road transport, distribution, electric goods, city

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TRANSPORT SERVICING OF THE DISTRIBUTION IN CITY

Summary. This work gives an overview of the state of transport services for distribution in a city with the size of 100 000 to 200 000. The attention is directed to the conditions in Ruse - one of the 10 largest cities in Bulgaria. Based on a survey of the values of the performance in replacing conventional vehicles powered by internal combustion engines with electric, it was concluded on the effectiveness of using electric vehicles for distribution in the city**.**

ТРАНСПОРТНЫЕ УСЛУГИ ПО ДОСТАВКЕ В ГОРОДЕ

Аннотация. Данная работа дает краткий обзор состояния транспортных услуг по доставке в городе с населением от 100 000 до 200 000 жителей. Внимание уделено состоянию в городе Русе - одном из 10 крупнейших городов Болгарии. Опираясь на обзор преимуществ замены обычных транспортных средств, приводимых в действие двигателями внутреннего сгорания на электрические, был сделан вывод об эффективности использования электромобилей для осуществления доставок в городе.

1. INTRODUCTION

The influence of urbanization in the last few decades has led to an increasing number of urban population and density of the residential buildings, shops and other community buildings. This and the increasing number of private vehicles traveling in the city road network whose throughput remains unchanged, leads to queues and traffic jam on main roads and cross-roads. For the last 10 years, from 1998 to 2008 in Bulgaria the number of tractors with semitrailers, cars and trucks has increased from 2 051 618 to 2 665 357, which is an increase of 29,9%. The rate of increase of trucks is 23,5%, cars 30,7%, [3]. Along with private vehicles and public transport - buses, trolleybuses, taxis; the supply of goods to the commercial and industrial sites, courier and postal services are carried out on the road network. Due to heavy use of urban roads with vehicles causing traffic jams, which temporary blocks the traffic and frustrates the travelers, restrictive measures have been taken slightly reducing the impact of vehicles engaged in distribution in the city. These decisions include: routes for traffic of trucks with weight exceeding 10 tonnes; mainly using vehicles with payload of 0,8 t and 1,8 tonnes for larger loads; transporting mainly at night, when the load of the road network is lighter, or in strictly define hours during the day, [1].

Another problem for the cities is the pollutants released by the cars. This is due to the use of vehicles with internal combustion engines, working mainly with liquid fuels: petrol and diesel, rare gases: LPG and methane, because most of the cars used by the transport companies have been created

from the factory producer to work with liquid fuels. This in turn, draws attention to the use of vehicles meeting the environmental standards Euro 3, Euro 4 and Euro 5 or an alternative environmentally friendly transport, [2].

2. EXPOSITION

2.1. General characteristics of the transport services for the city

Freight is an essential part of the transport of a modern city. They have a direct impact on the economy and meeting the needs of the residents of the city and are a major factor in supplying the manufacturing and trade centers with the necessary raw materials and goods, and also have a direct impact on the courier, postal and other services.

The movement of incoming and outgoing cargo flows in one of the biggest cities in Bulgaria, Rousse with about 150 000 inhabitants between 2004 and 2007, is about 2,3 million tons of cargo per year (Fig. 1). The analysis of these flows shows that there are relatively equal volumes of inbound and outbound cargo flows, the outflows during the period were about 15% greater than inflows.

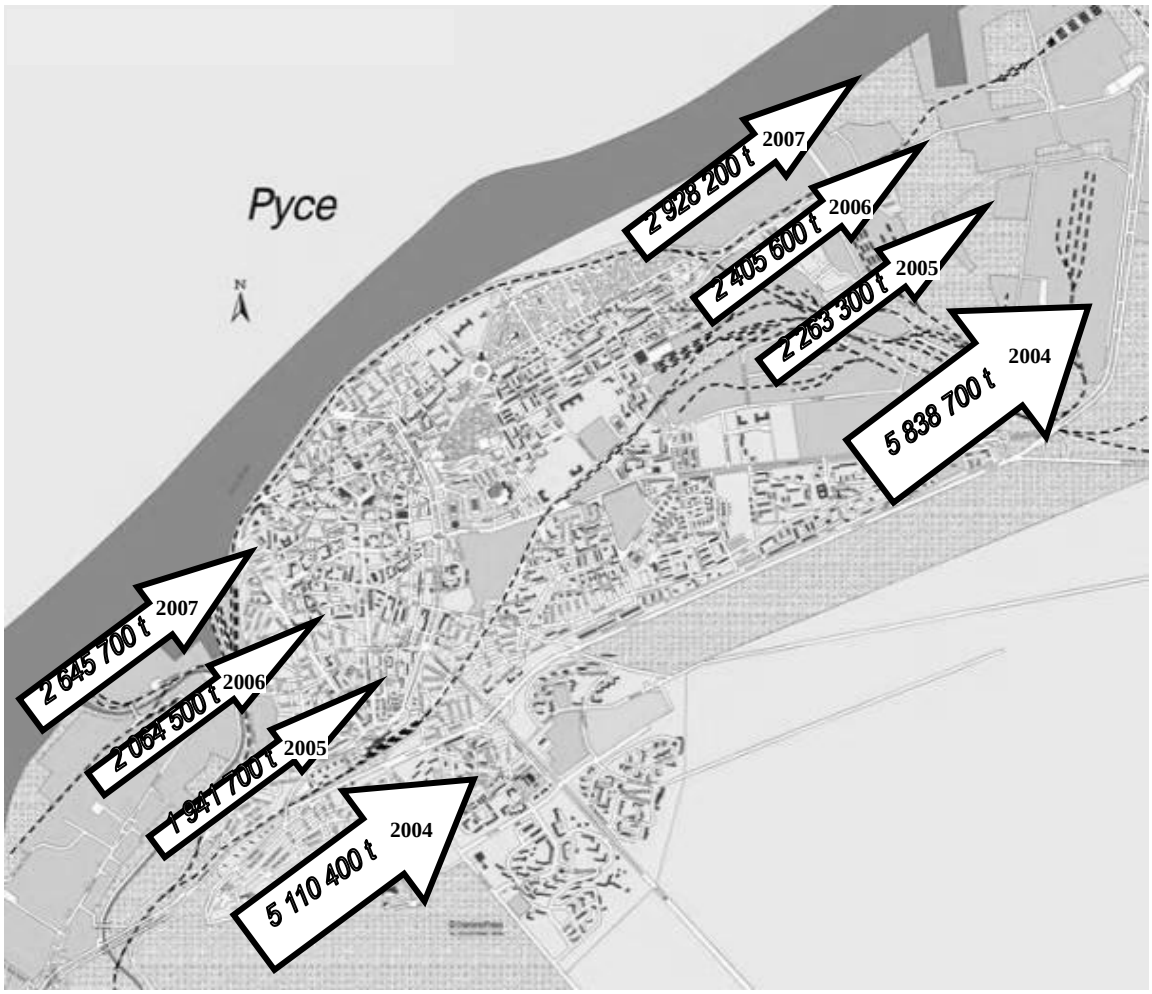

Fig. 1. Incoming and outgoing quantities of goods transported for domestic road transport for the period 2004 – 2007 in the town of Rousse [4]

Рис. 1. Входящие и выходящие потоки товаров, перевозимых внутренним транспортом в городе Русе за период с 2004 по 2007 год. [4]

The flows in Figure 1 are mainly transported in the new city routes for movement of vehicles with load capacity exceeding 10 tones. For Ruse the routes are as follows (Figure 2):

- Bulgaria Blvd - Third March Blvd - Western Industrial Zone;
- Third March Blvd - Erma Str. - M. Stoykov Str. - Rousse Shipyard;
- Bulgaria Blvd - Tutrakan Blvd - East Industrial Zone;
- Bulgaria Blvd - Lipnik Blvd - Mototehnika - Ivan Veder Str. - Potsdam Str or Lipnik Blvd – crossroad Olympus – N. Petkov Str. – the storage area;
- Tutrakan Blvd - Dorostol/Str. Pliska Str. – Tulcha Str – N. Petkov Str.

A large part of the cargo is achieved to the residential buildings and the main attraction centers, shops, schools, postal and courier stations on the main network of the city. The streams, which runs on the city network, are primarily divided between:

- Cars (personal, business and taxi transport);
- Public transport (bus, trolleybus);
- Freight cars. According to the authorization of the city, freight cars are divided into: heavy over 10 tones, which runs on special routes, vehicles load to 10 tones, which are divided into cars with limited licensing and capacity over 1,8 tons and light trucks with unlimited licensing, which are prevalent - over 60% of the park, conducting operations in the city, with a payload of 0,8 tons. The advantages of organization that allows the city to be offloaded from the big trucks that are prerequisites for obstructing urban traffic and provide higher average speeds and safer movement.

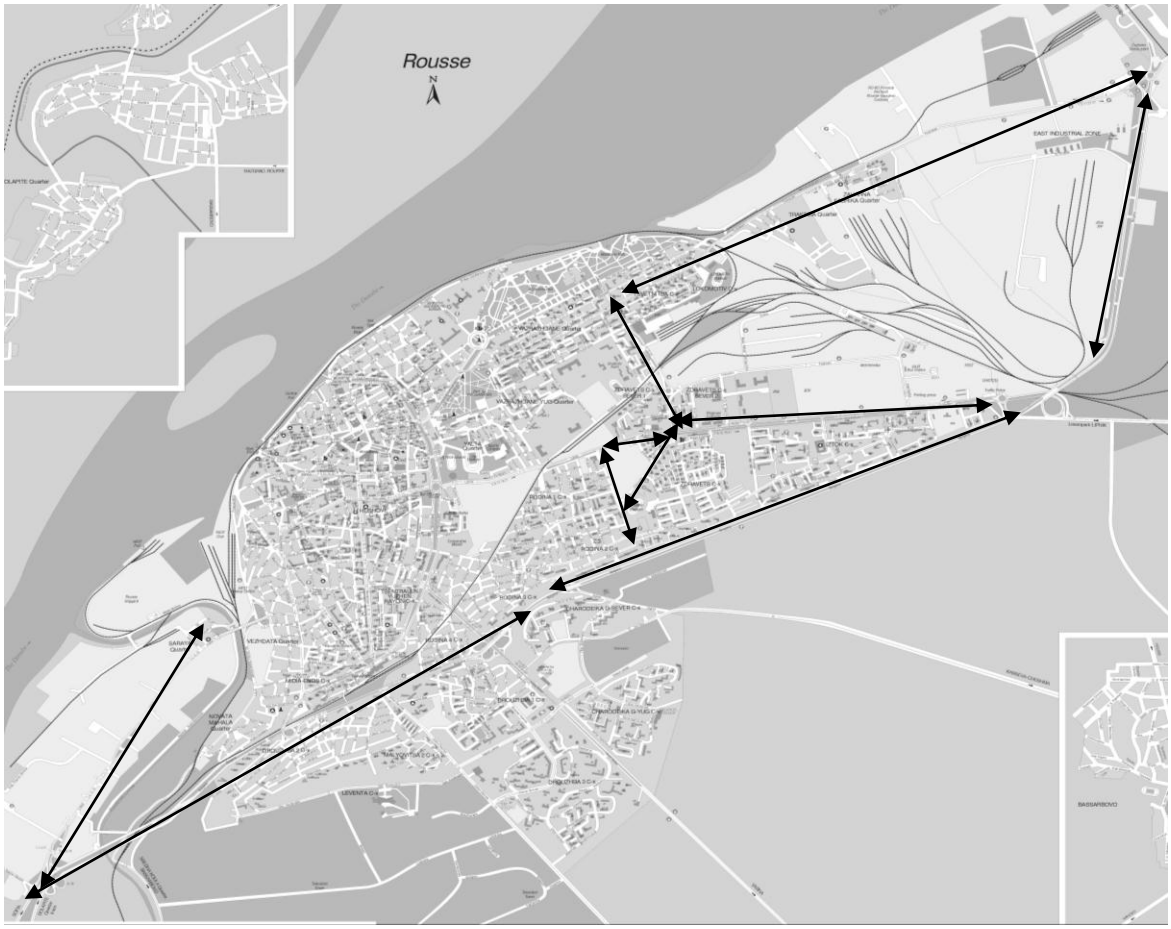

Fig. 2. Routes in Ruse on the movement of vehicles with load capacity exceeding 10 tones [1]
Рис. 2. Маршруты движения транспортных средств с грузоподъемностью превышающей 10 тонн в городе Русе [1]

On the other hand there are indicated the following disadvantages of the transport [5]:

- It does not build a positive value on the product and is the only additional cost that is added to the price of the product and makes it uncompetitive;
- Raises the cost of resources and energy;
- Increases the pollution and urban air with the waste from combustion exhaust gases, noise (76-80dB), waste materials - fuel, oil, antifreeze, rubber products, etc.;
- Adversely affect human health by leading to health problems, stress, injuries, increased risk of illness and death;
- Reduction of green areas - parks with grass and wooded areas, reduce the water areas and others due to the infrastructure construction.

2.2. Road trace and models for transport optimization

The majorities of routes for transport services of the city are picking up, drop off and pick up-drop off, [3]. Such paths are typical models of the type shown on Fig.3.

In the presence of *m* consignors forming plurality *{M}*, which transported cargo to *n* recipients, forms plurality *{N}*, (Fig. 3). Unification of the two sets *(M∪N)* forms the set of all corresponding points.

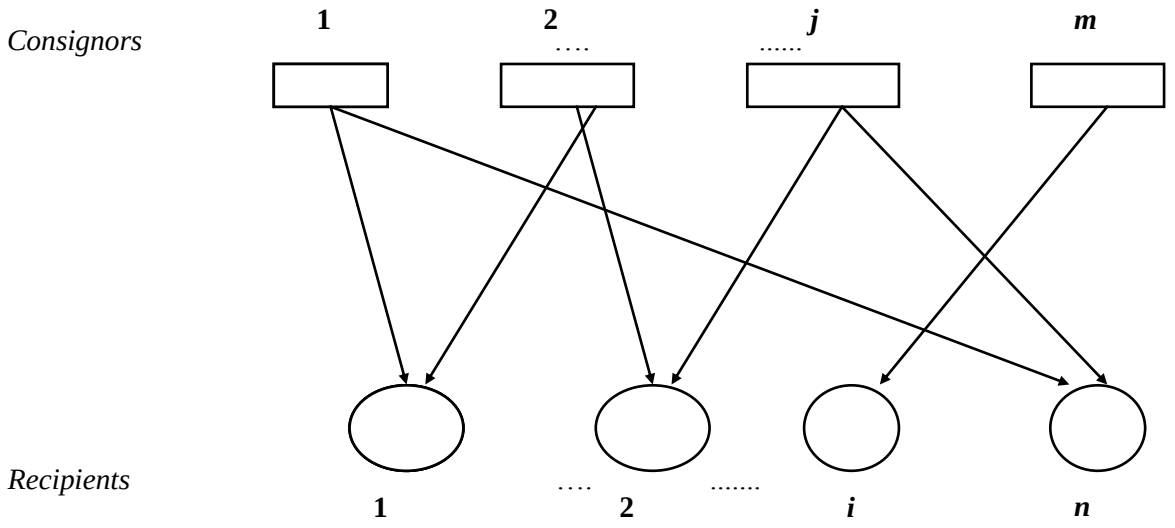

Fig. 3. Scheme of positions and connections between corresponding points
Рис. 3. Схема расположений и связей между соответствующими (обменивающимися) пунктами

Each *j*-th (*j=1,2,.....,m*) sender for a specified period of time sends Q_j $(Q_j \geq 0)$ uniform cargo units, and each *i*-th $(i=1,2,.....,n)$ the recipient receives G_i $(G_i \geq 0)$ unit load for the same period.

For transportation of goods is used a car park from *l* vehicles, where each *k*-th $(k=1,2,.....,l)$, from them loading q_k $(q_k \geq 0)$ units.

Let $m=1$ *u* $n>1$, or one consignor (sending *Q* units of goods) provide more than one recipient, receiving $G_i(i=1,2,...,n)$ units of goods. In this case the number of corresponding points is $n+1$.

Assume that there is a balance between sent and received cargo quantity as in inflows and outflows of Figure 1. Then:

$$Q = \sum_{i=1}^{n} G_i \tag{1}$$

In:

$$Q > \sum_{i=1}^{n} G_i \tag{2}$$

in the consignor has more units ($Q - \sum_{i=1}^{n} G_i$)load from the required amount. This case (2) is converted to (1), the units remain in inventories at the sender.

In:

$$Q < \sum_{i=1}^{n} G_i \tag{3}$$

load required for beneficiaries is more (c $\sum_{i=1}^{n} G_i - Q$ units) from available to the consignors. In this case establishes priority of supply.

Multiple requests N ranged as α subsets $N_1, N_2,.....,N_\alpha$, ranged in order of priority as $N_1 \cup N_2..... \cup N_\alpha = N$ *u* $N_1 \cap N_2..... \cap N_\alpha = 0$.

N_1- the set of requests with the highest priority;

N_2.....

.....

$N\propto$ - the set of requests with the lowest priority.

If $\sum_{i \in N\alpha} Gi \geq \sum_{i=1}^{n} Gi - Q$, then exclude from consideration requests with the lowest priority (ie, requests from the subset N_α). Then if $\sum_{i \in N_1 \cup N_2 \cup ... N_{\alpha-1}} G_i \leq Q$, the task is converted in case (1) or (2), otherwise continue with exclusion orders from the next priority in subsets and again re-align formally task (3) to (1) or (2).

Let $\{G_1, G_2,.....,G_n\}$ is a tidy set (i.e. $G_i \leq G_{i+1}$, for $i=1,2,..,n-1$).

If you have a car with a nominal load q

When $q > G_i$ for $i=1,2,.....n$

A problem arises on goods in small batches in delivery routes.

When $q \leq G_i$ for $i \geq i_k$, $i=1,2,..i_k,..,n$

We reduce the set $\{G\}$ in the form (4)

$$\{G\}: G_1, G_2,.....,G_{i_{k-1}}, G_{i_k}', ...,G_i' ....G_n' . \tag{4}$$

where: $G_i' = G_i - sq \geq 0, s \in Z^+$; $s = [\frac{G_i}{q}]$ (i.e. s is the integral part of division of G_i and q, or comparable with the module) and $G_i' \leq q$.

The cargo sq is transported in s linear reversible routes $\{0 \rightarrow i \rightarrow 0\}$.

For set (4) again arises the task of cargo in small batches.

Let l be the number of vehicles with load respectively $q_1, q_2,..., q_l$ units and $\{q_1, q_2,..., q_l\}$ is a tidy set $(q_k \leq q_{k-1}$, за $\kappa=1,2,.....,l-1)$.

If $q_1 > G_i$, $i=1,2,.....,n$ again arises the task of cargo in small batches.

If $q_k \leq G_i$ за $k > k_p$ we reduce the set G in the form (4).

It follows that the set G can always provide in type (4), where it arises the task of planning for freight in small batches.

When $\sum_{i=1}^{n} G_i \leq \max_k q_k, (k = 1,2,.....,l)$, all cargo can be delivered to the recipients of a car for one route.

When $\sum_{i=1}^{n} G_i > \max_k q_k, (k = 1,2,.....,l)$, should build more than one route starting and ending at the sender.

When *m>1* and *n=1*, each of the senders, sent to one recipient Q_j *(j=1,2,.....,m)* units of goods. Arises the task of drawing up the so-called collection routes.

Let *m>1* and *n>1 (m<<n),* i.e. senders are more than one, but recipients are much more senders.

The multitude of these tasks can be divided into two subsets. One subset is the one in which many of the recipients are broken between the sender so that each recipient is supplied by a single consignor, i.e. each sender has its own service area and provide supply only "own" recipients.

If $\{M_i\}$ e set of senders supplying the *i*-th receiver, then $|M_i|=1, i=1,2,.....,n,$

where $|M_i|$ is thenumber of elements in the set M_i.

Another subset is the opposite of organization form, where each recipient can receive cargo from each sender $|M_i|=m, i=1,2,.....,n.$

Between these extreme cases, is possible intermediate form, where some recipients may receive a load of some (but not necessarily all) senders. Then:

$1 \le |M_i| \le m, i=1,2,.....,n.$

In the latest two cases, the task can be broken down into simpler, tackling the task of fixing the recipients to consigners.

2.3. Using the alternative vehicles powered by fuel, differently than liquid fuels

In all routes for transportation of goods used vehicles with internal combustion engines operating on liquid and gaseous fuels (gasoline, diesel, LPG, CNG). Exhaust from these vehicles separated and remain entirely in urban areas where they are and living areas. Basic daily mileage, which is taken from the vehicles, examined routes in the city ranged from 80 to 150 km. Also considering that the cars are not moving only on one route, but few are usually in the range between 5 and 30 km. This makes it possible to seek a variant which instead of cars with internal combustion engines with capacity up to 0,8 and 1,8 tons, using alternative vehicles - EVs.

In the project Green Post, [5] was carried out research in Bulgarian Posts EAD, Ruse under the existing pick up and drop off routes.

Fig. 4 shows one of the surveyed collection routes. One of the cars - VAZ 2104, was replaced by electrical car Free DUCK, production of Ducati Energy, especially for mail transport, (Fig. 5).

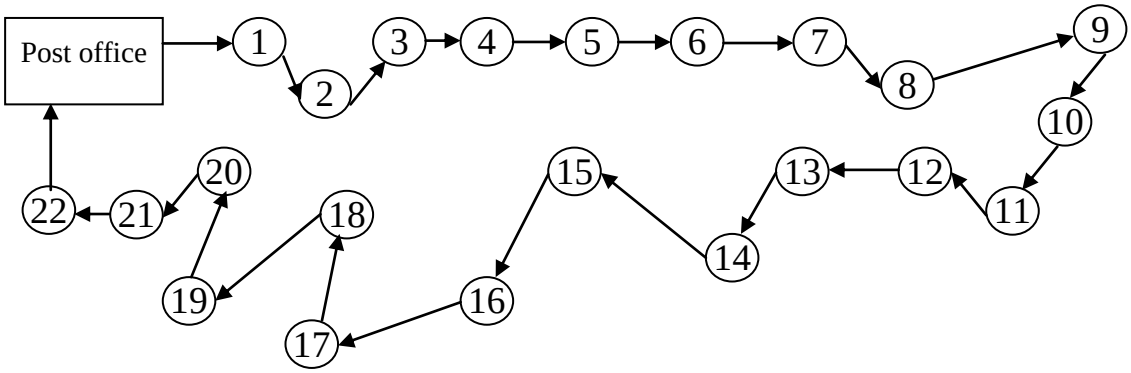

Fig. 4. Outline of the collection of the letters in the city of Ruse, including post office and 22 post boxes
Рис. 4. Схема потоков писем в городе Русе, включая почтовое отделение и 22 почтовых ящика

The survey results shows that: the length of the circular assembly route is 17,77 km; technical speed 20,35 km / h; operating speed 17 km / h; traffic time 2885 sec; total time on route 3761 sec (63 min); average time of stay in a mailbox to collect letters 40 sec. For that route, it appears that electric car replaced successfully the traditional car. The results showed a good practice to replace the traditional park with an alternative [6].

Using the less polluting transport is facilitated by the lower mileage vehicles that travel, as well as lower speed in cities, which for Bulgaria is limited to 50 km/h.

For future implementation of alternative vehicles in the cities is needed infrastructure development with power plants and selection of appropriate for transportation of goods electrical car. In such organization of work is possible reduction of discharges in the city exhaust emissions from cars, courier and postal services, transport of freights to and from the center of gravity, such as shops, markets, warehouses, factories and firms.

Fig. 5. Using electrical car Free Duck
Рис. 5. Используемый электромобиль Free Duck

3. CONCLUSION

The results of the survey shows that it is possible to transport activities related to transport of goods and mail letters and parcels in cities, successfully to be carried out by electrical car with nominal load up to 0,8 tons and range per one charge up to 150 km.

To be a successful introduction of electric vehicles in a city, like Ruse, is necessary to build an infrastructure with charging stations and a selection of electrical cars with technical indicators that provide alternative replacement of traditional vehicles for transport in cities.

The Support from the government and municipal authorities with tax and financial incentives and promotional campaigns, as a first step in starting a campaign to update fleet with cleaner vehicles, is one of the necessary conditions for successful implementation of such activities.

Bibliography

1. Андонова И.: *Проектно решение за трасетата за движение на товарни автомобили над 10 тона.* Община Русе, 2004.
2. Бързев К.; Станков К.: *Екологични проблеми на транспорта*. Русе, 2007.
3. Симеонов Д., Пенчева В.: *Взаимодействие на видовете транспорт.* Русе, 2001.
4. *Национален статистически годишник*. НСИ. София.2009.
5. Pencheva V., Asenov A., Savev E.: *Noise Reducing in urban environments, using alternative vehicles*. Beograd, Serbia, 2011.
6. *Green Post*. http://greenpostproject.eu/.

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