AARMS Vol. 22, No. 1 (2023) 5–21.

10.32565/aarms.2023.1.1

Special Vehicles and Equipment in Fire Operations Used in Different Regions[1]

Péter PÁNTYA[2]

Different parts of the world have different disasters or fire and technical rescue events. Economic, infrastructural and natural environmental differences cause great variances. The nations employ various organisations, depending on the available possibilities, with diverse technical solutions to eliminate the sources of fire, disaster, incident dangers. In case of fires and technical rescue occasions that have already occurred and require intervention and pose a direct threat to human life, physical integrity and property, these tasks are typically performed by fire brigade organisations. These organisations also carry out more or less extensive activities in their areas of responsibility; however, national solutions may involve the use of firefighting vehicles and equipment that differ significantly from one neighbouring country to another.

The article presents the general firefighting vehicles used internationally and in Hungary and their characteristic capabilities, together with the widely used technical equipment and devices worldwide, built-in or mobile firefighting machines. In this paper a wide-ranging inspection of firefighting vehicles are demonstrated, and the description of the firefighting equipment can be interpreted together with the carrier vehicles. By special fire engines, the author here means vehicles that are on standby in each country, but only in small numbers and only alerted a few times a year. An important aspect in this category is that the design and equipment of these firefighting vehicles are planned to eliminate special incident situations that are unlikely to occur, but pose a great threat to human life, physical integrity or the property of the country and citizens, even in the short term. The article focuses also on these less frequent, more specialised firefighting vehicles and technical devices, with a description of their typical deployment conditions.

When drawing the conclusions, the ideas and solutions found during the international outlook worthy of Hungarian adaptation are presented. Here the national adaptation possibilities of each international, special firefighting vehicle, the advantages they can provide and the expected disadvantages are examined. The content of the article is a general summary that fills a gap due to the small amount of international literature, which can also be used during research, investigation and education in this research field.

Keywords: *fire, fire operation, intervention, special firefighting vehicle, equipment*

[1] The work was implemented in the framework of project TKP2020-NKA-09, financed by the Thematic Excellence Program 2020 from the National Research Development and Innovation Fund.

[2] Assistant Professor, University of Public Service, e-mail: pantya.peter@uni-nke.hu

Introduction

Different disasters or fire and technical rescue events are happening all over the world. Economic, infrastructural and natural environmental differences cause great variances. Each nation engages different forms of organisation, depending on the available possibilities, with diverse technical solutions to eliminate the sources of danger. In case of fires and technical rescue occasions that have already occurred and require intervention, and pose a direct threat to human life, physical integrity and property, these tasks are typically performed by fire brigade organisations. These organisations also carry out more or less extensive activities in their areas of responsibility; however, in practice, national solutions may involve the use of firefighting vehicles and equipment that differ significantly from one neighbouring country to another.

In accordance with its title, the article presents the general firefighting vehicles used internationally and also in Hungary, and their characteristic capabilities, together with the widely used – also typical – technical equipment and devices worldwide, even built-in or mobile firefighting small–medium machines. A wide-ranging inspection of firefighting vehicles made and the description of the firefighting equipment can be interpreted together with the carrier vehicles. In the study, general fire vehicles include fire engines, water carriers, aerial apparatuses (ladders, platforms), but also mobile container carriers and cranes are presented. By special fire engines, the author here means vehicles that are on standby in each country, but only in small numbers and only alerted a few times a year. An important aspect in this category is that the design and equipment of these firefighting vehicles are planned to eliminate special situations that are unlikely to occur, but pose a great threat to human life, physical integrity or the property of the country and citizens, even in the short term.

The article focuses on these less frequent, more specialised fire vehicles and technical equipment and devices, with a description of their typical deployment conditions. The rationale for keeping them ready and deploying them will also be described. When drawing the final conclusions, the ideas and solutions found during the international outlook worthy of Hungarian adaptation are presented. Here, taking into account the geographical, road network and industrialisation conditions and economic opportunities in Hungary, the national adaptation possibilities of each international, special firefighting vehicle, the advantages they can provide and the expected disadvantages (e.g. maintenance, operation) are examined.

The article focuses mainly on traditional firefighting and technical rescue activities and the firefighting vehicles and equipment used. Due to the special needs and equipment of medical rescues, it is not discussed this time.

The present work is a niche work due to the very limited Hungarian and international literature. Its aim is to provide a brief description and characterisation of general and special internationally used firefighting vehicles, and to provide a broader background for further research in the field, also for non-mainstream firefighters and researchers. By drawing attention to the various specific vehicles and solutions, even among fire vehicles, future possibilities of national adaptations or development studies can be attached.

For space and editorial reasons, only a short textual and general description of the professional, national firefighting vehicles and equipment of the different countries is given, without illustrative pictures. For the specific reasons of the more specialised industrial fire brigade designs, which are adapted to local characteristics, there are still solutions that have not been considered here.

Methods

In preparing the article, a literature research was carried out in the Hungarian and mainly English language using public sources. In addition to a review of various journals or books, data found at and provided by different manufacturers were also used and researched. The available literature on the subject is rather scarce, so this article is intended to fill a gap.

The author also used his own experience gained in his firefighting profession, university teaching and research activities. Personal participation has been made through field research at recent international exhibitions in the last years, targeted consultations with industry experts in this field.

Results

The first thing to clarify is the basic purpose of the fire brigade and disaster management forces themselves. Typically, in most countries of the world, this is to save lives, carry out firefighting and technical rescue tasks.[3] In many countries, such as the United States of America or Germany, and in some cases Romania, the fire brigade is the basic health-related relief organisation, with the ambulances and medical equipment and supplies provided for this purpose. As it was delimited at the beginning of this article, this primary health rescue and ambulance service provided by the firefighting service area will not be examined in this work. Firefighting vessels of various sizes, boats and single-person watercraft used by fire brigades are not included in this article, nor are aircraft and equipment used for firefighting purposes.

The rescue of persons in immediate danger of their lives, various outdoor fires involving buildings or vehicles, or technical rescue operations in a variety of environments (road accidents, building damage) may require firefighting vehicles of various types to be on the scene of the incident.[4] In addition, there are a small number of incidents where the use of specific and specialised firefighting vehicles, which are also very different from ordinary fire vehicles, is justified.

[3] Goodenough 1978.
[4] Restás et al. 2018: 340–340.

General categories of firefighting vehicles

The fire engines

Typically, the basic firefighting vehicle in Hungary and in most countries of the world is the fire engine. There are also different sizes and designs of this category internationally; they are classified as light, medium and heavy (possibly with the designation small, medium, large). The difference between them lies in the size of the vehicle, the power of the engine, the power of the pump, the amount of extinguishing water–foam forming agent carried and, due to the physical differences in size, the amount and design of the portable firefighting equipment. As a practical example, in addition to the installed pumping equipment, the light–small category carries around 1,000 litres of extinguishing water, the medium category carries around 2,000 litres, and the heavy–large fire engine carries around 4,000 litres in Hungary, with a proportionately increased quantity of foam and other firefighting equipment. The advantage of the larger quantity of extinguishing agent and equipment available from larger vehicles is accompanied by the disadvantages of more difficult inner-city transport and mobility.

Within this category, there are also lightweight or pick-up versions intended primarily for small fire brigades and volunteer fire brigades. Compared to larger fire engines, there are solutions involving the pump, where removable, portable firefighting pumps provide the water stream as opposed to the built-in versions.

The basic purpose of the fire engines is to enable general firefighting operations to be carried out at a basic level, while also being able to transport the required number of firefighters. They carry breathing apparatuses and rescue bags, life-saving ropes, extinguishing water and fire extinguishers and their accessories, and various hand tools and small machines, as well as various other protective equipment and accessories for technical rescue. All of these are carried in a permanently ready and accessible state in the fire vehicle's cargo area, so that they are available at all times without the need to send out special equipment.

Other fire vehicles

In addition to fire engines, other general-purpose firefighting vehicles, which are relatively frequently alarmed to the scene of a fire, include:

- *The water carriers.* Their basic aim is to provide, transport and supply large quantities of firefighting water in water-scarce areas, even by shuttle. Thanks to their built-in pumps and the limited amount of firefighting equipment compared with the fire engines, they can even intervene independently, albeit to a limited extent. Their capacity for transporting personnel, i.e. intervening firefighters, is also limited, typically one to three personnel. The capacity to transport water can vary from around 6,000 litres up to 40,000 litres, depending on the country and the needs. This means that there are water transporters ranging from the heavy category to tractor-

trailer solutions, although the latter are limited in their applicability to long-distance transport of extinguishing water.

- *Aerial ladders, platforms.* These fire vehicles are basically on standby to rescue lives from different floors of higher buildings. In addition to this, they can also be used for water cannon firefighting from various angles from above during fires and for long-distance, even thermal imaging, reconnaissance and, in some versions, they can deploy their rescue platforms not only at height but also, to a limited extent, at depth – even under a bridge. They can be of either ladder or platform system design, these also affect their tactical usability in different incident scenes, environments.
- *The technical rescue vehicles.* Their primary tasks, as their name suggests, are to support the technical rescue fire activities, typically with technical equipment, and the typical staffing levels are accordingly reduced; in Europe typically one to two firefighters. Their design, similarly to that of fire engines, also includes light and heavy categories. The light category may be designated as 'rapid intervention' or 'road', as its role is to provide a basic primary technical rescue capability in the event of a road accident. On roads with higher traffic congestion, the smaller size helps the travelling and the deployment to the scene of the incident, but it is also considered more agile in terms of speed and acceleration. Due to the smaller cargo size, they are only able to carry basic, essential technical rescue equipment. Firefighting vehicles in the medium or heavy category naturally sacrifice these advantages in order to offer a wider range of equipment and the ability to carry larger sizes or numbers of items of rescue equipment. Some designs can provide additional lifting capabilities for the fire brigade with built-in or mounted rescue cranes, but with limited load capacity.
- *The firefighter crane trucks.* Their only task and ability is to lift and secure large, heavy objects during various fire and disaster management intervention activities. This can be lifting trucks or tractor-trailers in road accidents, but also craning damaged building elements. Apart from the fire brigade forces, only special crane vehicles from the construction industry or some associated services (e.g. the armed forces) are available for similar purposes.

Typical equipment carried by general firefighting vehicles

As described above, the fire engines carry the required number of firefighting personnel and the specialised machinery and equipment installed, as well as a variety of firefighting and disaster management equipment. These varied tools are available in the fire vehicles' cargo holds to support life-saving, firefighting and technical rescue tasks. These tools can be categorised according to several criteria. In one aspect, they may be manually or mechanically operated, but they can also be distinguished according to their purpose as firefighting, technical rescue, communication, and personal protection or other.

Briefly, the typical firefighting equipment supplied is as follows:

- Portable fire extinguishers of various sizes and extinguishing capacities, agents
- Hoses of various sizes and their fittings and tools
- Equipment for the supply of extinguishing water and the handling of hydrants

- Equipment for different types of fire extinguishing jets, ways (water, foam, powder)
- A variety of personal protective equipment such as breathing apparatus, boots, gloves, etc.
- Various hand tools, such as saws, shovels, axes, fire swatters
- Ladders ranging from small adjustable and folding ladders to larger extendable ladders
- Signalling, lighting and communication equipment such as traffic control devices, buoys, radios

A very important element is the variety of mechanical equipment that can be removed from the cargo holds by the firefighters and which can be used on the scene to assist fire operations. These can be chainsaws, hydraulic rescue – cutting equipment, disc cutters or generators.

Machinery and equipment installed in various fire vehicles

In addition to the obligatory elements, these vehicles are also equipped with blue lights and siren sound signalling and radio communication devices, as well as built-in normal/high pressure pumps, typically located in the rear behind the fire extinguishing water tank (with some exceptions, such as in the case of high-altitude rescue vehicles), but examples can also be seen mounted on the front of the vehicle or installed in the middle.

Other built-in equipment and devices include winches, work lights to illuminate the area – possibly floodlights, water cannons requiring manual operation and remote-controlled extinguishing streams, known as water monitors, extinguishers of various types, rigid or preassembled with a flat hose, quick-acting fire hoses, self-protection extinguishing systems and brass extinguishers. Less frequently, we can found extinguishing arms with occasional spikes, generators to support the vehicle itself and the intervention. There are also smaller cranes in less commonly seen built-in form and built-in compressed air tanks with quick-charging connectors for the on-site rapid charging of firefighters' personal breathing apparatus.

Modern versions of firefighting vehicles also have on-board computers, displays (monitors) and even printers to provide backup IT support during the firefighting operation or at the scene of the incident. In recent years, solutions based on removable and therefore portable tablets have been gaining ground.

Traditional multi-stage, normal and high-pressure pumps are commonly found in fire engines, with modified versions such as CAFS (Compressed Air Foam System), which requires a water-saving foam agent, and UHPS (Ultra High Pressure System) built-in extinguishing systems, which are also water-saving but effective for smaller vegetation or some indoor, road fires.

The specialised firefighting vehicles

In this section, a summary of fire brigade and disaster management vehicles with major differences compared to general use fire engines is presented. The differences are mainly related to the purpose and design of the vehicle. The more specialised and unique firefighting vehicles are designed to support and effectively perform only some fire and disaster management tasks, but their annual run is not significant. The following list shows the wide range of special fire vehicles in use internationally, but their use and the extent of use varies considerably from country to country.

For the purposes of this article, the following firefighting vehicles are classified in this category:

- *Container carrier fire trucks.* These containers kept on standby can be used for technical rescue, hazardous material handling, water purification, social support for firefighters (rest, food, hygiene, sanitation), fire extinguishing containers with built-in and mobile water cannons, various extinguishing agents (foam, extinguishing powder), flood protection, mobile control point or health – medical purposes. In practice, this list can never be exhaustive, a wide range of capabilities needed on the scene of a disaster can be easily implemented and deployed in containerised form. In this way, special capabilities can be alerted at any time and deployed to a given geographical area or site of incident in a short time (typically within one to three hours) to support the on-site activities of fire brigades and disaster management forces. The size of the containers themselves, and therefore the size of the transport vehicles required, varies from country to country and from task to task, with light and heavy duty versions generally available, but also examples of ultra-lightweight solutions.

Picture 1: A medium size container carrier fire truck in Italy

Source: Photo taken by the author, 2017.

- *General transport, loading, road maintenance, firefighting personnel and equipment vehicles.* These are basically similar to ordinary civil, industrial and commercial trucks, but with built-in blue lights, siren, markings, radio communication devices and the ability to be kept at the disposal of the vehicle by the emergency services at all times, to assist the fire brigade and disaster management organisations in their priority incident response activities. There are even different types of earth-moving equipment among the fire vehicles in some countries.
- *General command and administration vehicles.* Similarly to the above, a command or administrative vehicle differs only slightly from an ordinary vehicle, command vehicles may have additional equipment due to differences between countries and/or tasks. These could be, for example, the specialised firefighting equipment of the Hungarian disaster management operational service or the single command points and on-board terminals developed in other countries, specifically to support the on-site command activities of the specialised field.
- *Fire motorcycles and snowmobiles.* They are not commonly used, but in several countries (e.g. Germany, Spain, the United Kingdom) there are fast-moving fire motorcycles with the advantage of faster arrival, and thus faster on-scene reconnaissance and the start of the first intervention. Their disadvantage is the ability to transport only one firefighter with minimal special equipment. Snowmobiles are naturally used for the same purpose and with the same disadvantages, but only in certain countries where weather conditions warrant it.

Picture 2: Fire motorcycles in England

Source: Photo taken by the author 2017.

- *Airport fire engines.* There are several different types of designs, but it is important to note that the purpose of this article is to summarise general fire vehicle knowledge

and that the number of operations carried out by airport fire brigades is significantly smaller than the number of operations carried out by general, everyday fire brigade operations. For this reason, the typical airport fire engines are listed here under one paragraph. The basic requirement here is to be able to start and travel as quickly as possible, while transporting the typically very large quantities of extinguishing agents, so that in case of extinguishing airport fire engines the built-in pump must start operating the various extinguishing streams even while the vehicle is in motion, in order to ensure effective extinguishing. Since in the aviation world, the individual incidents involve the transport of large numbers of passengers and large quantities of goods in the presence of considerable quantities of hazardous materials and fuel. It is important to rely on own transported extinguishing agents, tactical support for firefighting by means of high reach extendable turret and piercing nozzle, monitors or carried high-performance fans, but also cooling self-protection of vehicles. The supplying of extinguishing water from hydrants and the resulting loss of time during the initial phase of the intervention would be an undue disadvantage, and the location and distance of the aircraft to be extinguished from the hydrants could be particularly significant, justifying a specific and large transport and extinguishing capability. Fires and technical rescues occurring in airport areas may take place outside asphalt and concrete surfaces, even at a distance of several kilometres, and these vehicles must therefore be able to meet the above requirements in a wide range of weather conditions (e.g. snowy–muddy ground).

Picture 3: An airport fire engine with working monitors

Source: Photo taken by the author, 2017.

- *Forest, wildland fire trucks.* Compared to general urban, road fires and technical rescue incidents in forest or agricultural environments, there are additional requirements for the fire vehicles. Forest fire trucks are basically similar to conventional and general fire vehicles, the difference being based on the specificities of the geographical areas

targeted and protected and the fires that occur there. In these geographical areas, in the open vegetation and forested environment, there are no good quality and adequate width of regularly maintained roads, fire hydrants. For this reason, solutions with good off-road capabilities, with the narrowest possible superstructure due to narrow and wooded roads and capable of transporting several firefighters are required, in addition to which water saving extinguishing methods (e.g. CAFS or UHPS) and the transport of their equipment (special hand tools and extinguishing equipment) are a priority.[5]

- *Reconnaissance, on-site mobile laboratories for fire brigades, disaster management.* The ability to detect the presence, exact substance and quantity of hazardous substances, known or unknown, but less frequently encountered, and the direction of spread, is not available to fire brigades in general fire operations, either by default or internationally. A rapid airborne analyser capable of detecting some typical gases (e.g. oxygen and carbon monoxide) is available in most countries on various fire engines, but needs that are more extensive can be met either in central laboratories or in mobilised, on-board versions designed for fire brigade and law enforcement purposes. In almost all countries, such specialised vehicle-mounted or transportable containerised solutions are available, providing rapid detection results at the scene of damage from different sources and in different forms (gaseous, liquid, solid powder), even in the fleet of several military or law enforcement agencies (e.g. police, defence, army).[6]
- *Vehicles handling the release of dangerous substances.* Diverse and specific equipment is needed to eliminate the immediate threat to the environment, human life and physical integrity posed by hazardous substances that have already been released. Incidents of this type are rare in comparison with general firefighting operations, but it is necessary to supplement general firefighting equipment and machinery in this respect. Such special equipment may include hoses, pumps or temporary storage containers resistant to various dangerous substances, but also special protective clothing and its accessories. These equipment and devices are kept in a vehicle or transportable container for easy and flexible alerting.
- *Mobile command vehicles.* The command of fire and disaster management incidents involving several fire brigades and associated services, affecting a large part of the population and covering a large geographical area, involves the difficulty of managing the intervention forces from several different organisations and the difficulty of maintaining visibility of the area. Additional levels of command and other support posts will need to be established on a temporary basis in relation to the direct command mode. The most common technical rescue or firefighting operations do not require such an apparatus and, importantly, do not require a major infrastructure. In case of different types of incidents, both command and control and the necessary support and administrative activities need to be carried out in a variety of external locations (e.g. out of town in winter and at night). Fire vehicles are essentially trucks, possibly passenger vehicles, with very limited office space (e.g. desk, keeping multiple documents on paper, briefing and tasking several participants simultaneously in a confined area, etc.).

[5] Wu et al. 2016: 174–184.
[6] Horváth et al. 2021: 110–125.

Mobile command vehicles can meet these needs as a minimum, either on vehicles of various sizes (from lightweight to extendable and semi-trailer versions) or in transportable swap-body container form.

- *Fire vehicles with a high degree of self-protection.* In an environment where particularly high or even varied hazards are present and intervention cannot be delayed, fire vehicles with a higher degree of self-protection can create safer conditions for both the vehicle and the firefighters on the move. Internationally, the number of such incidents is very low, while the cost of acquiring and operating fire vehicles designed for such an environment is high due to the small number of units and the special protection needs. Nevertheless, it is difficult to circumvent or replace their use by other means to achieve the objectives of the above-mentioned environments. They can be designed to provide protection against multiple hazards, such as explosions, thermal effects or hazardous substances of different types and composition.

Picture 4: An ultralight fire vehicle on duty in Slovakia

Source: Photo taken by the author, 2022.

- *Ultralight fire vehicles.* As there may be firefighting service interventions that require heavy-duty equipment, there may be a need for specially designed small fire vehicles for fire or disaster purposes in many areas. Such environments may include industrial, utility tunnels in the built environment or mountainous, heavily forested areas in the

natural environment. What they have in common is the scarcity of access roads, but fire interventions also require the transport of personnel, intervention forces and various specialised firefighting equipment, tools to the scene. For such purposes, depending on the environment, specially adapted (e.g. made to measure for tunnels) or modified versions of existing ordinary vehicles can be used, such as quads, ultralight flatbed or body-on-frame single or double four-wheelers. Ultralight fire vehicles can also be cab or open quads with rubber tyres and tracked, snowmobile versions, depending on the expected needs.

- *Remote-controlled special fire vehicles.* Over the last decade, there has been an increasing trend towards fully remote-controlled fire vehicles of various types and sizes or firefighting special purpose vehicles. These can be complex designs with dozer, knuckle or high reach extendable turret, pump and nozzles, water cannons, with near-vehicle suppressing capability, or special purpose solutions such as pressurised fans or mobile water cannons. They may also have limited towing capabilities and may be fitted with rubber or tracked undercarriages. They can also be deployed in marshy, near-water environments and in environments that pose a high load or hazard to humans, and range in size from the smaller half-metre to the size of a passenger car.

Picture 5: A remote controlled fire vehicle at an exhibition

Source: Photo taken by the author, 2022.

- *Tracked, special undercarriage fire brigade, disaster relief vehicles.* They can transport firefighting and other personnel, specialist equipment and intervention materials over extremely difficult terrain. In marshy, flooded natural environments, the more costly airborne capability, which provides only a short-term presence in the area, or the tracked and floating carrier vehicles mentioned here and found in several countries, which offer a more favourable alternative to the airborne solution, may be considered. This could also include firefighting with capabilities for use on tracks in a railroad environment or on private tracks in a winter mountainous environment, with similar size and intervention capabilities to those in general use.
- *Water, ice rescue, dive fire vehicles.* These fire vehicles are primarily for life-saving purposes from various forms of water (rivers and lakes, whether frozen surface or deeper bed) and from different forms of water. The purpose of the vehicles is to search and rescue persons who are in the water. The aim is to support the fire units by transporting specialised and protective equipment and built-in equipment, devices. In addition to rescuing persons, fire tasks include the search for, and possible recovery or support of various objects and vehicles in the water, but also special surface or underwater activities in case of various water structures, for example during flood protection. Fire vehicles providing water rescue capability typically consist of conventional light or medium-duty cargo vehicles with specialised cargo compartment design and possibly rubber dinghy towing or roof carrying capabilities.
- *Breathable air support vehicles.* Many fire tasks naturally take place in the presence of smoke, hazardous materials release or reduced oxygen levels, for example in the case of building fires. Respiratory protection of fire brigades is almost entirely provided by compressed air breathing apparatus, which requires the use of air cylinders that are already pre-filled and kept ready. These can provide 30 to 40 minutes of protection for the firefighter using them and, with the reserves carried by the fire engines, can support a one to two hour operation. In addition to the reserves held at fire stations, for prolonged and extensive incidents, it may be necessary to provide a larger stock on the scene of the incident, or even to provide a continuous solution for on-site refilling. These air support vehicles may be of a pallet or containerised design.
- *Rescue air cushion carrier.* Specially designed for specialised rescue operations from height, the specialised nature of these fire vehicles is almost exclusively in the rescue equipment they carry and its accessories. In practice, their design is achieved by providing a larger bale space and the basic equipment of a fire brigade emergency vehicle, even a light transport vehicle. The number of firefighters required to set up the bouncing cushion device is not transported by the vehicle, but by other fire vehicles.
- *Generator fire vehicles.* Vehicles designed to provide and support higher-powered electric power supply to incident sites or vital life safety or possibly medical – critical infrastructure buildings. As in some of the previous examples, their specialisation is limited to the provision of a single-purpose task, in this case by means of a light category carrier vehicle, trailer or containerised design. Apart from a trained driver, no additional operator firefighting staff are required.

- *Search dog fire vehicles.* Search for persons (under rubble or in forested–open areas), where search dogs can assist fire or other law enforcement forces, is also a life-saving activity within the scope of the fire brigade, disaster management. Among their tasks is the search for various materials or remains of materials at the scene to assist fire or police investigation. These fire transport vehicles are also mission-related, but they are not only used to transport the machinery, tools and protective equipment associated with the task, but also, and above all, to transport specially trained search dogs with special skills and the means to protect, care for and look after them.
- *Hose transport vehicles.* In several countries, vehicles carrying hoses of various types and sizes have been kept ready to support firefighting activities. These contain hoses specifically designed to provide firefighting water over long distances or in large quantities, possibly laid out and then recollected by their mechanised means when the stand-by is returned. Their use is not necessary for everyday fires, but for more serious incidents, their large size and volume make them necessary and larger, medium-heavy fire vehicles typically use them.

Picture 6: An impulse fire extinguishing fire vehicle at an exhibition

Source: Photo taken by the author, 2015.

- *Passenger buses, vans, trucks.* Both for general fire and disaster management tasks and for incidents requiring a larger number of personnel, it may be necessary to use vehicles for the transport of persons only. They can vary in design from light category to heavy category or large bus design, but are typically not equipped with special fire

brigade equipment and facilities other than basic radio communication, blue light, siren but examples of mobile command post capability can be seen.

- *Special, unique firefighting vehicles.* It may be used in relation to general firefighting activities where the vehicles and equipment available at conventional fire stations are not sufficient. The commonly available fire vehicles carry, to a limited extent, additional different extinguishing agents and solutions for their application on or in the firefighting vehicle. These special fire vehicles and the extinguishing agents they carry, such as foaming agents and extinguishing powders, are very rarely used for alarm and even less frequently for actual fire operations. The need to keep them on standby is more justified in an industrial environment, in or near a hazardous activity or plant, given that in such an environment the extent of a fire can be significant within a short time and can only be extinguished effectively and with less likely damage by special extinguishing agents. Typical extinguishing agents kept ready on board of the firefighting vehicles may include extinguishing powders, foam-forming agents, or certain extinguishing gases. There are also examples of water-based, but so-called impulse fire extinguishing vehicle-based solutions and turbine extinguishers with aircraft jet engines. The former can be used for small distances (a few metres) but for very short extinguishing times (a few seconds), while the latter can be used for longer extinguishing–cooling tasks, even over long distances of tens of metres, up to hours.[7]

Conclusions and discussion

The evolution of fire vehicles in the coming period

The changes in fire vehicles over the next few years will mainly be seen in the driven system. In several countries, and particularly in the more prominent, inner-city–industrial environments, we can see examples of the experimental use of all-electric driven in scattered locations in Germany, Spain or the U.K., as opposed to conventional diesel engines. It is expected that these will be developed in the near future, particularly in the area of battery capacity and fast charging. The main problem for electric fire vehicles is to keep the vehicle running for as long as possible, from start-up to the point of arrival at the scene, even at a remote location, and to keep it running for hours, taking into account the need to keep the energy-intensive installed equipment (e.g. pump) supplied. After the intervention, the vehicle must be able to return safely to the fire station, expecting that, while it is on the move, it may be alerted by another location with similar energy requirements. A further issue is the refuelling time to restore readiness, which for a diesel tank takes only minutes, which is still difficult to keep up with current capabilities.

There is also a slight change and evolution in the transported, portable firefighting equipment, with the petrol engine equipment being replaced steadily, at international level, by battery-powered, electric driven machinery. These firefighting appliances can

[7] Wallington 2004; Dermek 2011.

be easily replaced in the cargo holds of existing fire vehicles, and modernisation can be carried out within a day.

With the increasing mobility of battery-powered small appliances for firefighting purposes, less attention is being paid to the issue of fire engines as a power source. Nevertheless, in this section of the article, the author draws attention to the possibility of this, i.e. the availability of an on-board generator power capability and compressed air system. The power source they provide can be used within a limited distance from the fire engine, but within a few metres to ten metres with an electrical extension cord or air hose.

Keeping maintenance and operating costs for the firefighting service low will continue to be a priority in the near future. This can also be achieved by solutions that can perform as many functions as possible in one vehicle, i.e. a single fire engine design should be sufficient to meet the needs of firefighters in widely differing fire and technical rescue situations.

The range of equipment for remote-controlled fire vehicles and appliances is expected to continue to expand, as will their capabilities, with increasingly high-quality standard and thermal imaging cameras, greater extinguishing capacity, and more firefighting, other equipment systems both integrated and installed.[8]

The next step forward is the training of drivers of fire vehicles

Virtual training, including the development of near realistic driving and pump or other equipment handling simulation-training tools in fire vehicles, as well as software simulation training using virtual augmented reality, are becoming increasingly popular. Even hybrid target solutions are available today, such as the control of the pump only on a wall panel with monitors or projected surfaces, or the creation of a realistic driver's cab with visual displays or projectors. These solutions are expected to become more realistic and to be developed for an increasing number of devices, with more detailed digital virtual representations as the IT back-end develops.

For reasons of space and editing, this article only gives a general description of the various firefighting vehicles and equipment, but it is planned to expand on the various sub-areas which could be particularly useful in the field of education or for a real primary introduction to the field.

References

Dermek, Milan (2011): *Hasicské automobily na Slovensku.* Zilina, Slovakia.

Goodenough, Simon (1978): *Fire! The Story of the Fire Engine.* New York: Chartwell Books.

Horváth, Hermina – Kátai-Urbán, Lajos – Vass, Gyula (2021): Transportation of Flammable Dangerous Goods in Hungary. *Védelem Tudomány,* 4(4), 110–125.

[8] Suslavičius–Bogdevičius 2003: 89–96; Sivakumar et al. 2020.

Restás, Ágoston – Pántya, Péter – Rácz, Sándor – Érces, Gergő – Hesz, József – Bodnár, László (2018): A megelőző és mentő tűzvédelem valamint az iparbiztonság kapcsolódásai. In Vass, Gyula – Mógor, Judit – Kovács, Gábor – Dobor, József – Horváth, Hermina (eds.): *Katasztrófavédelem 2018: Veszélyes tevékenységek biztonsága.* Budapest: NDG DM. 340–340.

Sivakumar, A. – Babu Sekar, Jagadeesh – Vignesh, Sathya – Muthukumar, Shyam – Yogapriya, J. (2020): Autonomous Standalone Fire Engine with LIDAR-ROS. European *Journal of Molecular and Clinical Medicine*, 7(4).

Suslavičius, Vladimiras – Bogdevičius, Marijonas (2003): Improvement of Technical Parameters of Fire Vehicles and Equipment. *Transport*, 18(2), 89–96. Online: https://doi.org/10.3846/16483840.2003.10414072

Wallington, Neil (2004): *The World Encyclopedia of Fire Engines and Firefighting.* London: Annes Publishing.

Wu, Chengxuan – Zheng, Yanping – Wang, Zhe (2016): Design of a Multifunctional Forest Fire Vehicle. *Open Journal of Transportation Technologies*, 5(6), 174–184. Online: https://doi.org/10.12677/OJTT.2016.56022