological institution services is 128. The simulation of evacuation from gerontology institution was realized for four different scenarios: The first, when all the elevators are in function and all stairs are accessible; the second, when none of the elevators works but stairs are accessible; the third, when only emergency stairs are in function; the fourth, when only main stairs are in function. Each of these four scenarios has four different situations that depend on the evaluated speed of patient`s movement.
Results: The evacuation time when it is possible to use all elevators and stairs is from 895 seconds (14.9 minutes) (for the fastest movement of persons - the first situation) to 958 seconds (16 minutes) (for the slowest movement of persons - the fourth situation), for main and emergency stairs from 984 to 1111.1 seconds (16.4-18.5 minutes), only for emergency stairs from 1997.6 to 2765.3 seconds (33.3-46.1 minutes), and only for main stairs from 1365 to 2342 seconds (22.8-39.0 minutes).
Conclusion: The usage of computer software *Pathfinder 2020* for the simulation of evacuation presents a very important, safe and cheap way for predicting evacuation way and speed, which can contribute to the national strategy for emergency situations.

Keywords: evacuation, simulation, gerontology object, emergency situations

Introduction

Sanitary objects present very important objects for human health, treatment, recovery and other activities. Those objects include the presence of a large number of people, as well as the presence of very important, complex, sophisticated and expensive medical and other equipment. Sanitary objects, in dependence on their purposes, can be different and can involve different objects such as clinics, sanatoriums, operating rooms, laboratories, rehabilitation objects, gerontology objects and a lot of other objects. Notwithstanding their purpose, sanitary objects include the presence of a large number of people, where one part of those people presents patients, the second part presents medical personnel and the third part is represented by people who happened to be there by accident or with some intention. Patients in sanitary objects can be stationed in medical rooms, fixed or movable medical beds. Their movement can be independent or assisted by someone. As an example, some patients can move in wheelchairs independently or with the assistance of one person; some patients can be moved in medical beds and they need the assistance of two or four persons; some patients can move with different medical apparatuses, such as crutches, etc. (1-5).

ezuje sve sobe, uvek se javljaju problemi prilikom evakuacije, naročito kada su u pitanju nepokretne osobe. Gerontološke ustanove su, takođe, veoma problematične i složene za evakuaciju u hitnim slučajevima, što se pokazalo i tokom epidemije kovida-19.

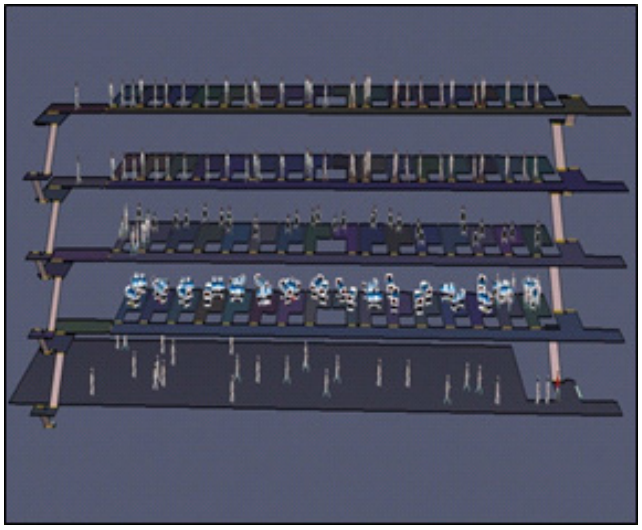
Evakuacija može biti neophodna zbog požara, poplave, terorističkog napada ili pretnje, zemljotresa, razornih vetrova itd. Glavni problemi prilikom evakuacije iz zdravstvenih objekata sa nepokretnim osobama su usporenost, velika verovatnoća zastoja i stvaranja gužve, spora eliminacija gužve, kao i dimenzije korišćenih medicinskih pomagala. Zbog navedenih razloga, veoma je važno predvideti što je moguće više scenarija evakuacije da bi se kreirala najbolja strategija evakuacije u nekoj određenoj situaciji. Jedan od najboljih načina za predviđanje evakuacije i izračunavanje neophodnog vremena evakuacije je korišćenje odgovarajućeg kompjuterskog softvera *Pathfinder 2020* (6). Ovaj program simulacije omogućava preciznu, brzu, bezbednu i jeftinu kalkulaciju neophodnog vremena za evakuaciju u skladu sa potrebama, što posledično obezbeđuje optimalne puteve i vreme evakuacije (7-10).

Metode

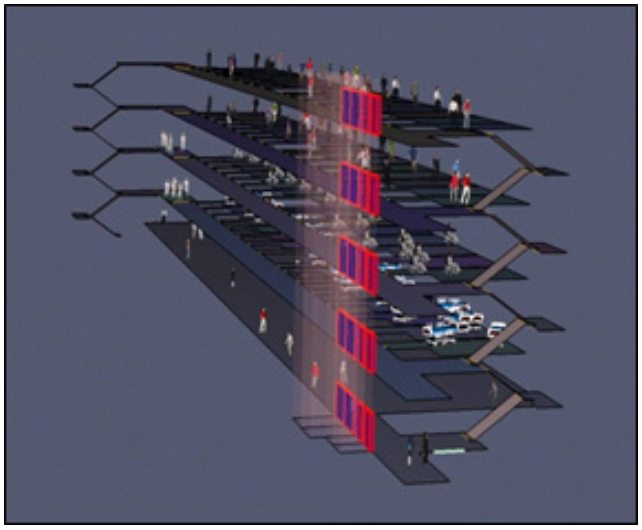
U okviru ovog istraživanja korišćen je softver Pathfinder 2020, koji je jedan od najpoznatijih softvera za izračunavanje vremena evakuacije i predviđenje potencijalnih situacija prilikom evakuacije lica iz bilo koje ustanove, a u našem primeru iz gerontološke ustanove (6). Ovaj softver predstavlja grafički korisnički interfejs za dizajn i izvršenje simulacije. On omogućava 2D i 3D vizualizaciju. Postoje dva različita modela simulacije evakuacije koji se mogu koristiti u *Pathfinder*-u („Steering“ model i „SFPE“ model evakuacije). Od ova dva modela simulacije, u radu je korišćen „SFPE“ model. Ovim programom moguće je podesiti različite brzine kretanja osoba i izračunati neophodno vreme evakuacije.

Gerontološka ustanova, kao model za simulaciju u ovom istraživanju, predstavlja objekat koji ima prizemlje i četiri sprata. U osnovi objekat je površine 80 m × 20 m. Visina svakog sprata je 3,15 m. Prva dva sprata su namenjena za nepokretne osobe, prvi za nepokretne pacijente vezane za krevet, a drugi za nepokretne pacijente u kolicima. Treći i četvrti sprat namenjeni su za pokretne osobe. Svi spratovi, osim prizemlja, imaju 16 soba za pacijente površine otprilike 16 m^2 i sa vratima dužine 1,2 m. Pretpostavljeno je da se nepokretne osobe vezane za krevet kreću samo uz pomoć dva zdravstvena radnika, nepokretne osobe u kolicima uz pomoć jednog, a da se sve ostale osobe mogu kretati samostalno. Dimenzije medicinskih kreveta su 200 cm × 90 cm × 75 cm, dok su dimenzije kolica 110 cm × 65 cm × 92 cm.

Spratovi su povezani glavnim stepeništem, požarnim stepenicama (stepenicama za slučaj opasnosti) i liftovima. Maksimalna širina običnih stepenica je 150 cm dok je maksimalna širina stepenica za hitne situacije 120 cm. Izlazna vrata sa



Slika 1. *Pathfinder 2020* model simulacije u gerontološkoj ustanovi sa korisnicima unutar objekta – prednji prikaz



Slika 2. *Pathfinder 2020* model simulacije u gerontološkoj ustanovi sa korisnicima unutar objekta – prikaz sa strane

According to all noted, it is obvious that evacuation of any sanitary object presents a very hard, complex and responsible task. Although the sanitary objects were built by cliché, which usually includes one basic communication route that connects all rooms, the problems with evacuation can always occur, especially in cases with immobile persons. Gerontological institutions are also very problematic and complex for the emergency evacuation, which was shown during the epidemic of Covid-19.

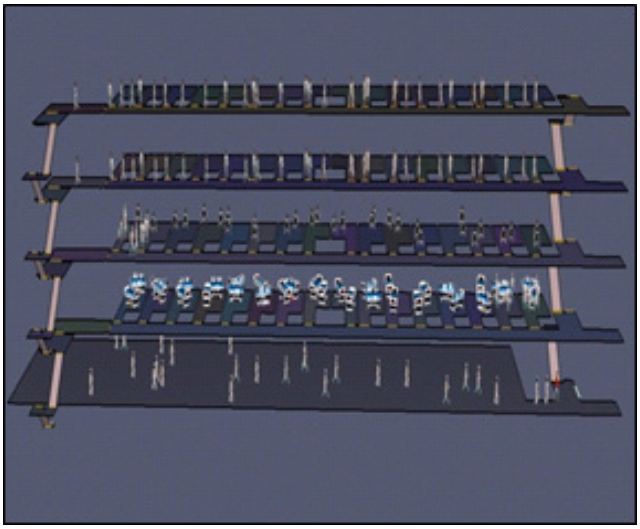
The evacuation may be required for a variety of different reasons: fire, floods, terrorism attacks or threats, earthquake, destructive winds etc. The main problems in the evacuation of sanitary objects with immobile persons are slowness, sluggishness, high probability of crowding and congestion, slow elimination of congestion, dimensions of used medical devices. Because of the above-mentioned reasons, it is very important to predict as many as possible evacuation scenarios in order to create the best evacuation strategy for some specific situation. One of the best ways for the prediction of evacuations and calculation of necessary evacuation times is the usage of appropriate computer software, such as *Pathfinder 2020* (6). This program enables precise, fast, safe and cheap calculation of necessary time for the evacuation in accordance with needs, which consequently enables optimal evacuation routes and evacuation times (7-10).

The aim of this paper is to present several evacuation ways of immobile and hard-mobile persons older than 70 from gerontology institutions and to evaluate the necessary evacuation time with the help of proper simulation software *Pathfinder 2020*.

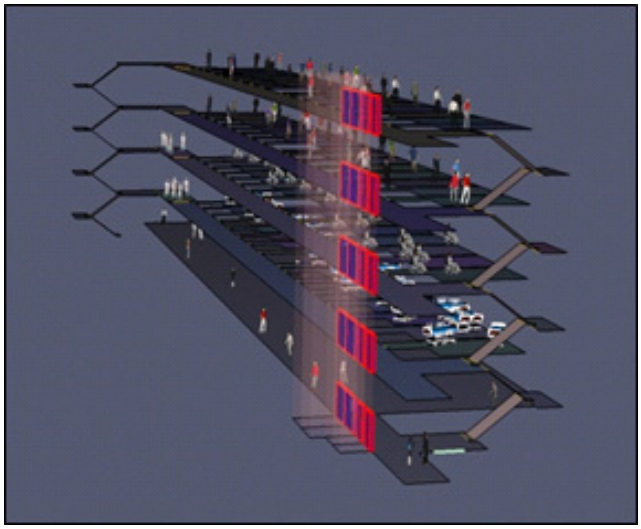
Methods

For this research, the software *Pathfinder* 2020 was used, which is one of the most famous software programs for the calculation of evacuation times and predicting of potential situations during the evacuation of persons from any kind of objects, and in our example from the gerontology institution (6). This software presents a graphical user interface for the simulation design and execution. It enables 2D and 3D visualization. There are two different simulation ways that *Pathfinder* can use ("Steering" mode and "SFPE" mode). Of these two simulation models, the "SFPE" model was used in the paper. It is possible to set different moving speeds of persons and calculate the necessary evacuation time.

The gerontology institution, as a model for simulation in this research, presents an object with a basement and four floors. In its base, the area of the object was 80 m × 20 m. The height of every floor was 3.15 m. The first two floors were for immobile persons, the first for immobile patients in medical beds and the second for immobile patients in wheelchairs. The third and fourth floors were for mobile persons. Each floor except the ground floor has 16 rooms for patients with an approximate area of 16 m^2 and a door was 1.2 m in length. Immobile patients in medical beds were



Picture 1. Pathfinder 2020 simulation model of Gerontology institution with occupants inside-front view



Picture 2. Pathfinder simulation model of Gerontology institution with occupants inside-side view

prednje strane objekta su širine 200 cm, dok su izlazna vrata na pomoćnom stepeništu širine 130 cm. Ukupno su dva izlaza iz objekta.

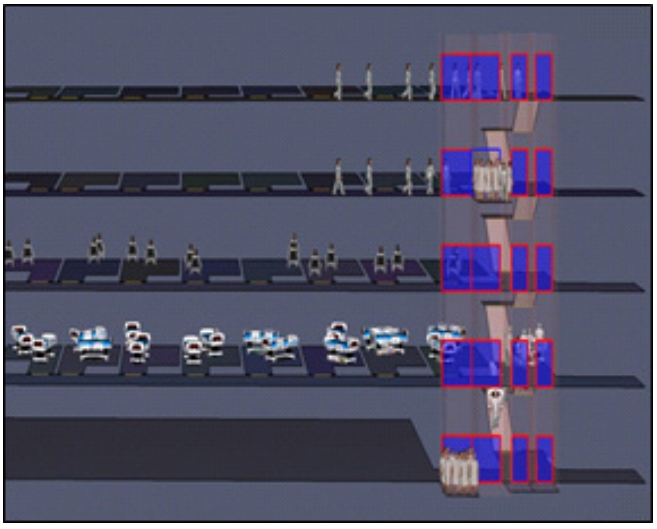
U objektu su četiri lifta. Dva lifta su teretni liftovi koji su predviđeni za 12 osoba i u njih, na osnovu dimenzija, mogu da stanu jedan medicinski krevet ili dvoja kolica, dok su ostala dva maloteretna lifta predviđena za 6 osoba.

Medicinsko osoblje i drugo zdravstveno i administrativno osoblje je stacionirano u prizemlju. Ukupan broj medicinskog i administrativnog osoblja je 44. U svakoj sobi su po dve stare osobe što znači da su na na svakom spratu 32 korisnika gerontološke ustanove. To znači da je ukupan broj korisnika objekta 172, od kojih je 128 starih osoba i 44 člana medicinskog ili administrativnog osoblja.

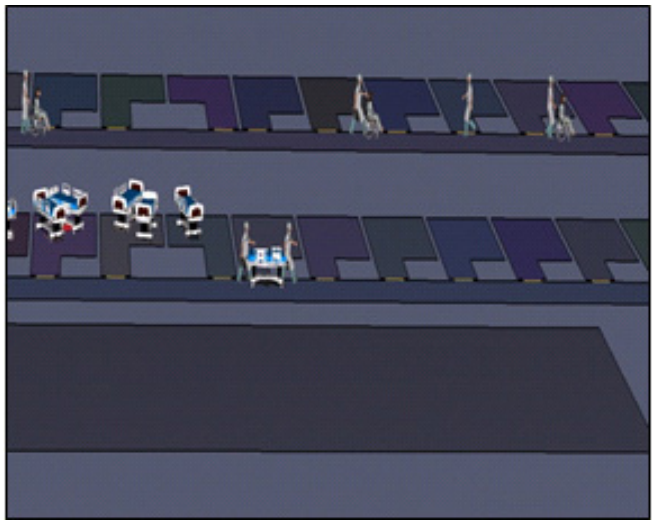
Pathfinder model simulacije u gerontološkoj ustanovi, predstavljen je na slikama 1 i 2 koje prikazuju prednju stranu objekta i objekat prikazan sa strane sa korisnicima koji su unutar objekta.

Simulacija evakuacije iz gerontološke ustanove prikazana je u ovom radu za četiri različita scenarija. U prvom scenariju (slika 3) svi liftovi rade i sve stepenice su dostupne (glavne i požarne), u drugom (slika 4) nijedan lift ne radi ali stepenište je dostupno, u trećem (slika 5) nijedan lift ne radi i samo su dostupne požarne stepenice, i u četvrtom (slika 6) liftovi ne rade i samo su dostupne glavne stepenice.

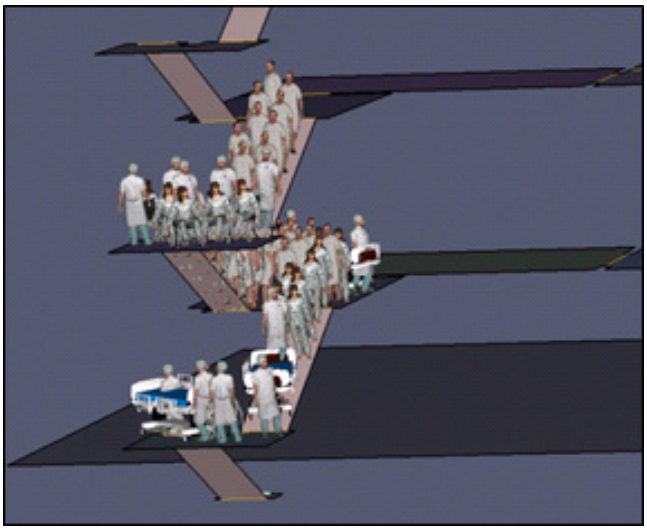
Svaki scenario imao je četiri različite situacije. U prvoj situaciji, brzina kretanja pokretnih pacijenata je 0,5 m/s, pacijenata u kolicima kojima je



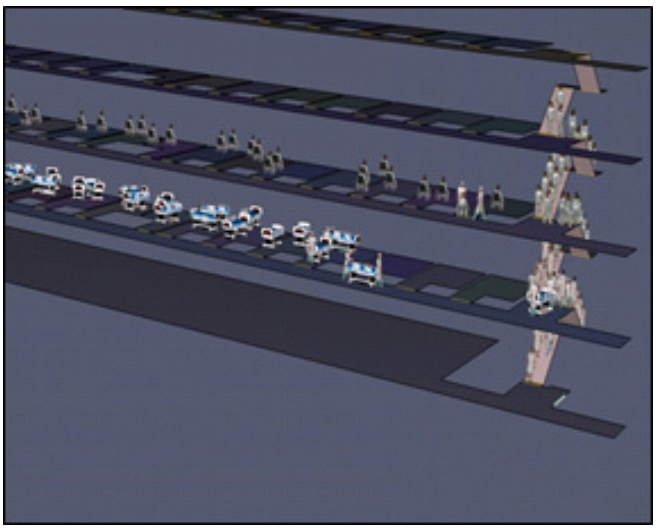
Slika 3. Trenutak simulacije za prvi scenario kada svi liftovi rade i kada su dostupne sve stepenice



Slika 4. Trenutak simulacije za drugi scenario kada nijedan lift ne radi i kada su dostupne glavne i požarne stepenice



Slika 5. Trenutak simulacije za treći scenario kada nijedan lift ne radi i kada su samo dostupne glavne stepenice



Slika 6. Trenutak simulacije za četvrti scenario kada nijedan lift ne radi i kada su dostupne samo požarne stepenice

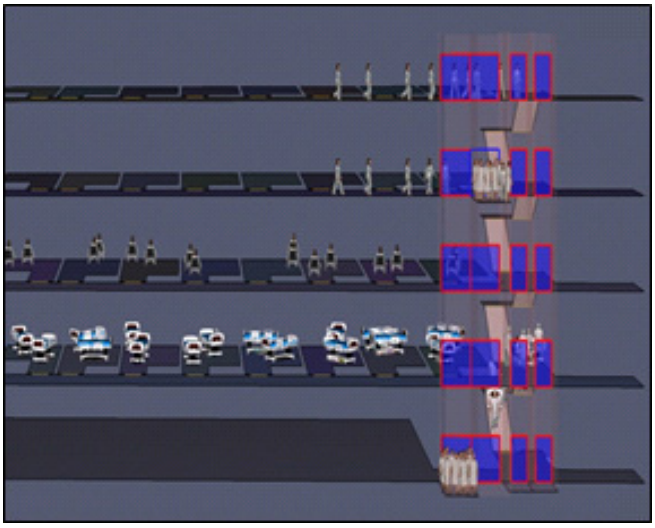
able to move only with the assistance of two medical persons, while immobile persons in wheelchairs were able to move only with the assistance of one medical person, while the other patients were able to move on their own. The dimensions of medical beds were 200 cm × 90 cm × 75 cm, while the dimensions of wheelchairs were 110 cm × 65 cm × 92 cm.

The floors were connected with ordinary stairs, emergency stairs and elevators. The maximal width of ordinary stairs was 150 cm, while maximal width of emergency stairs was 120 cm. Exit doors in the front of the object had a width of 200 cm, while exit door intended for emergency stairs had length of 130 cm. The complete number of exits from the object was 2.

There were four elevators in the object. Two elevators were cargo elevators with the capacity of 12 persons or one medical bed or two wheelchairs, while the other two elevators were with the capacity of 6 persons.

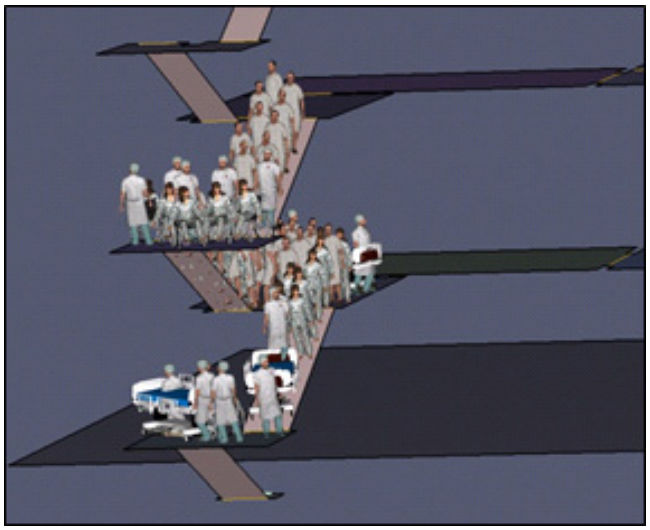
Medical staff and other medical and administrative staff were stationed on the ground floor. The total number of medical and administrative staff was 44. There were two elderly people in each room, which means that there were 32 users of the gerontology institution on each floor. This means that the total number of users of the object was 172, of which 128 were elderly and 44 were members of medical or administrative staff.

Pathfinder simulation model in the gerontology institution is presented in picture 1 and 2 that

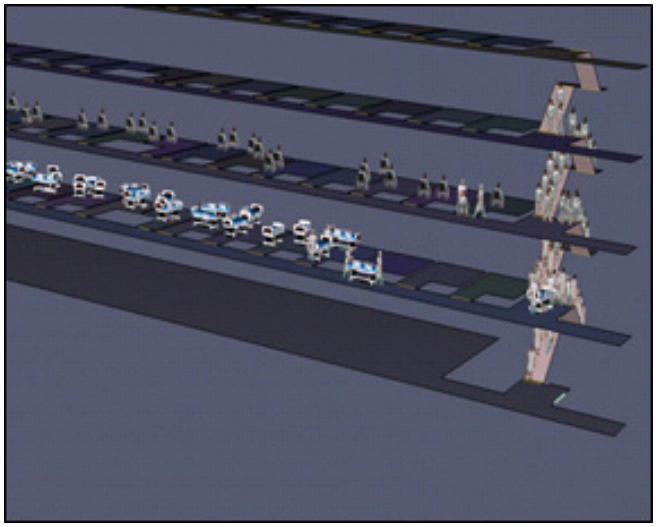


Picture 3. Simulation moment for the first scenario when all elevators are working and when all stairs are available

Picture 4. Simulation moment for the second scenario when no elevator is working and when the main and auxiliary stairs are available



Picture 5. Simulation moment for the third scenario when no elevator is working and when only the main stairs are accessible



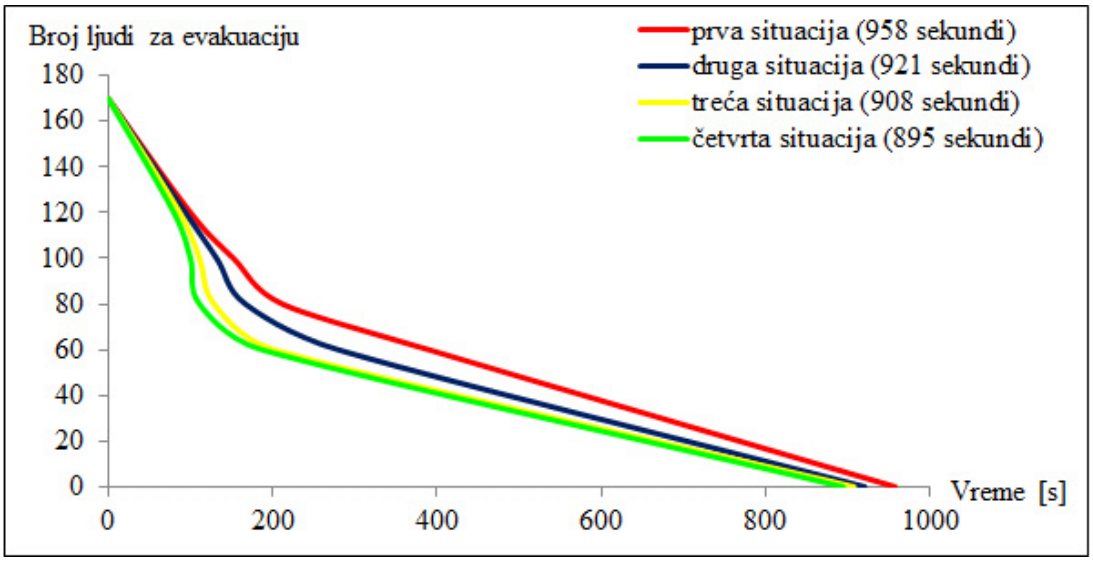
Picture 6. Simulation moment for the fourth scenario when no elevator is working and only auxiliary stairs are available

potrebna pomoć jednog zdravstvenog radnika je od 0,5 m/s do 1,3 m/s u zavisnosti od toga gde su se kretali, a pacijenata u medicinskim krevetima, kojima je bila potrebna pomoć dva zdravstvena radnika, je od 0,2 m/s do 0,9 m/s u zavisnosti od toga gde su se kretali, dok je brzina medicinskog i administrativnog osoblja 1 m/s.

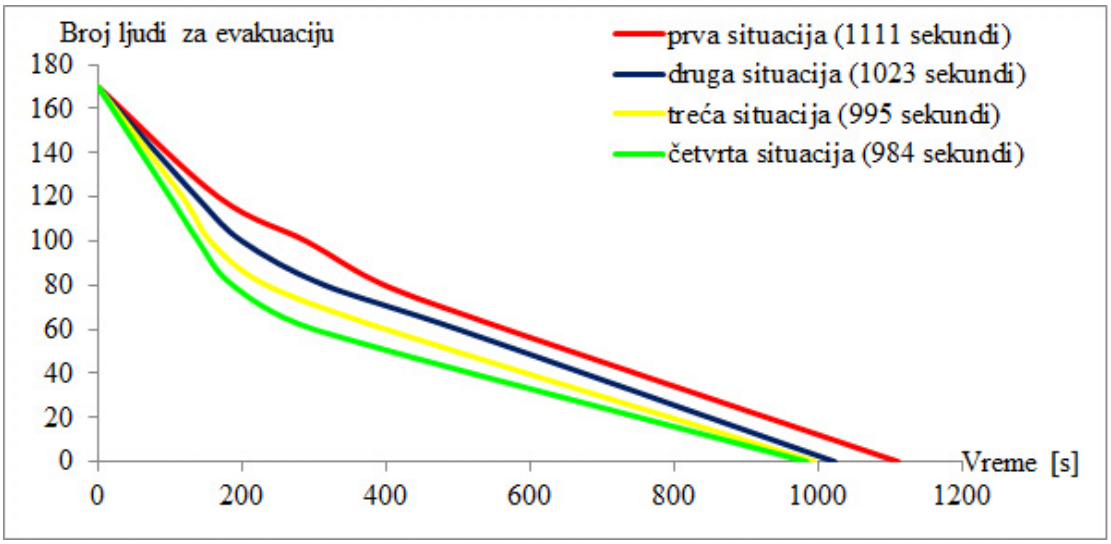
U drugoj situaciji, brzina kretanja pokretnih pacijenata je 0,6 m/s, pacijenata u kolicima kojima je potrebna pomoć jednog zdravstvenog radnika je od 0,5 m/s do 1,3 m/s u zavisnosti od toga gde su se kretali, a pacijenata u medicinskim krevetima, kojima je bila potrebna pomoć dva zdravstvena radnika, je od 0,2 m/s do 0,9 m/s u zavisnosti od toga gde su se kretali, dok je brzina medicinskog i administrativnog osoblja 1 m/s.

U trećoj situaciji, brzina kretanja pokretnih pacijenata je 0,7 m/s, pacijenata u kolicima kojima je bila potrebna pomoć jednog zdravstvenog radnika je od 0,5 m/s do 1,3 m/s u zavisnosti od toga gde su se kretali, a pacijenata u medicinskim krevetima, kojima je bila potrebna pomoć dva zdravstvena radnika, je od 0,2 m/s do 0,9 m/s u zavisnosti od toga gde su se kretali, dok je brzina medicinskog i administrativnog osoblja 1 m/s.

U četvrtoj situaciji, brzina kretanja pokretnih pacijenata je 0,8 m/s, pacijenata u kolicima kojima je bila potrebna pomoć jednog zdravstvenog radnika je od 0,5 m/s do 1,3 m/s u zavisnosti od toga gde su se kretali, a pacijenata u medicinskim krevetima, kojima je bila potrebna pomoć dva zdravstvena radnika, je od 0,2 m/s do 0,9 m/s u zavisnosti



Grafikon 1. Brzina evakuacije za prvi scenario (liftovi i stepenište) za sve četiri situacije (od najsporijeg do najbržeg kretanja)



Grafikon 2. Brzina evakuacije za drugi scenario (glavno i požarno stepenište) za sve četiri situacije (od najsporijeg do najbržeg kretanja)

present front side of the object and object by side with occupants inside the object.

The simulation of evacuation from the gerontology institution in this paper was realized for four different scenarios. The first evacuation scenario (Picture 3) considered that all elevators were enabled and all available stairs (main and emergency) were enabled, the second scenario (Picture 4) considered that all elevators were disabled and all available stairs were enabled, the third scenario (Picture 5) considered that all elevators were disabled and main stairs were disabled, while emergency stairs were enabled and the fourth scenario (Picture 6) considered that all elevators were disabled and emergency stairs were disabled, while main stairs were enabled.

Each scenario had four different situations. In the first situation, the speed of mobile patients is 0.5 m/s; the speed of patients in wheelchairs that needed the assistance of one medical person is from 0.5 m/s to 1.3 m/s in dependence on where they moved; the speed of patients in medical beds that needed the assistance of two medical persons is from 0.2 m/s to 0.9 m/s, in dependence on where they moved and the speed of all other medical and administrative personnel is 1 m/s.

In the second situation, the speed of mobile patients is 0.6 m/s; the speed of patients in wheelchairs that needed the assistance of one medical person is from 0.5 m/s to 1.3 m/s in dependence on where they moved; the speed of patients in medical beds that needed the assistance of two medical

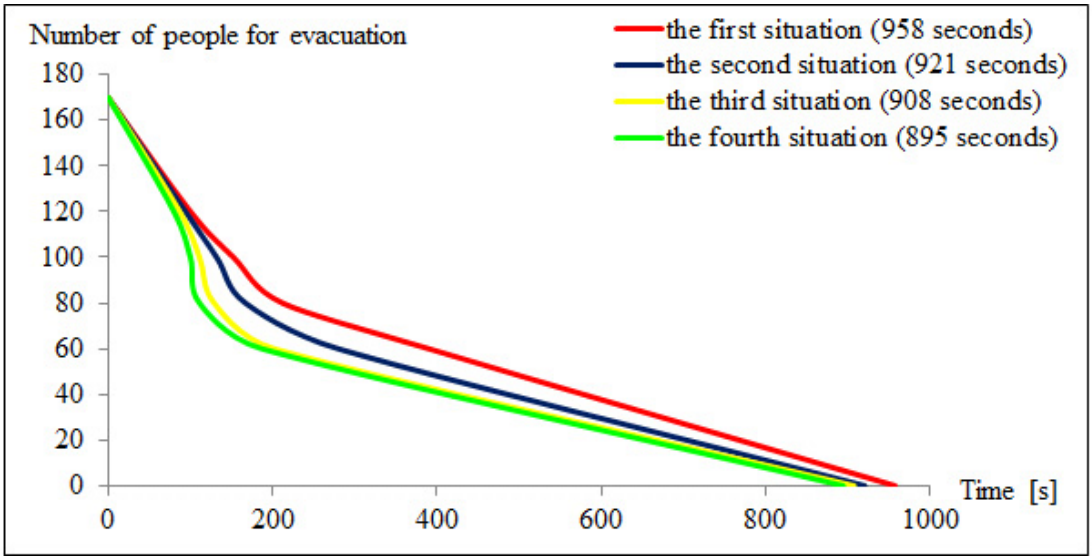


Figure 1. Speed of evacuation for the first scenario when all elevators are working and when all stairs are available for all four situations (from slowest fo fastest)

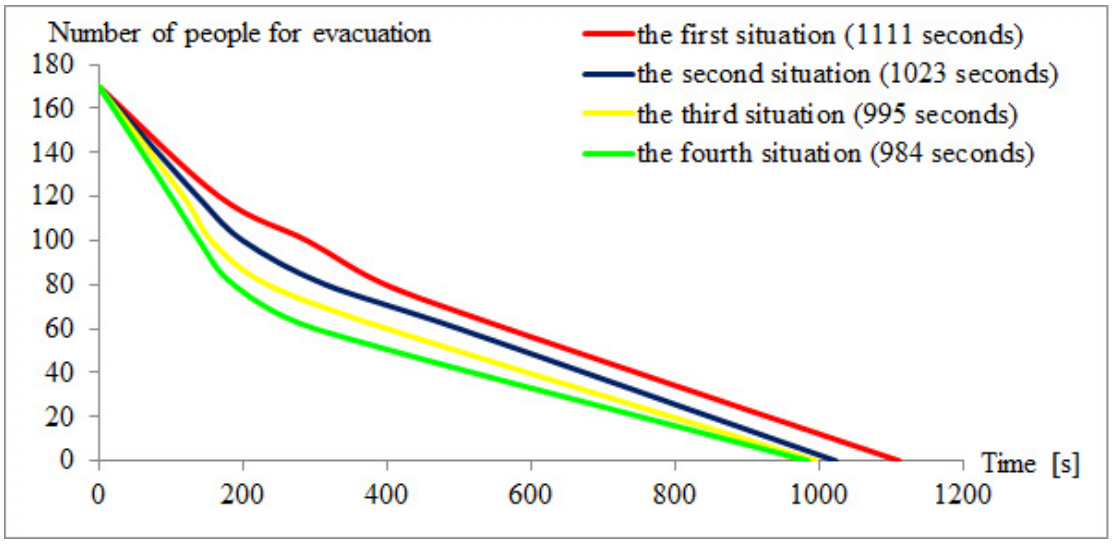
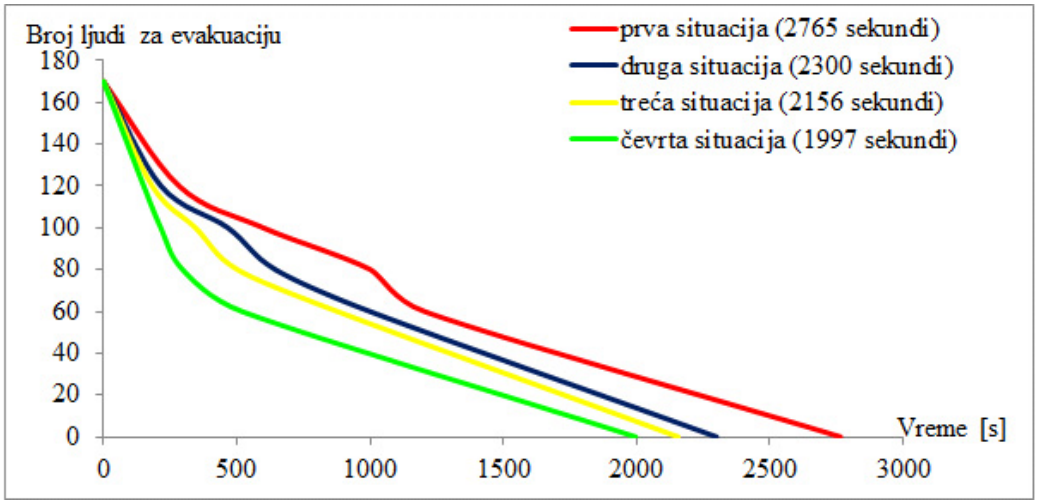
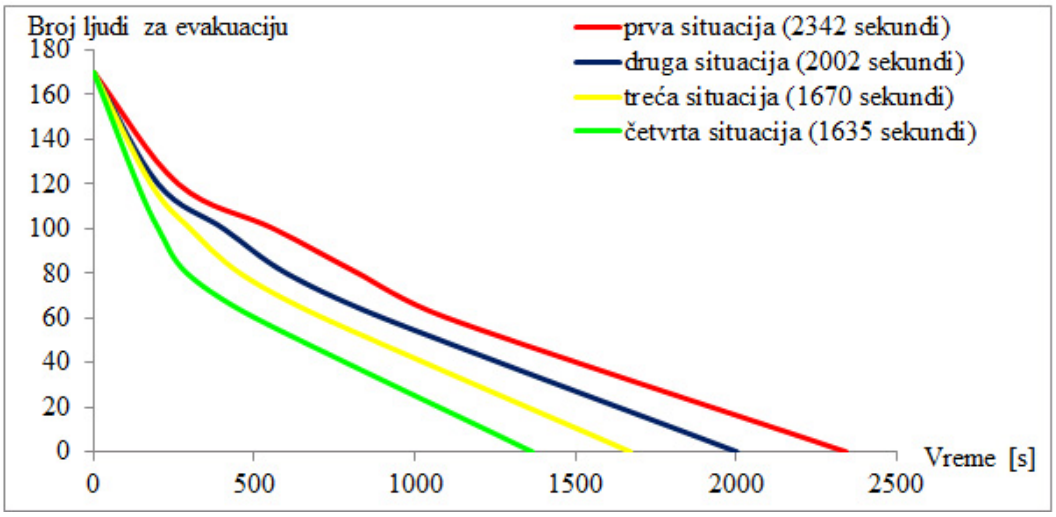


Figure 2. Speed of evacuation for the second scenario when no elevator is working and when the main and auxiliary stairs are available stairs are available for all four situations (from slowest fo fastest)



Grafikon 3. Brzina evakuacije za treći scenario kada nijedan lift ne radi i kada su dostupne samo požarne stepenice za sve četiri situacije (od najsporije do najbrže)



Grafikon 4. Brzina evakuacije za četvrti scenario kada nijedan lift ne radi i kada su dostupne samo glavne stepenice za sve četiri situacije (od najsporije do najbrže)

od toga gde su se kretali, dok je brzina medicinskog i administrativnog osoblja 1 m/s.

Glavni razlog za odabir ovih brzina je činjenica da su korisnici usluga gerontološke ustanove osobe starije od 70 godina. Takođe, uzeto je u obzir da su brzine pokretnih pacijenata konstantne, da se medicinsko osoblje vraćalo po pacijente sve dok i poslednji pacijent nije evakuisan, kao i da su u sva četiri scenarija medicinsko osoblje i pacijenti znali gde treba da idu u slučaju evakuacije.

Rezultati

Rezultati simulacije za sva četiri scenarija u sve četiri situacije predstavljeni su na grafikonima 1-4.

Rezultati simulacije za prvi scenario (grafikon 1), kada su svi liftovi i kada su glavno i požarno stepenište bili u funkciji, pokazali su da se vreme evakuacije kretalo od 895 sekundi (14,9 minuta) (prva situacija) do 958 sekundi (16 minuta) (četvrta situacija).

U drugom scenariju (grafikon 2), kada nijedan lift nije radio i kada su bile dostupne glavne i požarne stepenice, vreme evakuacije se kretalo od 984 sekunde (16,4 minuta) (prva situacija) do 1111,1 sekunde (18,5 minuta) (četvrta situacija).

U trećem scenariju (grafikon 3), kada nijedan lift nije bio u funkciji i kada su bile dostupne požarne, ali ne i glavne stepenice, vreme evakuacije se kretalo od 1997,6 sekundi (33,3 minuta) (prva situacija) do 2765,3 sekunde (46,1 minuta) (četvrta situacija).

U četvrtom scenariju (grafikon 4), kada nijedan lift nije radio i kada su dostupne glavne, ali ne i požarne, stepenice vreme evakuacije se kretalo od 1365 sekundi (22,8 minuta) (prva situacija) do 2342 sekundi (39,0 minuta) (četvrta situacija).

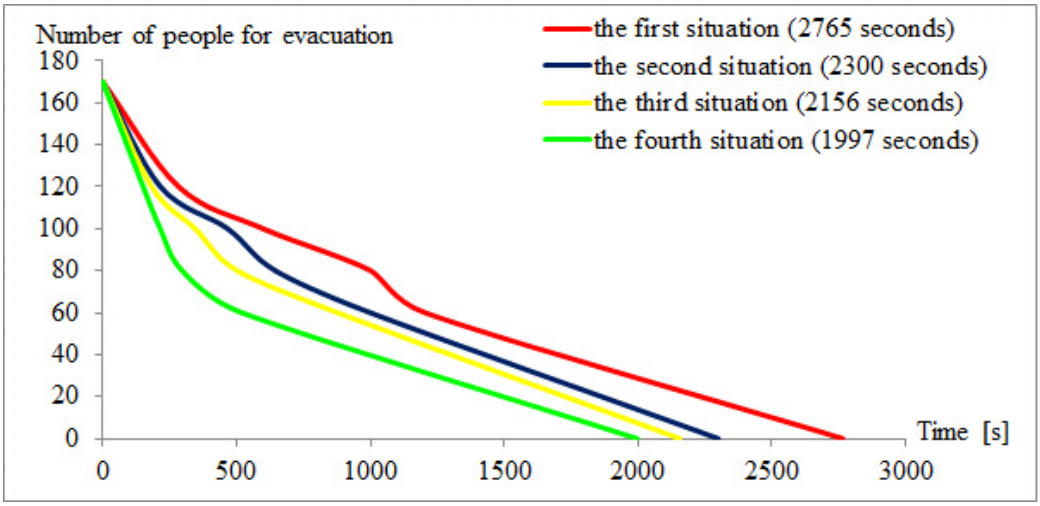


Figure 3. Speed of evacuation for the third scenario when no elevator is working and when only auxiliary stairs are accessible stairs are available for all four situations (from slowest fo fastest)

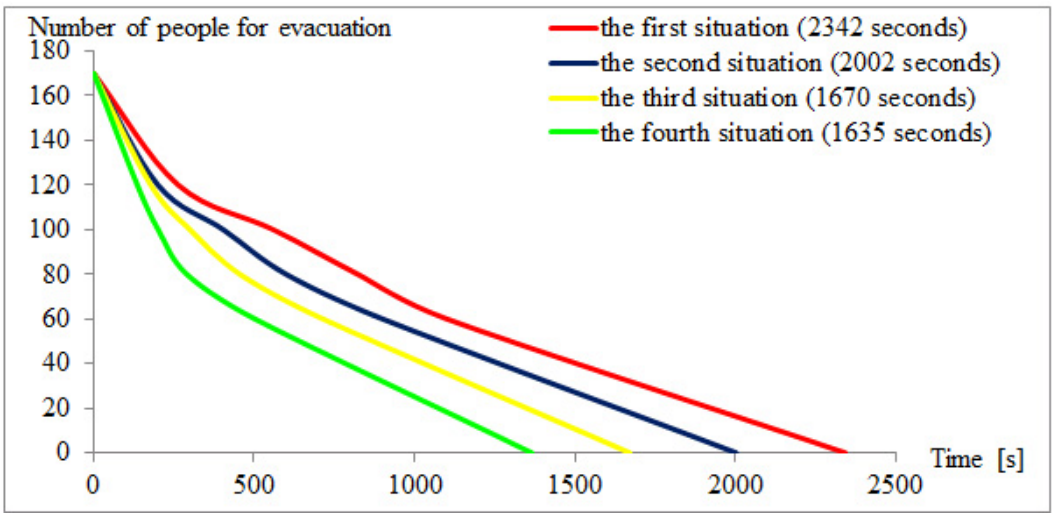


Figure 4. Speed of evacuation for the fourth scenario when no elevator is working and only the main stairs are available stairs are available for all four situations (from slowest fo fastest)

persons is from 0.2 m/s to 0.9 m/s, in dependence on where they moved and the speed of all other medical and administrative personnel is 1 m/s.

In the third situation, the speed of mobile patients is 0.7 m/s; the speed of patients in wheelchairs that needed the assistance of one medical person is from 0.5 m/s to 1.3 m/s in dependence on where they moved; the speed of patients in medical beds that needed the assistance of two medical persons is from 0.2 m/s to 0.9 m/s, in dependence on where they moved and the speed of all other medical and administrative personnel is 1 m/s.

In the fourth scenario, the speed of mobile patients is 0.8 m/s; the speed of patients in wheelchairs that needed the assistance of one medical person is from 0.5 m/s to 1.3 m/s in dependence on where they moved; the speed of patients in medical beds that needed the assistance of two medical persons is from 0.2 m/s to 0.9 m/s, in dependence on where they moved and the speed of all other medical and administrative personnel is 1 m/s.

The main reason for those speeds selection was in the fact that the users of gerontology institutions are persons older than 70 years. It was also taken into account that speeds of mobile patients was constant, that medical staff were returning for patients until the last patient was evacuated, so as the fact that in all of four scenarios medical staff and patients knew where to go in the case of evacuation.

Results

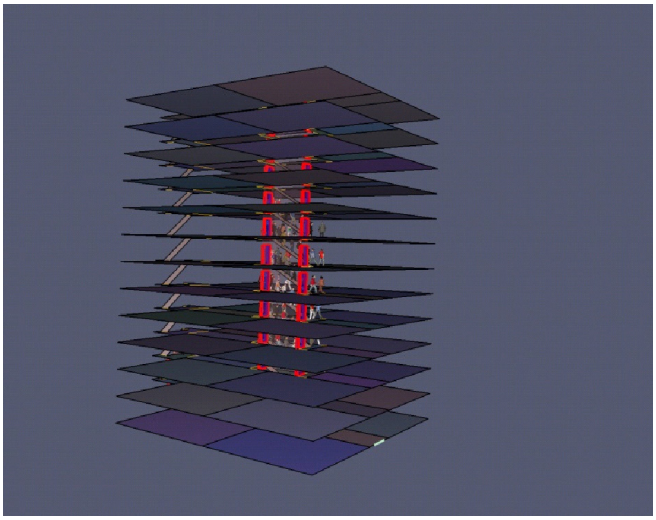
Results of simulation for each of four scenarios in all four situations are presented in figures from 1-4.

Diskusija

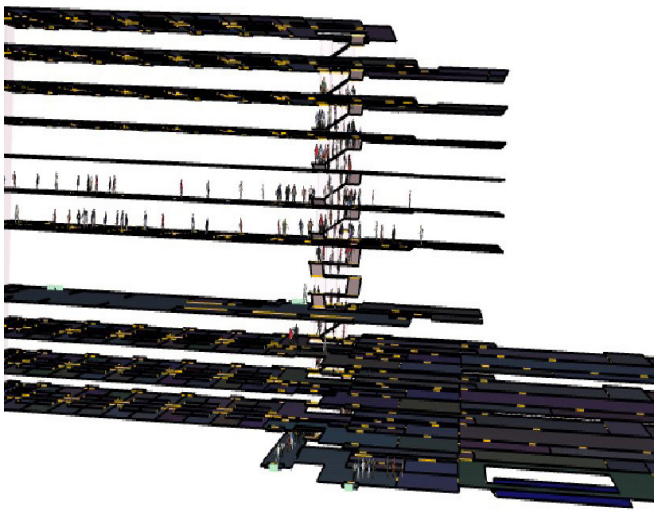
Rezultati našeg istraživanja ukazuju da brzina evakuacije gerotonloške ustanove, gde je pretpostavljeno da su smeštene osobe starije od 70 godina, koje mogu da budu pokretne, delimično pokretne i nepokretne, mogu da doprinesu unapređenju stategije za vanredne situacije. Procenjeno je, korišćenjem softverskog programa *Pathfinder 2020*, da je vreme evakuacije iz gerontološke ustanove određenog modela kada je moguće koristiti sve liftove i glavno i požarno stepenište 895-958 sekundi (tj. 14,9-16 minuta), kada se koriste glavno i požarno stepenište 984-1111,1 sekunde (tj. 16,4 -18,5 minuta), ako se koristi požarno stepenište 1997,6 -2765,3 sekunde (tj. 33,3-46,1 minuta) i ako se koristi samo glavno stepenište 1635 -2342 sekunde (tj. 22,8 -39,0 minuta).

U okviru ove studije korišćen je *Pathfinder*, jedan od najpoznatijih softvera za izračunavanje vremena evakuacije i predviđenje potencijalnih situacija prilikom evakuacije (6). Jedna od naročito pogodnih osobina ovog softvera je mogućnost da se „uveze“ fajl iz nekog kompjuterskog programa koji je dizajniran za crtanje i računanje, kao što su Auto Cad, FDS, PyroSim, itd. Ova mogućnost štedi vreme potrebno za dizajniranje objekta. Do sada je bilo nekoliko verzija *Pathfinder* softvera za simulaciju evakuacije. Verzija *Pathfinder*-a koja je korišćena u ovom radu je *Pathfinder 2020*. Ovim programom urađena je simulacija evakuacije, ne samo iz gerontološke ustanove, nego i iz visoke stambene zgrade (slika 7) (11), hotela Radon u Niškoj Banji (slika 8) (7) i Trgovinskog centra Zona I (12).

Simulacije koje su predstavljale evakuaciju stanovnika visoke stambene zgrade sa prisustvom nepokretnih osoba pokazale su koliko se može produžiti vreme potrebno za evakuaciju u zavisnosti od broja nepokretnih osoba (11). Simulacije evakuacija su realizovane tako da je prvo uzet slučaj bez prisustva nepokretnih osoba, zatim slučaj sa prisustvom 5%, a potom 10% nepokretnih osoba od ukupnog broja stanovnika. Procenja brzina evakuacije u optimalnim uslovima kada u zgradi nema nepokretnih je 150,2 sekunde, kada je 5% nepokretnih je 172 sekunde, a kada je 10% nepokretnih je 299 sekundi (11). U najnepovoljnijem slučaju, procenjena brzina evakuacije kada u zgradi nema nepokretnih je 451,6 sekundi, kada je 5% nepokretnih 599,6 sekundi, a kada je 10% nepokretnih je 754 sekunde (11). Simulacije koje su predstavljale evakuaciju osoba i osoblja iz hotela Radon u Niškoj Banji pokazale su koliko se može produžiti vreme evakuacije ukoliko su potrebne manje ili veće asistencije oko nepokretnih i delimično pokretnih osoba i kada se koriste različiti putevi za evakuaciju (7). U okviru ovog modela nepokretne i delimično pokretne osobe su se nalazile na petom i šestom spratu hotela i zahtevale su asistenciju osoblja. Procenjena brzina evakuacije svih osoba u hotelu Radon u Niškoj Banji u optimalnom slučaju je 450,4 sekunde, a u najnepovoljnijem slučaju 607,2 sekunde (7). Simulacije koje



Slika 7. Trenutak tokom simulacije evakuacije iz visoke stambene zgrade, *Pathfinder 2020*. prezentacija (11)



Slika 8. Trenutak tokom simulacije evakuacije iz Hotela Radon u Niškoj Banji, *Pathfinder 2012*. prezentacija (7)

Simulation results for the first scenario (Figure 1), when all elevators and main and emergency stairs were enabled, showed that the evacuation time ranged from 895 seconds (14.9 minutes) (first situation) to 958 seconds (16 minutes) (fourth situation).

In the second scenario (Figure 2), when all elevators were disabled while main and emergency stairs were enabled, the evacuation time ranged from 984 seconds (16.4 minutes) (first situation) to 1111.1 seconds (18.5 minutes) (fourth situation).

In the third scenario (Figure 3), when all elevators and main stairs were disabled, while emergency stairs were enabled, the evacuation time ranged from 1997.6 seconds (33.3 minutes) (first situation) to 2765.3 seconds (46.1 minutes) (fourth situation).

In the fourth scenario (Figure 4), when no elevator was working and when the main, but not emergency stairs were available, the evacuation time ranged from 1365 seconds (22.8 minutes) (first situation) to 2342 seconds (39 minutes) (fourth situation).

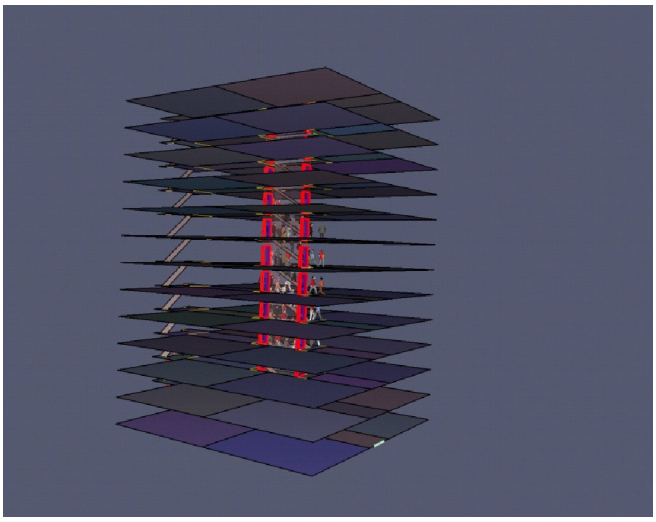
Discussion

The results of our research point to the fact that the evacuation time from the gerontology institution, where mobile, partly mobile and immobile persons older than 70 years were settled, can contribute to the improvement of emergency situations strategy.

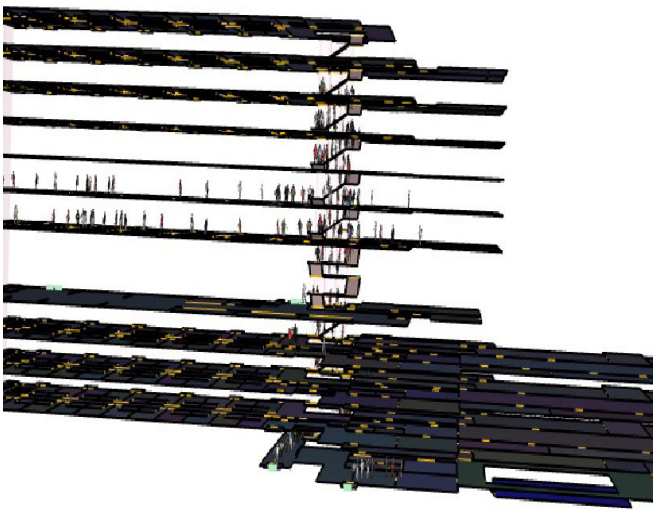
It was evaluated, by the usage of *Pathfinder* 2020 software, that the evacuation time from the gerontology institution of a certain model, when all elevators and all stairs are accessible, is 895-958 seconds (14.9-16 minutes), when main and emergency stairs are used 984-1111.1 seconds (16.4-18.5 minutes), when emergency stairs are used 1997-2765 seconds (33.3-46.1 minutes) and when only main stairs are used 1635-2342 seconds (22.8-39.0 minutes).

For this research, the *Pathfinder*, one of the most famous software programs for the calculation of evacuation times and prediction of potential situations during the evacuation was used (6). One of the particularly appropriate properties of this software is a potential to “import” a file from some computer software designed for drawing and calculation, such as Auto Cad, FDS, PyroSim etc. This potential saves the time needed for the object design. So far, there have been several versions of *Pathfinder* simulation software. The version of *Pathfinder* used in this paper was *Pathfinder 2020* version. The simulation of evacuation by this program was used not only for the gerontology institution but also for the evacuation of people from the high residential building (Picture 7) (11), hotel Radon in Niška Banja (Picture 8) (7) and from market center Zona I (12).

The simulations that presented the evacuation of residents from a high residential building with the presence of immobile persons showed for how much the time needed for the evacuation can



Picture 7. A moment from the simulation of evacuation from high residential building, Pathfinder 2020 presentation (11)



Picture 8. A moment from the simulation of evacuation from Hotel Radon in Niška Banja, Pathfinder 2012 presentation (7)

su predstavljale evakuaciju prolaznika, posetilaca i radnika Trgovinskog centra Zona I pokazale su kako se može menjati vreme evakuacije u zavisnosti od broja i brzine kretanja prolaznika, posetilaca i radnika ovog centra (12). Pomoću ovakvog pristupa moguće je delimično predvideti gužve i zastoje koji mogu nastati i na taj način uticati na efikasnost evakuacije. Procenjeno je da se vreme evakuacije kada je 80 ljudi po spratu objekta 51-75 sekundi, za 100 ljudi po spratu 65-90 sekundi, a za 150 ljudi po spratu 1600 do 1900 sekundi (12).

Prema proceni Ujedinjenih nacija očekuje se dalji porast stanovništva starijeg od 65 godina, tako da je 2019. godine svaka jedanaesta osoba bila ovog uzrasta, a 2050. godine to će biti svaka šesta (13). Starenje populacije prisutno je u svakoj zemlji. Na globalnom nivou došlo je do porasta udela starih od 65 i više godina sa 9% u 2019. godini, na 16% u 2050. godini (13). Porast broja starih doprineće porastu opterećenja gerontoloških ustanova. Osim toga, briga o starima je još veća znajući da mogu imati fizička ili mentalna oštećenja koja im otežavaju brigu o sebi, pa samim tim i evakuaciju. Svaka evakuacija starijih lica, posebno delimično ili potpuno nepokretnih, zahteva i angažovanje medicinskih lica koja treba da im pruže pomoć u procesu evakuacije. Imajući sve ovo na umu, jako su važna istraživanja ove vrste, jer doprinose da se starija lica osećaju sigurnim i tokom vanrednih situacija. Nove mere i koncepti starenja stanovništva imaju značajne implikacije na procenu kvaliteta uslova življenja i njegovo stalno unapređivanje, pogotovo u gerontološkim ustanovama.

Zaključak

Korišćenje *Pathfinder* softvera za simulaciju evakuacije predstavlja veoma važan, bezbedan i finansijski povoljan način predviđanja evakuacije i izračunavanje vremena potrebnog za evakuaciju. Najvažnija prednost prilikom korišćenja ovog softvera za simulaciju je činjenica da se mogu testirati i porediti mnogi različiti scenariji simulacije, i na osnovu toga izabrati najbolji evakuacioni scenario. Najbolji evakuacioni scenario podrazumeva najbolji put evakuacije, najbolji model ponašanja korisnika i najbolje korišćenje stepeništa, liftova i vrata, što je naročito važno za složene objekte, kao što su objekti sa nepokretnim licima, poput bolnica i gerontoloških ustanova, institucije za rehabilitaciju i slično. Vreme evakuacije iz gerontološke ustanove je najkraće kada rade oba lifta i kada može da se koristi glavno i požarno stepenište, a najduže kada je u funkciji samo požarno stepenište.

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be extended in dependence on immobile persons' number (11). Simulations of evacuations were realized without the presence of immobile persons, with the presence of 5% and 10% immobile persons related to the total number of residents. The evaluated speed of evacuation without the presence of immobile persons was 150.2 seconds, with the presence of 5% of immobile persons 172 seconds and with the presence of 10% of immobile persons 299 seconds, in the optimal case (11). For the worst case, the evaluated speed of evacuation without the presence of immobile persons was 451.6 seconds, with the presence of 5% of immobile persons 599.6 seconds and with the presence of 10% of immobile persons 754 seconds (11). The simulations that presented the evacuation of patients and staff from hotel Radon in Niška Banja showed for how much the time needed for the evacuation can be extended in the dependence on smaller or bigger assistances for immobile or partially mobile persons and evacuation routes (7). Immobile and partially mobile persons were located on the sixth and fifth floor and they demanded the assistance of medical staff. The evaluated speed of evacuation of all persons from hotel Radon in Niška Banja in the optimal case was 450.4 seconds, and in the worst case, 607.2 seconds (7). Simulations that presented the evacuation of passers-by, visitors and workers of market center Zona I showed how the time of evacuation can be changed in dependance on the number and speed movement of passers-by, visitors and workers of this center (12). Using this approach, it is partially possible to predict crowds and jams that can occur, and in that way, increase the efficiency of evacuation. It was evaluated that the evacuation time for the case of 80 people per floor ranged from 51 to 75 seconds, in dependance on the evacuation speed. For the case of 100 people per floor, the evacuation time ranged from 65 to 90 seconds, in dependance on the evacuation speed. For the case of 150 people per floor, there were crowds and jams and then the evacuation time ranged from 1600 to 1900 seconds (12).

According to the United Nations evaluation, a further increase in the population over the age of 65 is expected so that in 2019 every eleventh person was from this age group and in 2050, it will be every sixth person (13). The ageing of population is present in every country. At the global level, there has been an increase in the share of people older than 65 from 9% in 2019 up to 16 % in 2050 (13). The increase of older persons will contribute to increasing the workload of gerontology institutions. Besides, the care for the elderly is even bigger when they have physical or mental disorders that make self-care and evacuation more difficult. Every evacuation of older persons, particularly partially moved or immobile demands the engagement of medical staff that should take care of them in the evacuation process. With all this in mind, the researches of this kind are very important because they contribute to older persons' safety during emergencies. New measurements and concepts of population ageing have significant implications on the evaluation of quality of life and its permanent improvement, especially in gerontology institutions.

Conclusion

Using *Pathfinder* evacuation simulation software is a very important, safe and financially favorable way to predict evacuation and calculate the time required for the evacuation. The most important advantage of simulation software usage is in the fact that many different simulation scenarios can be tested, compared and, based on that, the best evacuation scenario can be chosen. The best evacuation scenario implies the best evacuation route, the best model of user behavior and the best use of stairs, elevators and doors, which is especially important for complex objects, such as objects with the presence of immobile persons: hospitals, gerontology institutions, rehabilitation institutions and similar. The evacuation time from the gerontological institution is shorter when both elevators and the main and emergency staircase are in function, and the longest when only the emergency staircase is in function.

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