# VEHICLES FOR DISABLED PEOPLE ON TESTS AT THE MOTOR TRANSPORT INSTITUTE IN WARSAW (1945-1990)

Bartosz Zakrzewski

## Abstract

This extensive analytical article presents vehicles for disabled people, that were driving on the Polish roads in the years 1945-1990. Over the years, they have undergone detailed type-approval tests at the Motor Transport Institute in Warsaw, thanks to which the original technical characteristics and functional description of this type of vehicles have been analysed and presented for the first time. The material was illustrated with numerous photographs, drawings and tables, and appropriate conclusions were presented at the end.

## Keywords:

disabled people, invalids, homologation tests, Motor Transport Institute (ITS), tricycle, moped, wheelchair, Polish People's Republic (PRL), German Democratic Republic (GDR), Czechoslovakia, Polski Fiat 126P, semi-automatic clutch.

## Citation:

Zakrzewski B.: Vehicles for disabled people on tests at the Motor Transport Institute in Warsaw (1945-1990), Motor Transport, 67(1), s. 51-68

DOI: 10.5604/01.3001.0053.9433

## Introduction

A car for a disabled person is a basic device facilitating movement and mobility in society. Over the years, the development of modern technologies has significantly dealt with many dysfunctions, creating excellent substitutes for physical imperfections. A disabled driver or passenger can travel and be almost anywhere a fully able-bodied person can reach.

The basic legal act in force in the country is the Constitution of the Republic of Poland, which also contains provisions regulating many aspects related to disabled drivers. An important international act ratified by Poland is the Convention on the Rights of Persons with Disabilities, adopted by the UN General Assembly on December 13, 2006. This document, in Art. 20 entitled: "Mobility" states that people with disabilities have the full right to move about and freely [3].

According to the results of the National Population and Housing Census conducted in 2011, the total number of disabled people in Poland at the end of March 2011 was approximately 4.7 million (4,697.0 thousand to be precise). Thus, the number of disabled people in Poland constituted 12.2% of the country's population compared to 14.3% in 2002 (nearly 5.5 million disabled people in 2002) [15]. The share of men among disabled people was 46.1% compared to 53.9% for women. In 2011, over 3.1 million people (3,133.5 thousand to be exact) had legal confirmation of their disability. The population of people with legal and biological disabilities (at the same time) was 2,652.0 thousand, the legal alone – 479.5 thousand, biologically alone – 1,565.6 thousand. The number of people with biological disabilities was 4,217.6 thousand.

In December 2021, there were 2.3 million people in Poland receiving pension and disability benefits at the (ZUS) Social Insurance Institution, who had a certificate of the degree of disability (issued by teams for ascertaining disability) or a certificate of the degree of incapacity for work (issued by ZUS).

Nowadays, the most common causes of disability are diseases of the circulatory system, musculoskeletal system and neurological illnesses. However, the relatively lower percentage of people with visual and hearing impairments, mental illness and mental retardation in the group of disabled people still concerns thousands of people with reduced ability to function in everyday life, and therefore requiring a special approach in education, on the labour market and in everyday life [15].

These are problems of today's society, but already in the years 1945-1989, due to the development of individual motorism, the authorities of the Polish People's Republic (PRL) noticed the problem of moving about by the disabled people. It was decided to make it easier for them, to some extent using as an example the Czechoslovak vehicles – the Velorex vehicle for disabled and the GDR – the Piccolo Duo trolley (and then, from 1972, the Simson Duo and then the Robur Duo). The Polish response to the needs of disabled people was the creation of two wheelchair prototypes marked as W65.S65.N65. In the future, this vehicle was named Gacek. Then, the mass produced vehicles in Poland under license, such as the Polish Fiat 126P, were adapted to the needs of disabled people.

The article presents vehicles that served disabled people in the period of the Polish People's Republic until the end of the 1980s, most of which (except Velorex) underwent detailed homologation tests at the Motor Transport Institute [12]. The territorial scope of the study concerns the so-called countries of the people's democracy with particular emphasis on the Polish People's Republic, the GDR and Czechoslovakia.

**The objective of the article** is to present vehicles for disabled people driving on Polish roads in the years 1945-1990 and to analyse the results of road tests carried out at ITS. In addition, the answer to the question whether and how these tests contributed to improving the examined vehicles before the start of their series production and distribution. For this purpose, for the first time, an analysis of tests carried out at ITS on vehicles intended for disabled people was conducted. Appropriate conclusions were drawn based on the analysis. **The basis** for the analyses was a query conducted by the author in the archives of the Motor Transport Institute in Warsaw, a literature search in the ITS Library and information collected, including statistical information, from available sources, literature and reports. The main research method was archival research, observation, analysis and inference.

All this was set against a historical background. As it should be done for an analytical chapter, appropriate statistical information, photographs, drawings and tables were used. The material consists of nine sequentially and chronologically arranged points. Due to the breadth of the topic discussed, these scientific investigations should be viewed as an outline of the problem.

## Velorex

In the, so-called the Eastern Bloc countries, microcars were produced as vehicles for disabled people, because in a centrally controlled economy everything had to have a reason, as long as it was not a commercial reason. Since the early 1950s, the Velorex company (which was nationalized in socialist Czechoslovakia) produced vehicles for disabled people and valued sidecars for motorcycles. Many Velorex models were created, which differed from each other, for example with engines from Jawa motorcycles with different capacities: 175, 250 and 350 $cm^3$. Velorex cars were called umbrellas on wheels – as the body incorporated a skeleton of tubes covered with tarpaulin. The interior was quite sparse and designed to use other Czech car components, e.g. the odometer came from a Skoda 440. Jokingly speaking, the Czech Velorex was a cross between a motorcycle, a car and an umbrella.

In 1959, two new Czech microcars became the centre of attention at the Czechoslovak Brno Fair. These prototypes were to enter series production in 1960. One of them was the ESO T-250 tricycle, which was actually an encased version of a motorcycle with steering using a yoke transferring movement to the front wheels. It could accommodate two people sitting side by side on a fairly wide bench, and was powered by a 12 HP Jawa 250 motorcycle engine placed at the rear. The gearbox was four-speed, controlled by a handle that moved only in the lower plane. The rear gear was provided by an appropriate attachment that changed the direction of rotation of the rear driving wheel. The tricycle's tires had dimensions of 4.25 x 12. The operating data were as follows: maximum speed 75 km/h, average fuel consumption 3.7 dm3 per 100 km. The total weight did not exceed 230 kg, and the vehicle's insignificant weight was ensured by a body made of plastic materials.

Another attraction of the fair was the "motorovy vozik pro invalidy" Velorex 1960. It was the successor of the tarpaulin covered vehicles, also visible on Polish roads, known as Velorex Oskar. Initially, four prototype vehicles were tested before starting production in 1960 at the VELO plant in Hradec Kralove. The silhouette of the body of this two-seater microcar resembled amateur designs. The body was made of PWS (polyester filled with glass fibre), and e.g. the front and rear covers of the luggage compartment and engine were identical. The windshield and steering wheel were used from the Skoda Octavia, and the canvas roof was stretched over a tubular frame. At the rear of the vehicle there was a two-stroke 16 HP Jawa 350 engine, cooled by two blowers, which directed the air streams at the sticking point of the two cylinders, i.e. where the worst engine cooling conditions existed. The engine was started with a starter-generator motor and had a rear gear attachment.

The vehicle's wheels were suspended on oblique wishbones with rubber spring elements. The tire dimensions of 4.25 x 12 and the overall body dimensions of 3.00 x 1.35 x 1.30 resembled the Polish Mikrus. However, the Czech vehicle was used to transport only the disabled person and an accompanying person. The vehicle's curb weight was 365 kg, which, with a 16 HP engine, resulted in favourable kg/HP ratio even when using a maximum payload of 200 kg.

In 1971, the Velorex factory, also known to Poland, from Solnica near Rychnov on the Knieżna River (eastern areas of the present Czech Republic) began the production of a new type of motor vehicle intended for disabled people. The vehicle was marked as Velorex 4350 and was equipped with a serial Jawa 350 motorcycle engine. Fuel consumption was 6,5 $dm^3$ per 100 km and the permissible load was 200 kg. The steering system could be additionally adapted to the user's individual needs. The vehicle also had a reverse gear and a trunk large enough to accommodate a foldable wheelchair.

Disabled people in Czechoslovakia could purchase this type of vehicle at a relatively low price of 19,000 Crowns In addition, regional and district national councils provided the working members of the Federation of Czechoslovak Invalids with subsidies for the purchase of up to 15,000 Crowns and for retirees up to 7 thousand Crowns depending on the degree of disability. The organization of disabled people also made it possible to take out an interest-free loan of up to 5,000 Crowns for this purpose. The Velorex users had other benefits: for example, they only covered 50% of accident insurance fees. The tax on a motor vehicle was also lower, and the Velorex user was to be exempt from it.

Velorex, of course, could not compare with a production car adapted to be driven by a disabled person with a significant degree of health impairment. However, it was a prosthetic vehicle that allowed people to move from place to place for whom it would be impossible under other conditions. For many people, having Velorex meant an attempt to get back to work and everyday life.

At the turn of the 1960s and 1970s, there were problems in Poland with qualifying Velorex vehicles (three-wheelers) to the category of passenger cars, with all the resulting consequences, such as the amount of registration fees for motor vehicles, PZU fees, etc.

At that time, Velorex Oskar 16 three-wheeled vehicles with an engine capacity of 250 $cm^3$ (mostly based on components of the Jawa 250 motorcycle) were also available in Poland. As reported by readers of the weekly "Motor", for several years the vehicle was treated by the Transport Departments as a three-wheeled motorcycle vehicle, which was logical, because its weight was 270 kg and the maximum load of two people did not differ from the motorcycles found at that time, even with a side car. At some point, the Department of Transportation began to treat these vehicles as passenger cars based on the explanation that it had a steering system similar to that of a car.

The registration and insurance fees charged varied: For example, PZU determined the amount of insurance fees for Velorex vehicles as for three-wheeled motorcycles:

- the amount of the accident insurance and third party liability insurance fee (Order of the Minister of Finance of February 11, 1965, Monitor Polski No. 9, item 30) was PLN 320 per year if the vehicle owner did not have a disability discount;
- the amount of the voluntary comprehensive insurance fee (according to the tariff approved by the decision of the Minister of Finance of December 14, 1960) was, in one variant, PLN 220 per year without a disability discount, which constituted 30% of the fee.

Transport departments collected registration fees for motor vehicles, treating Velorex type vehicles as passenger cars based on the explanation of the Ministry of Transport, which was each time a response to the Department's inquiry. Therefore, the amount of the registration fee for a Velorex stroller was PLN 300 annual fee, i.e. the same as for cars, e.g. Opel Rekord 1700.

## Krause Piccolo tricycle for the disabled

The Krause Piccolo was a three-wheeled single-seater vehicle for disabled people from East Germany and the predecessor of the well-known (Krause) Duo. The Krause Piccolo Triumpf was manufactured by the East German Leipzig company Louis Krause. It was founded in 1880 and began building wheelchair vehicles in the late 1940s. Various models were produced, but the most reliable data concerns the Piccolo Triumpf.

Triumpf Piccolo was manufactured from 1955 to 1958 in approximately 3,000 units. The vehicle's engine was located on the right side under the seat and powered the right rear wheel. The front wishbone is also taken from the Simson SR1; the hood over the front wheel came from the IWL Pitty scooter. Both rear wheels were braked equally by pulling the steering column. The Piccolo Triumpf frame was made of folded sheet metal. In addition to motor drive, it was also possible to move by muscle power; to do this, one had to turn the lever and then move the steering column up and down.

The Piccolo Triumpf/5 looked very similar to its predecessor from the outside, but some technical details were changed: the engine was now more powerful and taken from the Simson SR2, it was located on the left side of the vehicle and accordingly powered the left rear wheel, braking was now (physically much more logical) by pressing the brake column. The maximum speed was about 30 km/h. This model was produced from 1958 to 1965 in approximately 4,500 units.

Between September 25 and October 10, 1961, the Krause Piccolo wheelchair tricycle was tested at the ITS Vehicle Testing Department. The research work was carried out for the Technical and Commercial Headquarters (CTH) *Motozbyt* in Warsaw based on the order No. TUD_24-4-6 of September 22, 1961. The final report was prepared in 6 copies, of which, apart from ITS, one copy was sent to the Ministry of Health, one to the Warsaw *Wytwórnia Protez* (Prosthesis manufacturer) and one to CTH Motozbyt [1].

The objective of the research was to determine the technical and operational properties of the Krause tricycle type Piccolo Triumph with engine number KR037553, chassis number 11522, manufactured in the GDR in 1961. The research included the development of the technical characteristics of the vehicle, performance of static and driving measurements, and evaluation of the vehicle's suitability [1].

Fig. 1. View of the engine located on the left hand side [1]

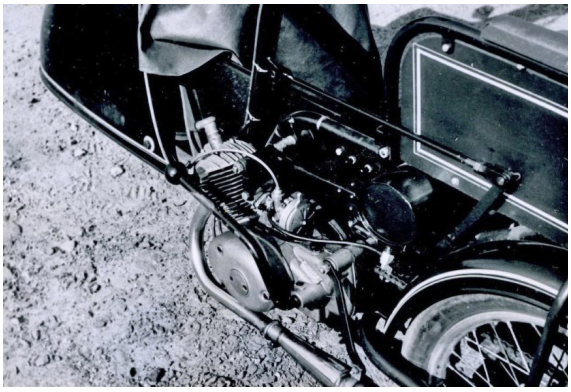


Fig. 2. View from the right hand side [1]

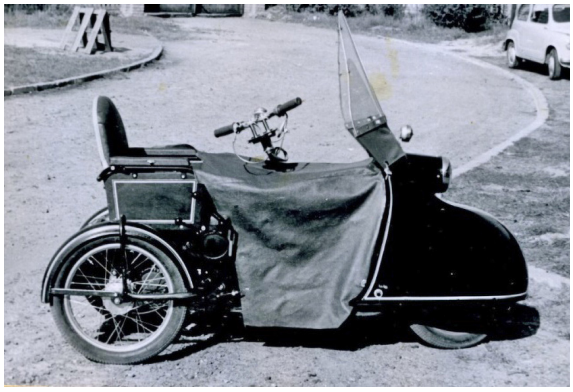


Fig. 3. View of the control mechanisms [1]

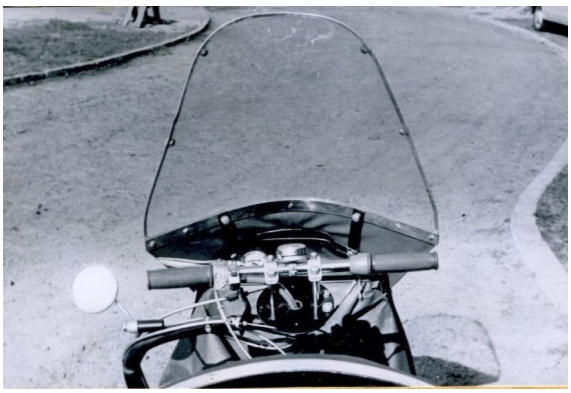


Fig. 4. General view of the engine [1]

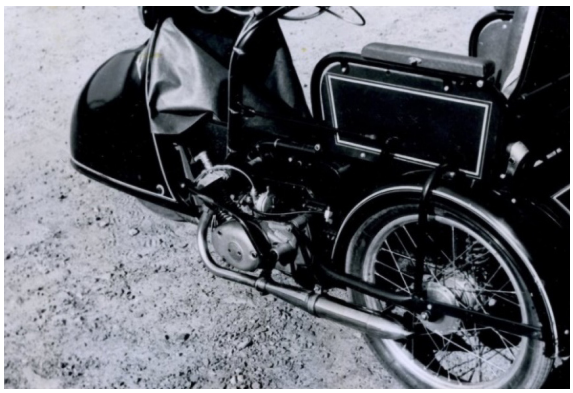


Fig. 5. Rear view of the wheelchair tricycle [1]

Fig. 6. Handbrake and manual drive engagement levers and driver's seat [1]

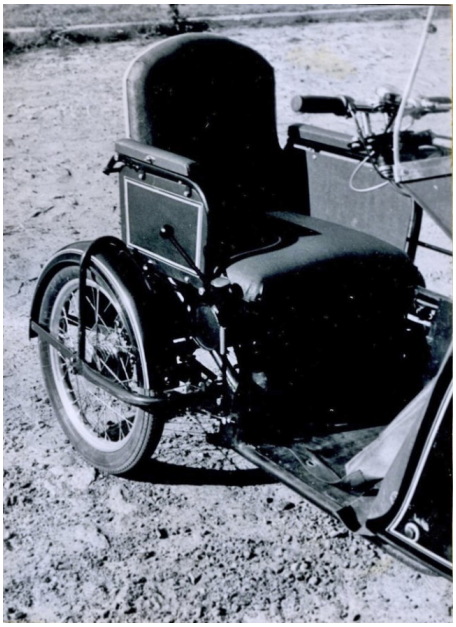


Fig. 7. Rear wheel suspension coil spring [1]

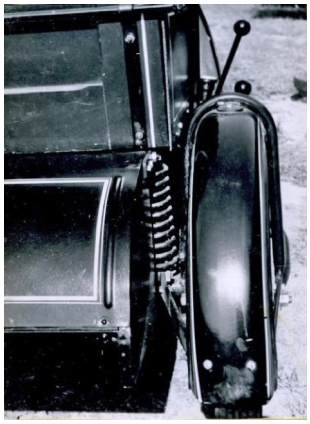
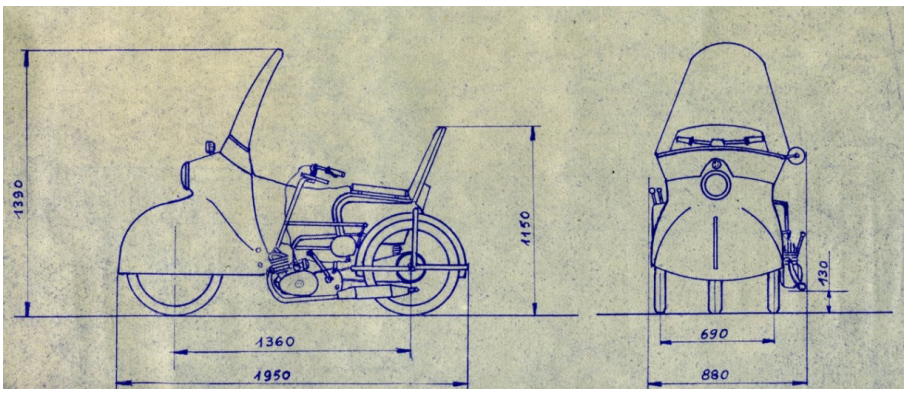
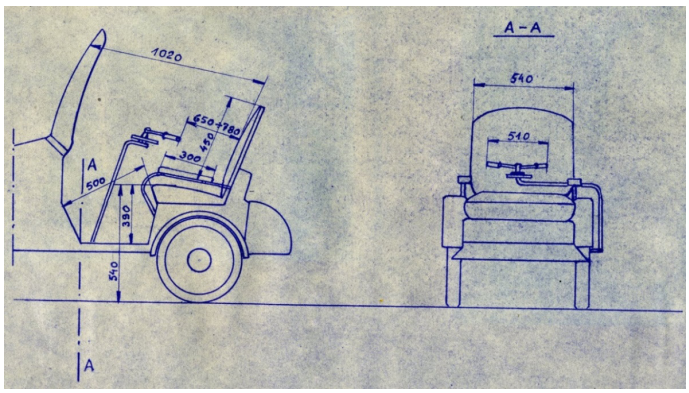


Fig. 8. Manual drive engagement wheel activated by lever on the right hand side [1]

Drawing. 1. External dimensions of the Krause-Piccolo tricycle (unladen vehicle) [1]




Drawing. 2. Dimensions determining the driver's position in the Krause-Piccolo tricycle [1]



The manufacturer of the vehicle's engine was VEB – Rheinmetall – Sommerda, and the chassis was made by Krause. It was a Krause wheelchair tricycle, type Piccolo-Triumph/5.

There were two types of drive: 1) a chain on the rear left wheel with 116 links, 2) manual, activated by a lever located on the right side of the vehicle. Moving the vehicle using a manual drive only was possible both forwards and backwards with the engine drive turned off and was done by moving the steering wheel forwards and backwards, as in a handcar.

The clutch was a three-disc, cork, wet clutch, activated by a hand lever on the left-hand steering wheel. Gearbox – two-speed built in with the engine, gearbox capacity 0.5 $dm^3$ of engine oil, rotating gear change knob incorporated with the clutch lever located on the left side of the steering bar, gear ratios of the first gear 3.5; 2nd gear 2, engine shaft – clutch ratio – 3.30, gearbox rear wheel – 2, total gear ratio in 1st gear was 23.1; 2nd gear – 13.2.

The vehicle had an open, welded steel pipe frame. Front wheel suspension on a short push arm with rubber spring elements, rear wheel suspension on a swing arm common to both wheels, on two coil springs without oil shock absorbers.

The armchair for the disabled was mounted on a frame without the possibility of adjustment (moving) and was permanently screwed on. Seat backrest was adjustable with reclining on a frame made of sheet metal and partly made of steel pipes, seat and seat backrest padded with foam rubber and covered with fabric in a colour matching the colour of the vehicle.

The motorcycle-type handlebar is rotationally placed on the manual drive lever. Transferring control to the front wheel fork – using two Bowden cables, front wheel without a brake drum, bicycle type, rear wheel with full-hub brake drums; tires 2.50 R16 front and rear wheels. Brakes – mechanical type, jaw system – manually operated, double, manual parking activated by a lever on the right side of the vehicle, acting on the right rear wheel, main acting on both rear wheels, activated by moving the steering lever forward.

The trunk is located behind the seat at the rear of the vehicle and is closed with a ratchet lock with access from the outside. The vehicle was equipped with a plexiglass windscreen with dimensions of 450-630 mm and a lower protective apron made of dermatoid, a speedometer with a km counter placed on the board under the windshield, driven by the front wheel of the vehicle. A set of tools placed in the rear trunk, an apron made of impregnated fabric covering the driver's legs and attached to the sides of the seat. The average operational fuel consumption over a distance of 300 km during the ITS tests was 2.85 $dm^3$ per 100 km [1].

The Piccolo tricycle was a means of transportation for disabled people without legs or with paresis. It could be successfully used on short routes up to 20 km, especially in the cities and housing estates when commuting to work, school, etc. It was a convenient means of transport for disabled people to move around the city or on small suburban routes. It could be used primarily on roads with good surfaces. Its use off-road or on mountainous roads was very limited. It could only be used in lowland areas where the elevation did not exceed 6%. It was easy to use and comfortable to ride. Low fuel consumption made it a cheap vehicle to operate. After removing the shortcomings and design errors, it should fulfil its purpose as a means of transportation for disabled people.

In order to increase the torque on the driving wheel of the vehicle and limit the maximum speed from 45 to 30 km/h, the gear ratio from the engine to the driving wheel had to be increased. This was to improve the ability to overcome larger hills. For reasons of driving safety, the brake design had to be improved to provide more even braking of both rear wheels, and the need to limit the speed on bends to 10 km/h should be specified in the owner's manual. Grease nipples had to be placed on the steering cable housings to allow easy lubrication of the cables [1].

It was also necessary to remove the causes of failures that occurred during vehicle operation, such as: jamming of the carburettor float, breaking off the end of the throttle cable, and the fuel tank filler should be enlarged so that fuel could be refuelled directly from the mixer. The windshield had to be adjusted so that the turbulence created behind the glass while driving did not occur at the level of the driver's face. The vehicle was quiet, but the trunk lid and rear fenders had to be protected against buzzing. It was also recommended to install a lock or padlock holders in the steering mechanism, which allowed the vehicle to be secured while parked.

As a result of ITS research, many of the indicated problems were removed, and these vehicles appeared on Polish roads, although it is not known in what numbers.

## Krause Piccolo Duo wheelchair tricycle

The Krause Piccolo Duo was already intended for two people. Between August 30 and September 30, 1962, the Krause Piccolo Duo type wheelchair tricycle was tested at the ITS Vehicle Testing Department. The research work was carried out for the Technical and Commercial Headquarters (CTH) Motozbyt in Warsaw based on the order No. TTd 214-4-12/62 of August 23, 1962. The final report was prepared in 10 copies, of which, apart from ITS, one copy went to the Ministry of Communication, one to the Ministry of Health, one to the Warsaw Prosthetic Factory, and one to CTH Motozbyt, one to COBiRTK.

The aim of the tests was to determine the technical and operational properties of the Krause Piccolo Duo tricycle in comparison to the Krause Piccolo tricycle, which was tested at ITS a year earlier. It was a two-seater Krause Piccolo Duo wheelchair tricycle, manufactured in the GDR in 1962, with engine number KR-060804, chassis number 187. The tests included the preparing the technical characteristics of the vehicle, performing static and driving measurements, evaluate the vehicle's suitability and analysing the tests results [2].

**Fig. 9. General view of the vehicle [2]**

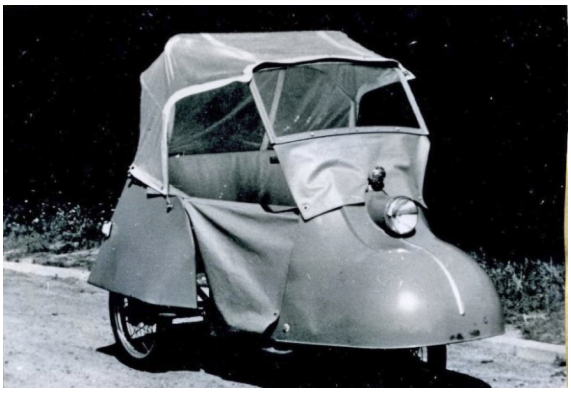


**Fig 10. View of the engine located on the left hand side [2]**

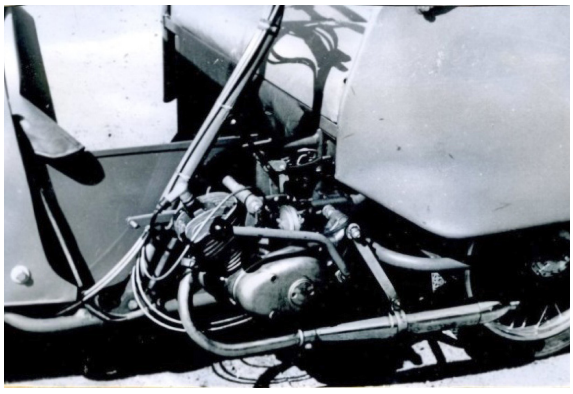


Fig. 11. View of the right hand side of the vehicle [2]

Fig. 12. View from the driver's seat of the steering mechanisms [2]

Fig. 13. Front view [2]

Fig. 14. Rear view of the tricycle [2]

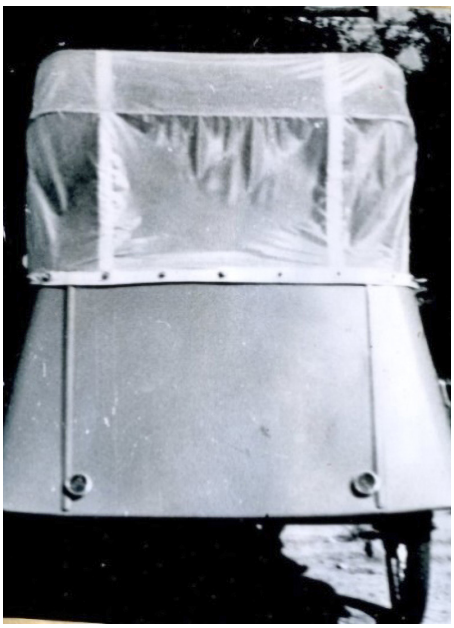


Fig. 15. General view of the vehicle with the roof folded [2]

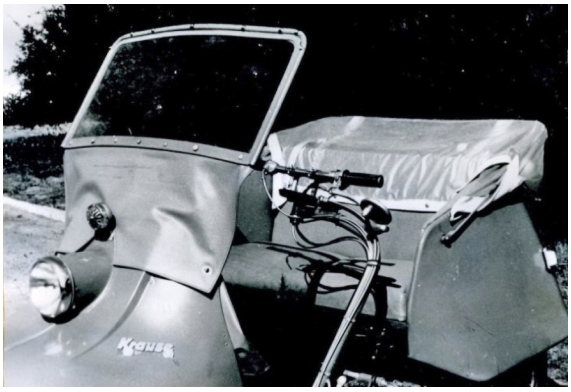
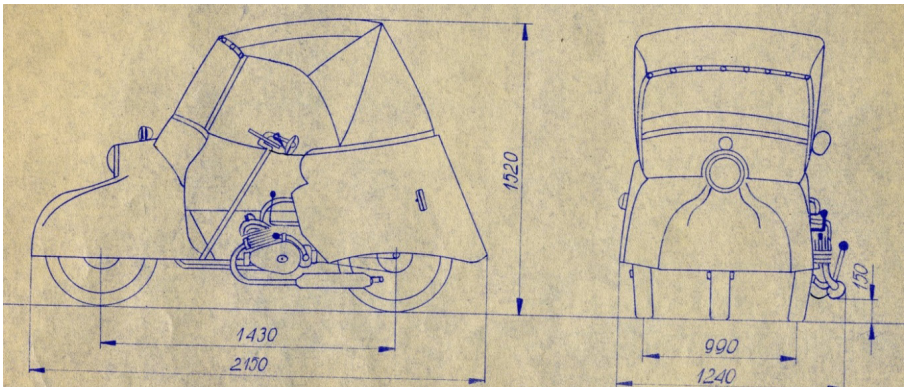
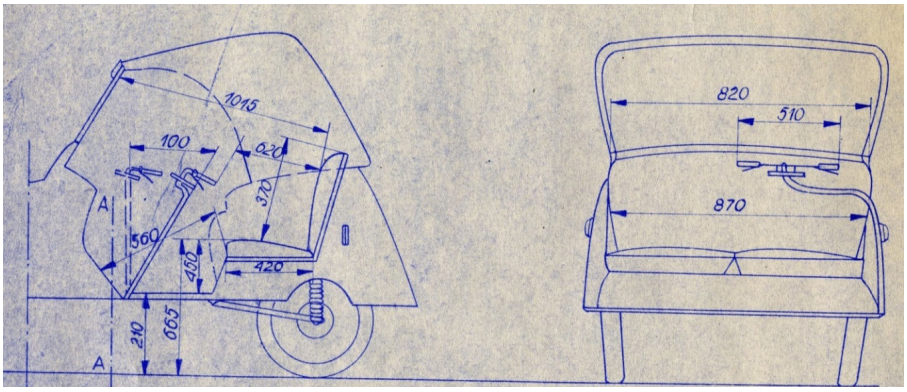


Fig. 16. View of the vehicle from the left hand side [2]

**Drawing. 3. External dimensions of the Krause Piccolo Duo tricycle – unladen vehicle [2]**




**Drawing 4. Dimensions determining the driver's position in the Krause Piccolo Duo tricycle [2]**




The tested vehicle had a double seat for the driver and passenger, mounted on a non-adjustable frame, permanently bolted to the chassis. The seat is made of a sheet metal frame and partly of plywood. The seats and seat backrest are lined with foam rubber and covered with fabric in a colour matching the colour of the vehicle.

A motorcycle-type handlebar mounted rotationally on a lever that is also used to brake the vehicle. Transfer of control to the front wheel fork using two Bowden cables. The vehicle had a load capacity of two people – about 150 kg. Fuel tank with a capacity of 8 $dm^3$ located under the driver's and passenger's seats. Access to the filler cap is possible by lifting the driver's seat cushion. A tap closing the fuel flow to the carburettor is located under the tank on the left side.

The average operational fuel consumption over a distance of 200 km during the ITS tests was 3.3 $dm^3$ per 100 km. The low engine power in relation to the vehicle's weight and low torque when driving in direct gear made it necessary to use first gear frequently, even on slopes of 6% when driving with a full load of two people. In practice, a slope of 6-8% can only be conquered after accelerating the vehicle to a speed of 35-40 km/h. Compared to the single-person Piccolo stroller, the Piccolo Duo stroller had worse dynamics.

The tricycle could be used with full load only on short routes of up to 20-30 km in the cities and housing estates, due to its low speed (20-25 km/h), weak acceleration and relatively high fuel consumption. Moreover, when it was loaded with two people with a total weight of 150 kg and the vehicle was driven for a longer period of time, the engine would overheat, even at quite low ambient temperatures, and after some time there would be a loss of power and a tendency to seize. It was advisable to use a blower to cool the engine. While driving with a load of one person weighing 72 kg, there were no symptoms of engine overheating or a tendency to seize [2].

The vehicle's control mechanisms were operated exclusively manually, their arrangement is convenient and their operation is easy and does not pose any difficulties. Changing gears, braking and turning the steering wheel required little effort. In case of difficulties in starting the engine (the engine was very sensitive to flooding) using the hand lever, the disabled was forced to use the help of third parties. Getting in and out of the vehicle was easy and convenient. The windshield, apron and foldable canopy completely protected the driver from rain and dust. Operating the vehicle in a winter was difficult due to poor protection of passengers against weather conditions. The position of the driver and passenger of average height was comfortable due to the width and softness of the seats. Comfort while driving, especially when driving on paved surfaces, was negatively affected by both the lack of adjustment of the seat backrest inclination and the lack of oil damping in the wheel suspension. Driving at a speed of 30 km/h with a load of 1-2 people was safe enough.

A more serious drawback was the low quality of the mattings fabric from which the foldable canopy of the tricycle was made. After a dozen or so folds of the canopy, the fabric was torn at the edges and the fastening

clamps on the side and rear of the body. Putting on and folding the visor was easy and took about 1 minute [2].

Based on the test results, it was concluded that the Piccolo Duo wheelchair tricycle was a sufficiently comfortable means of transportation for the disabled person to move around cities and possibly on short routes on suburban roads with hard and smooth surfaces. Operation with a load of two people, especially in mountainous areas, was limited. Ease of driving and sufficient driving comfort were the main advantages of this vehicle. It was easy to use and economical to operate. Another disadvantage was poor dynamic performance. In order to improve driving comfort and reliability, it was necessary to use a lock to protect the vehicle against theft and a canopy made of more durable fabric, as well as a closed compartment for tools and accessories, turn signals, a windshield made of a more transparent material, e.g. plexiglass, and a small rear window in the foldable canopy to improve rear visibility and side windows made of celluloid. It would also be necessary to install an engine cover on the top and side of the engine (protection against water and mud), equip the vehicle with a spare wheel mounted on the rear wall of the vehicle, and adjust the diameter of the fuel tank filler to the fuel distributor pipe nozzle.

## Vehicle W65.S65.N65 – WSK Gacek

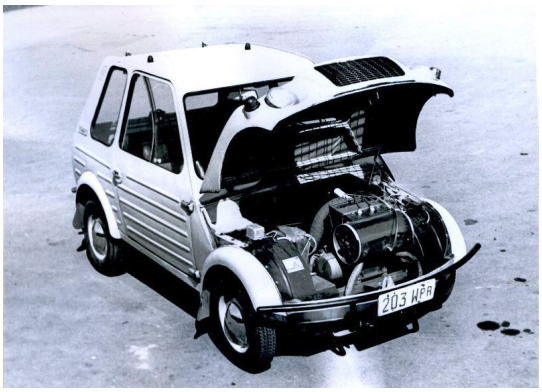
The W65.S65.N65 vehicle was a Polish prototype of a car intended for disabled people and this was its basic purpose. It received its name "Gacek" only after a few years, when its only two prototypes had already been on the road. Nowadays, automotive enthusiasts consider it one of the microcars [10]. However, the idea to start the production of this vehicle as a popular microcar was born only after road and operational tests were carried out, among the others, at the Motor Transport Institute (i.e. as a result), when it turned out that this vehicle had very good results of operational tests [13].

The task of designing the vehicle and making prototypes was entrusted to the Transport Equipment Factory (WSK) in Świdnik, known mainly from motorcycle and helicopter production. This was not accidental – the Czechoslovak Velorex and the GDR Piccolo Duo were also powered by motorcycle engines. The W65.S65.N65 microcar was intended to be a light, four-wheeled car that could accommodate two adults (including one disabled person) and two small children. In 1966, work began on the first mock-up of the vehicle. The vehicle used a two-stroke, two-cylinder Jawa 572/01 engine, which was used, among the others, in a Czechoslovak vehicle for disabled people – Velorex. However, in the Polish car, the engine was placed above the front wheel axle, and not at the rear of the vehicle.

Let us emphasize, therefore, that the future Gacek was originally intended to be a wheelchair vehicle and only after positive results of operational tests the possibly of it becoming a microcar for general use was considered. Especially since another Polish microcar, the Mikrus MR-300, had been out of production since 1960. The W65.S65.N65 microcar was distinguished by its modern solutions, including front drive, which was not used in small cars at that time. The steering and braking system came from a Trabant car. The body was made of bent sheet metal, and the front hood was made of plastic [10].

Between May 1, 1970 and September 30, 1970, the ITS Vehicle Technical Operation Department tested the W65.S65.N65 wheelchair car manufactured by WSK-Świdnik [11]. The test work was carried out on behalf of the Experimental Department at the Transport Equipment Factory (WSK) in Świdnik. The aim of the research was to determine the most important operational properties of a motor vehicle intended for disabled people, manufactured by the Experimental Plant at WSK-Świdnik. The object of the tests was a four-wheeled vehicle for disabled people, type W65.S65.N65, manufactured by the WSK-Świdnik Experimental Station with engine number 572-006246, chassis number 02, whose odometer reading at the time of the commencement of the research indicated 8,410 kilometres travelled. The subject of the research was to determine the technical characteristics and the most important operational properties of the vehicle tested at ITS in order to compare them with the regulations and standards in force at that time, as well as to evaluate its operational suitability. The vehicle tested at ITS is presented in its full glory on the photos below, published in this article. The word Gacek was never mentioned in the research report, so most likely this name was given to this microcar later [13].

**Fig 17. WSK wheelchair vehicle – general view of the engine with its bonnet open [11].**



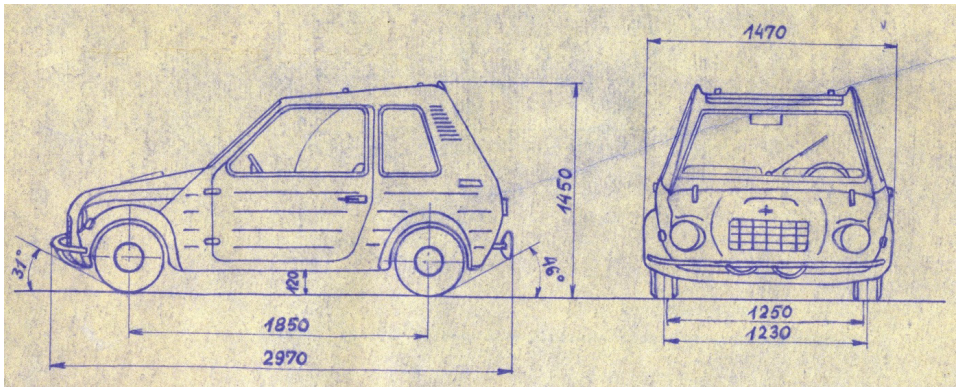
According to the specifications examined and prepared at the Motor Transport Institute in Warsaw, the WSK wheelchair vehicle was manufactured in 1969 and could transport two people and 90 kg of cargo. It had a Jawa engine from Czechoslovakia, type Jawa-350-572/01, two-stroke with reverse flushing, with two cylinders in a transverse arrangement. The cylinder diameter was 58 mm, piston stroke 65 mm, displacement 344 $cm^3$, compression ratio 7. Other characteristic features of the engine were as follows: maximum power 16 HP at 3800 rpm, maximum torque 3 kGm/3680 rpm, battery ignition, ignition setting 3-3.5 before TDC, Iskra M14 or Bosch 225 spark plug, two 12 V ignition coils, cam points, key-operated ignition, downdraft feed, IKOV-2926 SD-14b carburettor, throat diameter 26 mm, engine lubrication by adding oil to fuel in a ratio of 1:25, engine air cooling using two axial blowers mounted on a common shaft driven by a V-belt, engine weight 53 kg. The engine tested at ITS run on ethylene with an octane number of 78 and Lux Dw engine oil [11].

The capacity of the fuel tank was 23.5 $dm^3$ (including 4 $dm^3$ as a reserve), the gearbox capacity was 0.8 $dm^3$, the differential gear was 0.3 $dm^3$. According to ITS research, the average operational fuel consumption was 7.5 l/100 km, and the maximum speed with a load of two people and 80 kg of luggage was 70 km/h. The ability to overcome hills in first gear with the vehicle loaded with two people was 24.8% [11].

**Table 1. External dimensions of the WSK microcar, comparison of ITS test results with the manufacturer's data. Own study based on [11].**

| Specification | According to measurement at ITS | According to WSK manual |
|---|---|---|
| greatest length (mm) | 2970 | 2850 |
| greatest width (mm) | 1470 | 1400 |
| greatest height (mm) | 1450 | 1400 |
| wheelbase (mm) | 1850 | 1850 |
| front wheel track (mm) | 1230 | 1215 |
| rear wheel track (mm) | 1250 | 1245 |
| approach angle ° | 31 | 32 |
| departure angle ° | 46 | 48 |
| transverse clearance (mm) | 120 | 120 |
| transverse clearance (mm) | - | 185 |

**Drawing 5 External dimensions of the WSK S-65 microcar [11]" na "Drawing 5. External dimensions of the WSK S-65 microcar [11].**




The W.65.S65.N.65 microcar prototype delivered for testing at the Institute was manufactured by the WSK Experimental Plant in Świdnik. The vehicle was intended for disabled people, but the experience gathered by ITS experts during operational tests and the analysis of its utility values indicated that it could be more useful for ordinary road users, especially in urban traffic, where high manoeuvrability and mobility were required and the ability to park in small spaces. The W.65.S65.N.65 microcar, later called "Gacek", met these conditions, providing two transported people with driving comfort corresponding to mid-class passenger cars [14].

The two-door coupe body of the car had an aesthetic shape with a large straight front windscreen, large side windows and a rear window, which provided the user with excellent visibility both forward, sideways and rearwards from the vehicle. The position of the driver and passenger, even high ones, was very comfortable due to the shape and softness of the seats and the height of the car body – the driver and passenger were not tired even during long drives over several hundred kilometres [11].

During tests and practical drives, the engine worked flawlessly and could be started without difficulty, even at sub-zero temperatures. The clutch and gearbox connected to the engine worked without any problems during the tests and test operation and did not require any work apart from normal operation. The transmission of power to the rear wheels via the attachment box located between the gearbox and the differential worked properly. During the test operation, only the attachment housing leaked oil, which resulted in bearing damage [11].

The suspension in the W.65.S65.N.65 microcar had been selected properly, ensuring high driving comfort, despite the short wheelbase, even on roads with poor surfaces, both with a load of one and three people.

The steel, two-door coupe body made of bent sheet metal and steel sheet profiles had an aesthetic and modern shape, creating a harmonized shape and was highly appreciated both by ITS experts and a wide range of interested people viewing the vehicle. Getting in and out of the car was easy and comfortable thanks to the wide doors and the swivelling driver's seat. The front seats had longitudinal adjustment and backrest angle adjustment. The shape of the seats, their dimensions and covering met all requirements in this respect. Due to the shape of the seats and the softness of their cushions: the seat and backrest, the position of the driver and passenger was comfortable even during long drives covering many hundreds of kilometres.

The rear bench allowed to transport two children or 80-90 kg of luggage. Access to the luggage space was also possible through the opening rear window. Very good visibility was ensured by the large glass surface.

The speedometer and odometer readings showed quite significant differences from the real values. The magnitude of error in the speedometer readings varied and depended on the driving speed. The odometer readings showed an error of up to 42%!

The graph of fuel consumption versus driving speed obtained from the measurements was correct. Fuel consumption was moderate at lower speeds and increased with increasing speed. This was a normal phenomenon, especially since a two-stroke motorcycle engine was used to power the W.65.S65.N.65 minicar. Actual consumption at operational speeds in urban traffic was approximately 5 l/100 km for a speed of 40 km/h and approximately 6 l/100 km for a speed of 50 km/h. This consumption was measured when the vehicle was loaded with two people. The free travel distance of the vehicle measured from a speed of 60 km/h was 790 m, which was a large value, indicating low rolling resistance [11].

Taking into account the fact that the power source was a 16 HP engine, the vehicle had sufficient dynamic properties, even in city traffic with a load of two people: when starting from a place and changing gears, the vehicle reached a speed of 30 km/h in 7 seconds, 40 km/h in 13 seconds, 50 km/h in 20 seconds, and 60 km/h in 30 seconds. The maximum speed when loaded with two people was 72 km/h, which was a sufficient and correct value for this type of vehicle [11].

The external noise level was 80 dBA and did not exceed the permissible values. The internal noise level basically met the requirements of the standards, only when driving in third gear at a speed of 50 km/h it slightly exceeded the permissible value of 80 dBA for these conditions [11].

After analysing the test material collected during motion and operational tests, experts from the Motor Transport Institute authoritatively concluded that the W65.S65.N65 microcar with its design parameters and feature properties fully met the requirements set in this respect by the Highway Code and the standards in force in Poland. The vehicle was unquestionably suitable for use as a car for disabled, and it was also ready to be used as a small car, especially in city traffic, due to its high manoeuvrability and mobility as well as small dimensions, so important considering the lack of parking spaces at that time. However, the reality turned out to be different and the vehicle remained only in the prototype phase. Despite successful trial results and positive opinions from experts, including: from ITS, engineers and medics, the decision to start the production of the Gacek car for disabled has not been made.

The W65.S65.N65 wheelchair, later named "Gacek" after the name of a popular bat, successfully passed a series of tests at the manufacturer's and homologation tests: static, motion and operational at ITS in Warsaw. The Polish Association of Disabled People also gave a positive opinion about this car. Plans for the development of the car's structure were prepared at the WSK plant: based on Gacek, the following were planned (mainly in the form of drawings and sketches): delivery van – economy version, version with electric drive, version with a foldable tarpaulin roof, laminate body version without a roof and with the roof in place [14].

In 1970, after final refinement and road tests, the second version of the W65.S65.N65 Gacek mini car received an award from the then Minister of Culture and Art for outstanding achievements in the field of industrial design. In 1971, the vehicle's designers also received the NOT award for achievements in the field of technology. Prof. Cezary Nawrot made design drawings of several types of bodies, which were to be produced on a common platform. Versions with an extended wheelbase, designed for four people, and a body version with an electric motor were planned. Despite good test results at ITS, it was not decided to mass produce this vehicle. It is possible that it was assessed that such production was simply unprofitable. It is also possible that the production of a special type of vehicle for disabled people was abandoned.

## Polski Fiat 126P 650 I

FSM in Bielsko-Biała produced special series of popular Polski Fiat 126p for disabled people. Between July 30 and November 30, 1977, the ITS Vehicle Technical Operation Department conducted type-approval tests of the Polski Fiat 126 p passenger car, model 650I (for disabled) for people with lower limb dysfunction. The research work was carried out at the request of the FSM Research and Development Centre in Bielsko-Biała on the basis of order No. 862/OBR/EZ/77 FW of July 5, 1977. The final research report was reproduced in 20 copies, of which, apart from ITS, 2 copies were sent to Ministry of Transport, 5 copies to OBR FSM in Bielsko Biała, and 6 copies to the Homologation Commission.

The aim of the homologation tests was to check the technical data and properties of the Polski Fiat 126P 650I passenger car for disabled in comparison to the documentation provided by OBR FSM and to evaluate the car in terms of compliance with the regulations in force in the Polish People's Republic.

The object of the research was a passenger car – for disabled Polski Fiat 126 p 650I with engine number 7454696, chassis number 7129925, delivered for testing with an odometer reading of 5,866 km. The car was adapted to be used by people with lower limb dysfunction. The tested vehicle, along with solutions beneficial for disabled people, is presented in the photos below[6].

**Fig. 18. Driver's seat. Visible cover over the clutch, brake and accelerator pedals [6].**

**Fig. 19. Driver's seat [6].**

**Fig. 20. Manual control. Forward movement of the lever – braking [6]**

**Fig. 21. Manual control – movement of the lever down – disengaging clutch [6]**

**Fig. 22. Clutch disengaged. The lever automatically stays in the lower position [6]**

**Fig. 23. Driver's seat. Pedal cover removed [6]**

**Fig. 24. Driver's seat. Free access to the clutch, brake and accelerator pedals [6].**

Measurements of the dimensions of the movements location and loads of the control device (manual lever) were as follows: total working length of the manual (control) lever 0.4 m, length of the accelerator knob handle 0.118 m, diameter of the accelerator handle 0.042 m; location: distance of the hand lever from the floor – 0.61 m, distance of the hand lever from the dashboard (minimum) 0.11 m, distance of the throttle handle from the steering wheel – 0.11 m; movements of the hand control lever: travel for activating the brake with the hand lever, 0.09 m, travel for disengaging the clutch with the hand lever, 0.17 m, angle of rotation of the gas knob, 175°; load on the control device – force to disengage the clutch, hand lever 8.5 kg, rotation torque of the throttle knob 0.25 kGm.

The tested car, Polish Fiat 126 p model 650I, was intended for disabled people with dysfunction of the lower limbs, but who had full mobility of the upper limbs. This car was equipped with normally operating typical control devices in the form of clutch, brake and accelerator pedals,

and additionally with a control device in the form of a lever with which the functions of the pedals could be performed by manual control [6].

The manual control lever was located on the right side of the steering wheel and was operated with the right hand. Moving the lever down disengaged the clutch, and moving it towards the instrument panel (forward) had a braking effect. At the end of the lever there was an accelerator knob. All lever control movements were transmitted by external mechanisms to the appropriate pedals, which operated synchronously during manual control. This relationship was not maintained in the case of foot control. The manual control lever then remained stationary and had no influence on the operation of the pedals. There was a rotating ball knob mounted on the steering wheel on the left side, allowing the steering wheel to be turned with the left hand.

Moving off on a hill was enabled by a device that blocked the manual control lever with the wheels braked (main brake). Depending on individual needs, the pedals could be covered with a special cover. After removing the cover, the car was ready for use by able-bodied person.

The arrangement, movement ranges of the control lever as well as the forces and moments were selected quite accurately, which enabled the use of manual control without significant difficulties. The limitation of the forward movement of the lever with the clutch disengaged could, in special cases, be blocked by the left leg of the passenger sitting in the seat next to the driver. Such a threat could be reduced, for example, by moving the right front seat back [6].

The manual control system contributed little to reducing the car's dynamics. As one become more experienced in using the manual control system over time, the results should improve and come close to the performance with normal control. Testing the effectiveness of the brakes gave almost identical results for both types of control, but the forces necessary to control the main brake were approximately 50% lower when using the manual control lever. Based on the conducted homologation tests, it was found that the vehicle's properties met the requirements of Polish regulations, with the exception of exceeding the permissible internal noise level by 2 dBa.

## Polski Fiat 126P 650 I2

In 1979, ITS carried out homologation tests of the Polski Fiat 126 p 650 I2 passenger car intended for people with dysfunction of one upper limb. The work was carried out on behalf of OBR FSM in Bielsko-Biała based on order No. 86/OBR/EZ/35/79/FW of January 16, 1979.

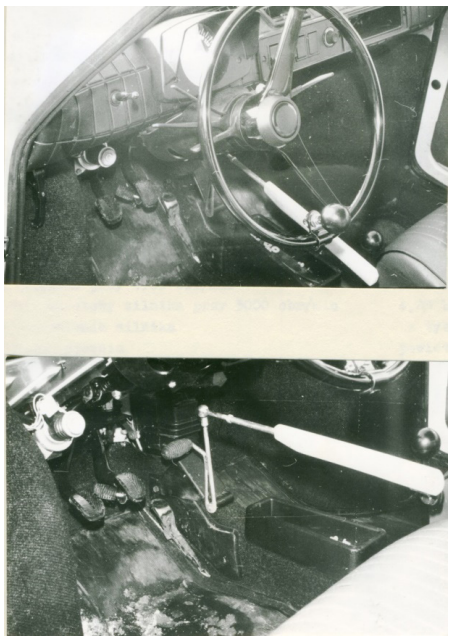
The aim of the homologation tests was to check the technical data and properties of the Polish Fiat 126P 650 I2 passenger car for disabled in comparison to the documentation provided by OBR FSM and to evaluate the car in terms of compliance with the regulations in force in the Polish People's Republic.

The object of tests was a Polski Fiat 126 p 650 I2 passenger car – engine number 7930676, chassis number 7421967. The car was adapted to be used by people with a right hand dysfunction [7].

In addition to the devices typical for a Fiat 126 p, the vehicle includes additional devices such as: foot-operated gear control mechanism, a brake pedal boom, a foot-operated windshield washer pump, an external lights switch and an instrument cluster lighting switch with an extended lever. The wiper lever arm, turn signal lever and headlight switch lever have been moved to the side appropriate for the type of disability. There is also an outside rear-view mirror, seats with adjustable backrests, a heated rear window and a knob on the steering wheel.

The car was intended for disabled people with dysfunction of one upper limb (left or right), but with full functionality of the other limbs. The car was equipped with a normally operating typical control devices, and additionally with devices adapting the car to be driven by a disabled person. These devices constituted separate units and could be easily mounted to any Polish Fiat 126P production car. The transition from one control system to the other did not require any switching over as both systems operated synchronously. The essential device was a mechanism enabling changing gears with the right foot. To enable the steering wheel to be turned with one hand, a ball knob was mounted on the steering wheel. The switches were operated with the fingers of a good hand resting on the steering wheel. The arrangement of the devices, levers' movement ranges and forces necessary for control were selected accurately, which allowed them to be used without significant difficulties [7].

**Fig. 25. Control devices in the Polski Fiat 126p 650 I2 car tested at ITS in 1979 [7].**



During the driving tests, it was found that the devices and switches adapting the car for disabled people, needed for driving, signalling and road lighting, were comparable to devices and switches of a production car in terms of ease and reliability of use, except for the inability to activate the auxiliary brake lever without taking one's hand off the steering wheel. This was necessary only when both circuits of the dual-circuit main brake system were damaged.

Based on the homologation tests carried out, it was found that the vehicle's properties met the regulatory requirements, except for the possibility of activating the auxiliary brake hand lever without taking your hand off the steering wheel.

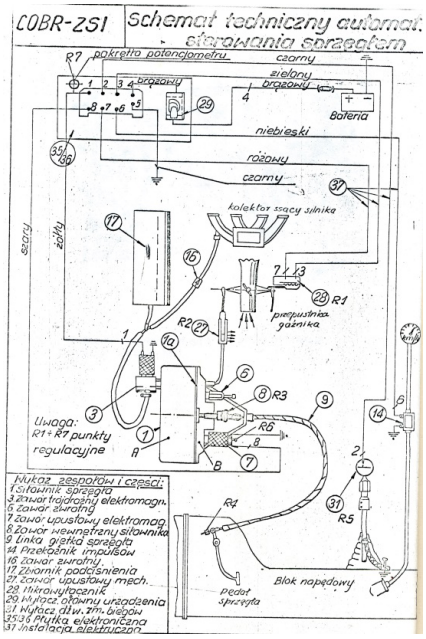
## Polski Fiat 126P I

Between August 15 and October 15, 1981, the ITS Vehicle Technical Operation Department carried out homologation tests of a Polish Fiat 126P-I car (for disabled) equipped with a semi-automatic clutch. The testing work was carried out at the request of the Research and Development Centre for Small-Capacity Cars (OBRSM) from Bielsko-Biała based on order No. 494/OBR/E2/264/81/FW of June 29, 1981. The aim of the tests was to compare a license built Polski Fiat 126P passenger car for disabled additionally equipped with a semi-automatic clutch with a mass-produced car, from the point of view of compliance with legal regulations.

The object of the research was a Polish Fiat 126P I passenger car equipped with a semi-automatic clutch, which was an additional device that activated the normal friction clutch without pressing the foot on the clutch pedal, which allowed the car to be driven by disabled people with dysfunction or the absence of one of the legs. The tested toddler had chassis number 07876163 type 126P and engine number 8475801 type 126.A.1.076-650. The vehicle delivered for testing had an odometer reading of 30,239 kilometres [9].

The automatic clutch device was designed, built and tested by the Central Research and Development Centre of the Central Association of Disabled Cooperatives in Warsaw. The clutch in normal Fiat 126p was activated by a pedal that transferred the foot pressure to the clutch release bearing using a Bowden cable. The clutch in the Fiat 126P-I car had an additional Bowden cable, which was actuated using a modified vacuum assist mechanism (used in the Polski Fiat 125P car). The modification consisted of adding four valves, using a cable and mounting brackets. The automatic clutch device included a number of elements. At idle engine speed, electric current controlled by an electronic board was supplied to both valves No. 3 and 7 (Fig 26). The activated valve 7 isolated chamber B (the supporting mechanism) from the atmosphere, and the activated valve 3 opened the connection of chamber A with the vacuum tank No. 17 (Fig 26). The piston of the supporting mechanism caused the cable to move and thus disconnected the clutch, and the first or reverse gear could be engaged [9]

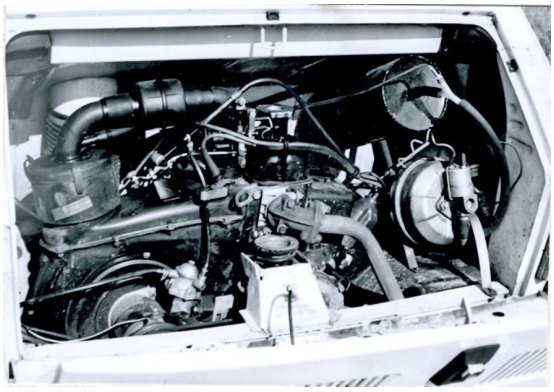
**Fig. 26. Technical diagram of automatic clutch control [9]**




Pressing the foot on the acceleration pedal disconnected the contacts of the microswitch 28 and cut off the power supply and closed the valve 3, thus connecting the chamber A with the atmosphere and simultaneously disconnecting it from the vacuum tank 17. The rapid movement of the piston took place until the valve 8 was closed, releasing the air from the chamber B. Further movement of the acceleration pedal caused the opening of the relief valve 27, which controlled further slow release of air from chamber B, ensuring proper soft coupling of the engine with the drive block. Possible removal of the foot from the pedal caused the electrical switch 28 to short-circuit and valve 3 to open, thus disengaging the clutch again.

After the car reached a speed of approximately 20 km/h, the electronic system, controlled by an impulse generator mounted on the speedometer cable, turned off the switch circuit and opened the wastegate and at the same time eliminated the slow movement of the clutch cable. Each time touching the gear lever knob, activated valve 3, there were rapid movements without throttling with valves 7 and 27 at speeds above 20 km/h. When braking below a speed of 20 km/h, the clutch was automatically disengaged. There was a switch on the dashboard that supplied the device with electricity. The up position of the lever turned on the device, the down position turned off the automatic clutch.

**Fig. 27. Automatic clutch device installed in the engine compartment [9]**



Since it seemed that the internal noise in the Fiat 126P-I car was lower due to the additional filling up the engine compartment, additional noise tests were carried out, comparing it with data obtained in serial vehicles with similar mileage. Operational tests, in turn, were aimed at determining the correct operation of the semi-automatic clutch and any possible features that make driving difficult in all road traffic conditions. The study was performed by drivers employed at ITS.

The fuel consumption test was carried out on a 1 km section of a flat, dry and even road at a wind speed of approximately 1.5 m/s in both driving directions. Fuel consumption at speeds of 60-90 km/h was from 6.35 to 7.28 $dm^3$ per 100 km with the semi-automatic clutch engaged and between 6.2 and 7.5 $dm^3$ per 100 km with the semi-automatic clutch disabled. In turn, in the urban cycle it was 9.58-9.61 $dm^3$/100 km with the semi-automatic clutch on and 9.36-9.54 with the semi-automatic clutch off. Both constant speed and urban consumption varied minimally and the results were within the error limits of the Flowtronic measuring instrument. The fuel consumption of the tested vehicle was increased compared to series vehicles, but this did not matter for comparative tests.

Braking efficiency tests concerned the influence of the automatic clutch. This device turned off automatically at a speed of 20 km/h and therefore affected the braking efficiency. The maximum braking delay was 0.76 g with an average of 0.66 g. There was no significant difference in braking parameters for measurements with the automatic clutch on and off. The magnitudes of braking delays with the semi-automatic clutch on and off were practically the same, slightly greater for the working semi-automatic clutch [9].

The internal noise in third gear at a speed of 80 km/h was 87 dBa and exceeded the permissible value by 3 dBa. The value was also exceeded in second gear at a driving speed above 70 km/h. Compared to other Fiat 126P, no significant differences in noise level were found.

Operational tests were carried out to check the convenience of using the semi-automatic clutch for a disabled person with a dysfunction of one leg, as well as for an able-bodied driver. With the semi-automatic clutch engaged, the car had a mileage of approximately 1,600 km mileage. Opinions were obtained from 7 drivers employed at ITS. After a short adaptation of the driver, starting the car was correct, making it easier even for an inexperienced driver, changing gears from lower to higher was smooth and correct, changing gears from higher to lower caused slight jerks of the vehicle, just like in conditions driving standard car. Engaging the first gear while driving could quickly damage the gear teeth. In a production car, this operation was difficult, with a semi-automatic clutch it was easier, but the possibility of damaging the gearbox increased. It was found that it was difficult to move slowly backwards from a parking space, especially when manoeuvring a parked vehicle out of a row of vehicles with small distances in between. This manoeuver could be performed smoothly by additionally using the auxiliary brake. Also in city traffic jams, when the vehicle speed was lower than 5 km/h, using the parking brake was easier than when driving backward [9].

During operational tests, two adjustments were made to the automatic clutch device at COBR of the Central Trade Union Cooperative of Disabled People. The first adjustment took place after 200 km, and the second one after 1,200 km. The cause of both defects and the need for repair was the uneven rotational speed of the long flexible cable of the speedometer. However, driving in such a vehicle was, in some situations, different from driving in a production vehicle. In parking manoeuvres, it was necessary to use the parking brake, e.g. when starting carefully in reverse, it was not allowed to switch gear 2 to 1 if the car was moving, before turning off the ignition lock the gear lever had to be set to neutral, otherwise the car would jump forward; each time one moved the gear lever, it was necessary to immediately remove hand from the lever knob. To smoothly switch gears from higher to lower, the engine speed could be increased, but the gear lever had to be set in the neutral position with the hand removed from the knob.

Based on the tests performed, it was found that fuel consumption was similar to that of production cars. The maximum braking deceleration met the standard requirements. The noise level was the same in stock cars and the cars for the disabled. Operational tests with the clutch working showed good functionality and sufficient reliability of the semi-automatic clutch. However, it was necessary to increase the durability of the relay of impulses received from the rotation of the speedometer drive cable. The technical and operational documentation also had to be supplemented with instructions for the semi-automatic clutch.

The tested vehicle could be intended for disabled people or people with a dysfunction or one of their legs missing, as well as for physically able drivers. The vehicle met the requirements of all Polish legal regulations.

## Duo 4/1 tricycle

Simson DUO was a simple, two-person three-wheeler, produced in the German Democratic Republic between 1972 and 1991, intended for people with motor disabilities. The DUO was created as a successor and development version of the Piccolo-DUO three-wheeler, produced in the 1960s in Leipzig. It was manufactured using Simson moped engines and parts and components of other vehicles produced in the GDR. Starting from 1972, it was manufactured at the FAB Brandis plant as DUO 4, and from 1973 DUO 4/1. In 1981, the production of the three-wheeler was moved to the VEB Robur-Werke plant in Zittau. In 1989, another DUO 4/2 model was developed here, equipped with a 4-speed M542E engine with an electric starter, derived from the Simson SR 50 moped. In 1990, production was again transferred to the FAB Brandis GmbH plant, and a year later the production of the three-wheeler completed. Exported in the 1980s to socialist countries, the DUO was a popular wheelchair vehicle in Central and Eastern Europe. It also was exported to Poland.

Between February and April 1988, the ITS Vehicle Testing and Homologation Department (ZBH) conducted type-approval tests of the DUO 4/1 wheelchair moped. The test work was performed for POL-MOT Spółka z o. o. based on order No. 34-24/D/bh/87 of December 9, 1988. Homologation tests were aimed at checking the compliance of the vehicle with the requirements of applicable regulations and determining the vehicle's operational characteristics.

The object of tests was a VEB Fahrzeugenbau tricycle for the disabled, type DUO 4/1, chassis number 187660, engine number 588081, manufactured in 1987, which was delivered to ITS by the client with an odometer

reading of only 35 km. The tested vehicle had a skeleton body. The place for attaching the nameplate was on the front wall on the right side, and the place for stamping the engine number on the engine casing was on the front left hand side [4].

**Fig. 28. Front view of the vehicle [4]**

**Fig. 29. Rear view of the vehicle [4]**

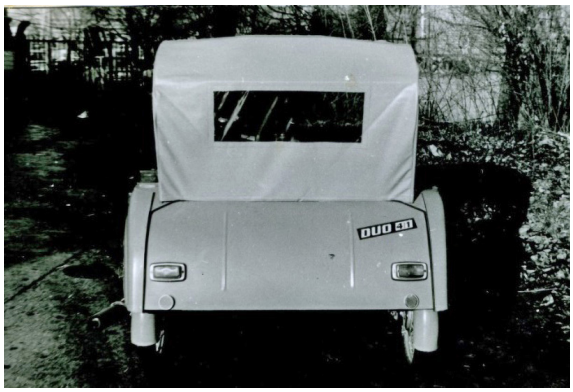



**Fig. 30. View of the vehicle from the left hand side [4]**

**Fig. 31. View of the vehicle from the right hand side [4]**

**Fig. 32. Data plate, metal, permanently attached to the front wall on the right hand side of the vehicle [4]**

According to ITS measurements, the tested vehicle had the following parameters: length 2130 mm, width 1530 mm, height 1420 mm, wheelbase 1520 mm, rear axle track 1140 mm, ground clearance 125 mm, curb weight 160 kg, permissible total weight 310 kg, maximum load front axle 85 kg, rear axle 225 kg, number of seats – two.

The vehicle was powered by an engine from the VEB Fahrzeugenbau und Ausrustung Brandis factory, a two-stroke, spark ignition type M53/I AR located on the side, single-cylinder with a displacement of 49.6 $cm^3$ and a power of 2.72 kW. The test fuel consumption was 3.2 $dm^3$/100 km. The minimum turning diameter to the right and left was 4.6 m, the maximum speed was 48.5 km/h, the fuel tank had a capacity of 14 $dm^3$, the external noise level was 76.3 dBa.

The basic identification details were placed on a metal plate permanently attached to the front wall on the right hand side of the vehicle. The device protecting against unauthorized use acted on the engine and steering system. This device is located on the right hand side of the steering column. It incorporated a cylinder lock activated by a key. After turning the key to the "0" position, the engine was turned off, and after removing the key and turning the steering wheel, the steering system was blocked [4].

The front windscreen was equipped with one wiper that sufficiently cleared the field of vision. The vehicle was equipped with two external mirrors providing rear visibility at a distance of 10 m. The main brake operated on three wheels via three flexible braided cables. It was activated by moving the steering column forward, in the direction of travel. The parking brake was activated using a lever that locked the steering column in the forward position.

During the test drives, it was found that the vehicle when turning right with one person on board (only the driver) had lower stability than when turning left. When turning left, the vehicle's stability was unquestionable. The vehicle stability was evaluated based on the determining the limiting tilt angles and the adhesion of the wheels to the road. It was found that the adhesion coefficient of approximately 0.44 could be used for braking, and only 0.28 when braking with an efficiency of 5 $m/s^2$. In both cases, on dry and wet roads, the vehicle could tip over when making a turn because the adhesion coefficient value found in practice exceeded these values. The vehicle's steering control, expressed in terms of its manoeuvrability and the force on the steering bar, was unquestionable [4].

ITS was of the opinion that it was necessary for the manufacturer to include in the vehicle's user manual information on the stability characteristics of this type of vehicle, paying attention to the need to exercise particular caution when driving in unfavourable weather conditions – when turning right, the vehicle with one person on board had less stability than when turning left.

Based on the conducted type-approval tests, it was found that the DUO type 4.1 tricycle imported by POL-MOT complied with the technical description of the vehicle type provided in the application for the type-approval certificate and met the technical conditions referred to in Polish law.

## Robur Duo 4/2 tricyle

At the end of the 1980s, the annual production of Duo tricycles was approximately 1,100 units, which were initially painted in olive green, and later exclusively in orange. There was no further development in the following years. The DUO 4/2 appeared in 1989 with an almost unchanged appearance, with improved electrical equipment, including an electric starter. Between December 1989 and March 1990, additional type-approval tests of the ROBUR DUO 4/2 mobility tricycle were carried out at ZBH ITS. The research work was carried out for POL-MOT based on the order No. B-5/Dz-57.

Homologation tests were aimed at checking the compliance of the vehicle with the requirements of applicable regulations and determining the vehicle's operational characteristics. The basis for the obligation to conduct these tests was the Regulation of the Minister of Communication of December 8, 1983.

The object of tests was a VEB Fahrzeugenbau mobility tricycle, type DUO 4/1, chassis number 18760, engine number 588081, manufactured in 1987, delivered for testing at ITS by the client. The scope of the tests included checking the compliance of the vehicle's parameters with the requirements and technical conditions contained in legal regulations. The VEB Robur-Werke Duo 4/2 mobility tricycle had an open frame body. The place for attaching the nameplate was on the front wall on the right side, and the place for stamping the engine number on the engine block was on the front left hand side. The chassis/body serial numbers of this type started with V9/89 [5].

**Fig 33. Front view of the vehicle [5]**

**Fig. 34. Rear view of the vehicle [5]**

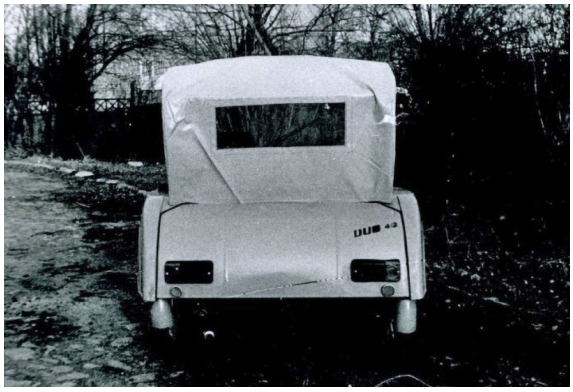


**Fig. 35. View of the vehicle from the left hand side [5]**

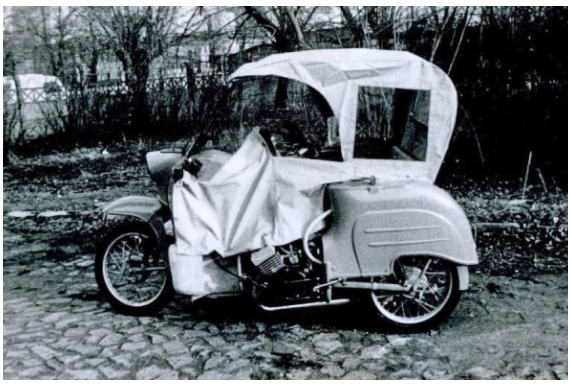


**Fig 36. View of the vehicle from the right hand side [5]**

**Fig. 37. Data plate, metal, permanently attached to the front wall on the right hand side of the vehicle [5]**


According to ITS measurements, the tested vehicle had the following parameters: length 2130 mm, width 1450 mm, height 1380 mm, wheelbase 1530 mm, rear axle track 1140 mm, ground clearance 125 mm, curb weight 160 kg, permissible total weight 320 kg, maximum load front axle 90 kg, rear axle 231 kg, number of seats – two.

The vehicle was powered by a two-stroke, spark ignition engine from the VEB Fahrzeugenbau factory, type M542E, located on the side, single-cylinder with a displacement of 49.9 $cm^3$ and a power of 2.72 kW. The test fuel consumption was 3.2 $dm^3$/100 km. The minimum turning diameter to the right and left was 4.6 m, the maximum speed was 48.5 km/h, the fuel tank had a capacity of 13 $dm^3$, the external noise level was 76 dBa [5].

Based on the conducted type-approval tests, it was found that the ROBUR mobility moped type DUO 4/2 imported by POL-MOT Spółka z o.o. complied with the technical description of the vehicle type provided in the application for issuing a type-approval certificate and met the technical conditions referred to in Polish law.

## Conclusion

Analysing the process of developing the design of vehicles intended for disabled people after World War II in Poland, the article presents vehicles that have undergone detailed type-approval tests at ITS in Warsaw. At this time we are dealing with, among the others, impact of the development of automotive designs on the increase in the mobility of disabled people. The article synthetically shows this issue on several examples (tricycles, mopeds, prototype vehicles, serial vehicles adapted to the needs of disabled people) in the time period 1945-1990.

The motor vehicles intended for disabled people presented in the article were examined at the Motor Transport Institute by outstanding specialists and experts such as Andrzej Cichowski and Konrad Malesa. The results of these tests, stored in the ITS archive, in the form of a final report, contain unique photos and tables, published in this article for the first time (apart from the WSK Gacek vehicle). The results of tests of these vehicles carried out at ITS showed many of their problems and had a significant impact on the corrections that were made to them before mass production.

The vehicles presented in chronological structure can be divided into microcars (Velorex), wheelchair tricycles (Krause Piccolo and Krause Piccolo Duo), prototype vehicles (WSK Gacek), production vehicles adapted to the needs of disabled people (Polski Fiat 126P), and mopeds (Duo and Robur Duo). In addition, one can distinguish vehicles imported from Czechoslovakia and the GDR and domestic vehicles manufactured in Poland.

Based on the analysis, own reflections and studies, as well as scientific research and the author's explanations that concern the content of this article, the following conclusions were formulated:

- after World War II, there were many war invalids in Polish society who, due to war injuries and sojourns in prisoner of war and concentration camps, were mentally and physically mutilated and largely excluded from transport activities;
- initially, in poor Polish society, there were no specialized vehicles for these people. The entire society struggled with the lack of a sufficient number of vehicles, and the communist state invested primarily in public transport;

- over time, mainly through the import of vehicles from neighbouring Czechoslovakia and the GDR, vehicles intended also for disabled people appeared on Polish roads, such as the Czechoslovak Velorex and the GDR's Krause Piccolo, and then the Duo. The trade press informed about it in detail, among the others:, e.g. the weekly "Motor";
- in the late 1960s and then in the 1970s, there was a rapid development of road transport in Poland. In order to keep up with trends and maintain the modernity of both products and their production methods, as well as to increase the mobility of disabled people, there have also been proposals of domestic designs for disabled people, e.g. WSK Gacek.
- in the mid-1960s, the authorities of the Polish People's Republic decided to purchase licenses for foreign motor vehicles. They led to the evolution of Polish technical thought and allowed to keep pace with world automotive leaders for some time;
- after the starting the production of the Polish Fiat 126P, Polish engineers also designed vehicles for disabled people, presented in this article, based on the production vehicle. These successful solutions are still used, to some extent, for today;
- domestic engineering thought created such a successful prototype as WSK Gacek, which, however, did not enter mass production;
- homologation tests of vehicles intended for disabled people conducted at ITS contributed to improving the tested vehicles in order to allow them to be used on Polish roads;
- the author's considerations will be continued by analysing the design of vehicles for disabled people also in the years 1990-2022. Moreover, they can be successfully developed by other researchers.

The formulated research question was therefore effectively solved. The question was answered: what was the impact of tests conducted at ITS on the development of vehicle designs intended for disabled people in the years 1945-1990 using the examples presented in the article.

## Bibliography:


1. Cichowski A., Karczewski T., *Sprawozdanie nr 1094/ZB/61 z badania trójkołowca inwalidzkiego marki KRAUSE PICCOLO*, Praca arch. nr 1007, ITS, Warszawa 1961.
2. Cichowski A., Morek S., Karczewski T., *Sprawozdanie nr 425/ZB/62 z badania trójkołowca inwalidzkiego marki KRAUSE typ Piccolo-Duo*, Praca arch. nr 1098, ITS, Warszawa 1962.
3. Konstytucja Rzeczypospolitej Polskiej (sejm.gov.pl) (z dn. 16.07.2023)
4. Krajczyński R., *Badania homologacyjne motoroweru inwalidzkiego DUO 4/1*, Praca arch. nr 4231, ITS, Warszawa 1988.
5. Krajczyński R., *Badania homologacyjne motoroweru inwalidzkiego ROBUR DUO 4/2*, Praca arch. nr 4306, ITS, Warszawa 1990.
6. Malesa K., *Badania homologacyjne samochodu osobowego Polski Fiat 126 p model 650 I (inwalidzki) dla osób z dysfunkcją kończyn dolnych*, Praca arch. nr 2482, IRS, Warszawa 1977.
7. Malesa K., *Badania homologacyjne samochodu osobowego Polski Fiat 126p 650 I2 przeznaczonego dla osób z dysfunkcją jednej górnej kończyny*, Praca arch. nr 2674, ITS, Warszawa 1979.
8. *Osoby niepełnosprawne w 2021 r.*, GUS, Warszawa 1.12.2022
9. Pionnier K., *Badanie homologacyjne samochodu Polski Fiat 126 p – I (inwalidzki) wyposażonego w sprzęgło półautomatyczne*, Praca arch. nr 2869, ITS, Warszawa 1981.
10. Steć R., *Polska w miniaturze: Gacek*, „Classic Auto" nr 96, wrzesień 2014, ss. 50-55.
11. Toczek S., Malesa K., Matuszowic G., Miazga J., *Badania samochodu inwalidzkiego W65.S65.N65 produkcji WSK – Świdnik*, Praca arch. nr 1765, ITS, Warszawa 1970.
12. Zakrzewski B., *60 lat minęło…1952-2012*, Instytut Transportu Samochodowego, Warszawa 2012
13. Zakrzewski B., *Samochód inwalidzki W65.S65.N65 – WSK Gacek*, „Logistyka" nr 6/2014, s. 11586-11605.
14. Zakrzewski B., *Polskie pojazdy samochodowe 1945-1990*, ITS, Warszawa 2021.
15. http://www.niepelnosprawni.gov.pl/niepelnosprawnosc-w-liczbach-/dane-demograficzne/ (z dn. 16.07.2023)
16. http://ckr.pl/ (z dn. 16.07.2023)


**Bartosz Zakrzewski**
*bartosz.zakrzewski@its.waw.pl*
*Motor Transport Institute*