

**WORK MANAGEMENT SOLUTION IN THE CONTEXT OF MODERN
SUPPORTING TECHNOLOGIES**

**SOLUÇÃO DE GESTÃO DO TRABALHO NO CONTEXTO DAS
TECNOLOGIAS DE SUPORTE MODERNAS**

**SOLUCIÓN DE GESTIÓN DEL TRABAJO EN EL CONTEXTO DE LAS
TECNOLOGÍAS DE SOPORTE MODERNAS**

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ABSTRACT

Objective: This paper presents the results of research on embedded systems and their potential to become supporting solutions for work management of disabled people. First, the general idea of work organization is presented. Then, the modern technologies have been presented and peoples' approach to modern technologies have been also described. What is more, the general rules of hiring disabled persons have been presented, with regard to older persons and other outsiders. Next, the general rules of hiring disabled persons have been presented.

Method: The scientific approach, logical reasoning and various analytical methods were used to verify if disabled people perceive the embedded systems as a modern supporting technology for work management solutions.

Results: According to the presented final results of the research that been presented, both the professionals having deep knowledge about electronics and the disabled persons recognize the potential in using the embedded systems for helping peoples with disabilities at work and as work management solutions.

Keywords: Work management solutions, Embedded systems, Work assistance, Work supporting technologies, Disability assistive technologies.

RESUMO

Objetivo: Este artigo apresenta os resultados de pesquisas sobre sistemas embarcados e seu potencial para se tornarem soluções de suporte para a gestão do trabalho de pessoas com deficiência. Primeiramente, é apresentada a ideia geral de organização do trabalho. Em seguida, as tecnologias modernas foram apresentadas e a abordagem das pessoas às tecnologias modernas também foi descrita. Além disso, foram apresentadas as regras gerais para a contratação de pessoas com deficiência, no que diz respeito a pessoas idosas e outras pessoas de fora. A seguir, foram apresentadas as regras gerais de contratação de pessoas com deficiência.

Método: A abordagem científica, o raciocínio lógico e vários métodos analíticos foram utilizados para verificar se as pessoas com deficiência percebem os sistemas embarcados como uma moderna tecnologia de apoio às soluções de gestão do trabalho.

Resultados: De acordo com os resultados finais da pesquisa apresentada, tanto os profissionais com profundo conhecimento em eletrônica quanto as pessoas com deficiência reconhecem o potencial da utilização de sistemas embarcados para ajudar pessoas com deficiência no trabalho e como soluções de gestão do trabalho.

Palavras-chave: Soluções de gestão do trabalho, Sistemas embarcados, Assistência ao trabalho, Tecnologias de suporte ao trabalho, Tecnologias assistivas à deficiência

RESUMEN

Objetivo: Este artículo presenta los resultados de la investigación sobre sistemas embebidos y su potencial para convertirse en soluciones de apoyo para la gestión del trabajo de las

personas con discapacidad. Primero, se presenta la idea general de organización del trabajo. Luego, se han presentado las tecnologías modernas y también se ha descrito el enfoque de las personas hacia las tecnologías modernas. Es más, se han presentado las reglas generales de contratación de personas discapacitadas, con respecto a las personas mayores y otras personas externas. A continuación, se han presentado las reglas generales de contratación de personas con discapacidad.

Método: Se utilizó el enfoque científico, el razonamiento lógico y varios métodos analíticos para verificar si las personas con discapacidad perciben los sistemas integrados como una tecnología de soporte moderna para las soluciones de gestión del trabajo.

Resultados: De acuerdo con los resultados finales presentados de la investigación presentada, tanto los profesionales con profundos conocimientos sobre electrónica como las personas con discapacidad reconocen el potencial del uso de los sistemas embebidos para ayudar a las personas con discapacidad en el trabajo y como soluciones de gestión del trabajo.

Palabras clave: soluciones de gestión del trabajo, sistemas integrados, asistencia en el trabajo, tecnologías de apoyo al trabajo, tecnologías de asistencia para discapacitados

1. INTRODUCTION

The organizational culture is as reach as the work management solution is effective. The better work management solution the better the organizational culture (Frățiciu, Mihăescu, & Andănuț, 2015; Isensee, Teuteberg, Griese, & Topi, 2020; Kapusta, Sukiennik, & Bąk, 2018; Klimecka-Tatar & Niciejewska, 2021). In recent years one may observe more and more intensified pace of technological progress and the influence of the technology on work and work management solutions increases (Bilan, Hussain, Haseeb, & Kot, 2020; Schwenk, 1986). Now, the most innovative technologies are modern micro controllers, which can use crucial solutions representing the new trends, f. ex.: artificial intelligence, 5G networks and neural networks. It is predicted that further development of those technologies will have a vast impact on the quality of our lives and work management (Alavi & Leidner, 1999; Gede Riana, Suparna, Gusti Made Suwandana, Kot, & Rajiani, 2020; Korpysa, 2021; Teo & Too, 2000; Tkachenko, Klymchuk, & Tkachenko, 2021).

The main challenge is the aspect of supporting technologies with relation to human disability. Disabled people need more and more specialized solutions to overcome the imperfections of their bodies and available level of medical services, which, in case of disabilities, very often turns out to be insufficient (Chajduga, 2021; Sharma, Zsarnoczky, &

Dunay, 2018). The above-mentioned technologies may have the potential to fulfill the gap between the needs of disabled persons and many engineers will certainly take the challenge to develop the technology that will have the influence on the general perception of disability in the societies, the perception of the disabled persons in work through pushing further the limits of capabilities and general work efficiency of disabled individuals. In fact, when analyzing the potential, they may pose the most important aggregation of supporting, assistive technologies in the work management solutions.

2. LITERATURE REVIEW

The COVID-19 pandemic has pushed the humanity into the new ways of organization (Baryshnikova, Kiriliuk, & Klimecka-Tatar, 2021). This contains also the organization of work, which turned mostly to online and remote solutions like for example Microsoft Teams and Google Meet. Another attempts are being made to make the using of such solutions easier and easier, more and more affordable in the context of bandwidth required to smooth operation. Good example is here Google Meet on Google Chrome browser. The Google engineers are doing their best to make stable video connection with the bandwidth of circa 30kB/s.

On the other hand, another aspects of work organization remain in 2021 the same. The organization is based on proper, regarded as most efficient to specified business, organizational structure and organizational culture. Business literature defines organizational culture in many ways (Frățiciu et al., 2015)

What is more, culture should be treated as inseparable element with occupational health and safety as one of the organizational culture elements. This relation sheds light on the question of work management and working people with disabilities. Organizational culture helps in the management and contributes to raise the level of orderly flow of information in enterprises (Ingaldi, 2018; Isensee et al., 2020; Kapusta et al., 2018; Klimecka-Tatar & Ingaldi, 2020).

First of all, the new technologies emerged to the level that the new potential can be recognized to enrich the supporting work management solutions soon (Gomes, Okano, & Otolá, 2020; Matusznyi, 2020; Pietraszek, Radek, & Goroshko, 2020). The author would like to put emphasis on the fact, that there has been developed many embedded systems and there are used in many industry branches (Frustaci, Perri, Cocorullo, & Corsonello, 2020; Kim,

Lee, Chun, & Lee, 2021; Liu & Feng, 2021; Zhang, 2021; Zhou, 2020). The way the embedded systems are produced gives range to develop its capabilities, specialize them according to really important to the right situation needs at affordable expenditure level. Thus, such systems are more and more often used in more and more projects. For example, the cheap and very affordable F100 micro-controller has been designed to be used as a e-book reader as well as the car media center. This variety makes possible to enrich capabilities of the final consumer device with time. For instance, the Trekstor e-book reader with basic functions of reading books can be upgraded to the far more advanced e-book reader Prestigio, that can additionally play movies. Last decade brought the challenge to design one micro-controller that could find many applications, more than just two, like described above. What is more, the last years brought the new challenges in embedded systems area: the expectation to easily implement advanced technologies f. ex. neural networks and artificial intelligence, also, the new types of sensors appeared on the market and use of them seemed do be particularly beneficial and more. Many of such new solutions turned out to be far more power-efficient (low current consuming) that previous generations, f. ex. new low-energy Bluetooth 5.0 that has the ability to stay powered online for a few years on a single alkaline battery life. Also, this is crucial due to the need of reduction of global consumption of fossil fuels. The care for our planet becomes more popular. All of mentioned elements put together an more resulted in the design incomparably flexible devices with great embedded systems that have high potential to be used in many solutions (projects). The following paragraphs present the main important micro-controllers.

One of the most developed and advanced solutions are micro-controllers produced by ARM Holdings PLC. These three letters stand for the abbreviation of Advanced RISC Machine, (originally in past called Acorn RISC Machine), which is 64-bit or 32-bit architecture of RISC-type processors. Vast amount of versions of ARM core processors are widely used in today's embedded systems. The most important key features of these micro-controllers are: implemented multi-threading mechanisms, possibility to use (often contained in the system) the TCP / IP stack and generally minimal power consumption. ARM-based processors are one of the most widely used processors in the world. The main and most often examples of usage the ARM solutions are: cell phones, routers, hard drives, calculators and toys. However, the usefulness and strength of ARM solutions can be

understood, when realize that, just in 2005, the number of produced processors is almost 1.7 billion (!). These accounted for 75% of all 32-bit processors on the market. The software working on those solutions are: Windows CE, Embedded Ubuntu Linux, FreeBSD, Embedded Debian Linux, NUTOS (Ethernut), and more.

The solutions that emerged on the ARM processors is STM32 - a family of 32-bit micro-controllers, integrated circuits produced by ST Microelectronics. The STMicroelectronics groups its chips into correlated series that are based around the same 32-bit ARM processor core. Each series can be characterized as having at least one processor specified to be most powerful and one processor with limited power but more energy saving. Also, there is always a few optional processors between, some faster in some aspects, some in other. This way the engineers who design the final products have ability to test and decide, which processor fits best to specific situation. Formally the ARM and ST have symbiotic cooperation based signed agreements. ST Microelectronics licenses the ARM Processor IP from ARM Holdings, presented previously. The ST company uses the core design delivered by ARM in the ST individual configuration. It can be said that ST Microelectronics develops the core idea of ARM. This development of this idea is easy to observe in ST own peripherals attached to its products.

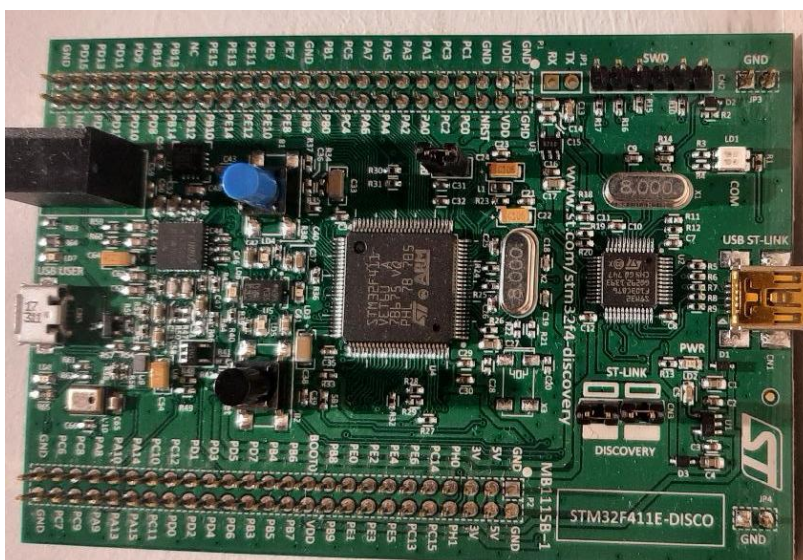


Fig 1. The ARM chip on development discovery board manufactured by ST Microelectronics

In contrary to ARM micro-controllers, Raspberry PI is a real computer system, with comparable to ordinary computers amount of RAM memory (2, 4 or 8GB for May of 2021), embedded with USB ports, RJ45 connector, HDMI port and Broadcom BCM2835 chip and able to connect via LAN or WIFI. Also, after the installation of one of the dedicated operating systems (Raspberry PI OS, Windows IOT, Linux Ubuntu for RPi) is possible to use Raspberry PI in the way the typical computers are used (with connected mouse, keyboard and monitor). In emphasize the differences between Raspberry PI and common computers, Raspberry PI is additionally equipped with General Purpose Input/Output ports shortly called GPIOs ports. This set of ports opens entirely new possibilities for Raspberry PI and its users. GPIOs ports make Raspberry easy to cooperate with variety of sensors and another controlled devices.

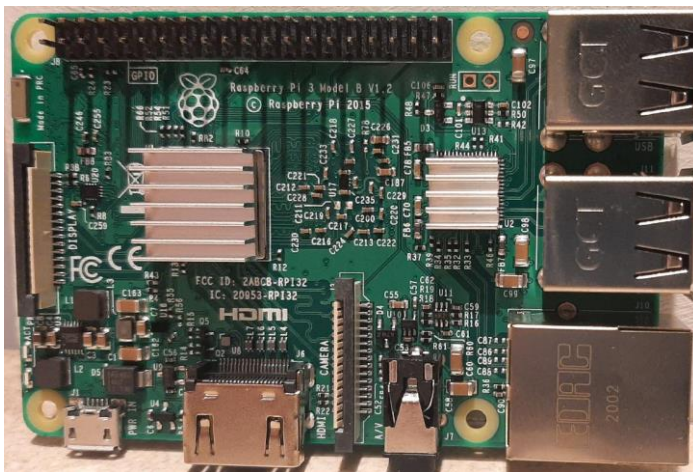


Fig 2. The Raspberry PI computer with radiator assembled on the ARM micro-controller (the bigger one)

Despite above mentioned solutions, other options are also available on the market, f. ex. Sony Spresense and Nvidia Jetson. The embedded system delivered by Sony is a Sony CXD5602 microcontroller with an ARM Cortex M4F Hexa-Core 156 MHz core build on compact development board. The microprocessor has an integrated GNSS system supporting GPS, QZSS and Glonass, audio codec with amplifier for audio output and support for output channels up to 8 microphones. The compact development board has an input for a dedicated camera too. While the name of Nvidia Jetson solution stands for entire series of embedded computing boards. The Jetson TK1, TX1 and TX2 models carry a Tegra

processor from Nvidia that integrates an ARM architecture processor. Similarly to described above, the Jetson solution is a low-power system but is mostly designed for acceleration of machine learning applications, so it supports the artificial intelligence. When to compare the Nvidia Jetson to competitors, is better in terms of high computing possibilities thanks to comparably powerful microprocessors, thus require highly efficient radiators. On the other hand, they use more power than others. To sum up, Nvidia Jetson seems to be used most often in situations where comparably large amount of data is required to be processed at once, simultaneously when even minor delay is not allowed.

Peoples' approach to modern technologies

In recent times the peoples' approach to modern technologies is quite positive and open. People treat the new technologies as way to make their life easier are more communicated (Chajduga, 2021; Grabara, Cehlar, & Dabylova, 2019; Ingaldi & Klimecka-Tatar, 2020). In addition, new technologies make both industry and life more sustainable (Chmielarz, 2019; Haque, Aston, Kozlovski, & Caha, 2020; Lazar, Klimecka-Tatar, & Obrecht, 2021). In addition, due to the new technology, robotization and digitization are definitely observed in the processes (Buhalis & Law, 2008; Lozhkin, Maiorov, & Bozek, 2021). On the other hand, it must be said that new technology makes our life faster and much more complex. More and more people treat next emerging technologies as basic and fundamental, what influences the social expectations of living. For example, to be socially active becomes the synonym of being present on many social web pages, which treat its users not only as clients but as products too, busily collecting data about users and developing tools for their analysis. Developing this subject, it must be stated, that some part of many societies is generally partially closed to modern technologies – rejecting them. These are mostly older people or people who decided to live outside the mainstream of technology, f. ex. Amish. However, in terms of people with disabilities, in general, they wait for the solutions that have capabilities to (at least in part) overcome their disability, helping them with everyday life (Sharma et al., 2018; Wright & Snell, 1998).

General rules of hiring disabled persons

General rules of hiring people with disabilities are assuming main three aspects. First, the workplace must be safe for the specified sort of disability. This means proper preparation

of the building, safe entrance ramp, easy access to elevator or additional markings on the walls if disabled persons are visually impaired or removal of items that may be disturbing when moving. Moreover, there are additional legal aspects that are required when hiring people with disabilities (Mistarihi, 2020; Safta, Stan, Suditu, & Iurea, 2011; Wuellrich, 2010).

In general, in majority of countries the local legislator requires the opinion of the medical doctor for the disabled person to start working. The problem is, it may happen, that the opinion of the doctor may discourage the potential employer to sign the contract. Another discouraging aspect can be the fact that law generally requires more days off from work in case of disabled people. On the other hand, most of legislators in developing and developed countries give subsidies for the employment of a disabled person, though sometimes they are connected with complex and not always easy reporting. For example, in Poland in middle Europe local legislator requires constant percentage level of employment of disabled people in order to maintain the level of subsidies.

The final aspect of general rules of hiring disabled persons is the activation of disabled people, stimulating them to more social life, improving life satisfaction and increasing the sense of being needed. The fact of having job is definitely helping factor in above-mentioned area. That is why, in general, legislators should be concerned and helpful in the process of hiring and supporting employment of disabled people (Knijn & van Wel, 2014).

3. METHODOLOGY

In terms of methodology, the scientific approach, logical reasoning and various analytical methods were used to verify if disabled people perceive the embedded systems as a modern supporting technology for work management solutions. The form of the tool was the internet questionnaire. Also, the professionals from the electronic industry have been asked if they assume the potential of micro-controllers is enough to be used in work-supporting management solutions for disabled peoples. Additionally, as the professionals have deeper knowledge about the embedded systems, their questionnaire was designed in the more detailed way – with regard to the previously mentioned types of micro-controllers:

- STM32;
- Raspberry PI;
- Sony Spreesense;

- Nvidia Jetson.

The disabled were acquainted with basic knowledge about embedded systems in order to realize, get to know and have the general idea, the big picture, what is the questionnaire really about. Some prices were mentioned, however, no names were given not to distort the outcome of the research. The questions asked in the questionnaire are presented in the table 1 below.

Table 1
The questions asked in the questionnaire

Part for disabled persons	Part for professionals
1. Do you think that modern embedded systems have the potential to become the assistive technology work management solution for disabled individuals?	1. Do you think that modern embedded systems have the potential to become the assistive technology work management solution for disabled individuals?
2. Do you know and recognize any embedded system? If so, put its name.	2. Do you think the embedded systems will lower costs of preparing a position or a disabled person for work?
3. Do you think the embedded system will lower costs of preparing a position or a disabled person for work?	3. According to you, what embedded system has the highest potential in the above mentioned area?
4. Do you think you could afford a solution based of embedded system today?	4. Why do you think so? What are the most important traits, that make specifically this system most suitable to this solution?
5. How do you think, what sort of disability may embedded system help with?	5. How do you think, what sort of disability may embedded system help with?

Each sample was chosen not randomly taking under consideration the fact of disability or the fact of having knowledge about electronics. Both samples consisted of 30 respondents each. The questionnaire was distributed via Google Forms tool among disabled people associated in POAPD (Polish Organizations Associating Persons with Disabilities). The fact of disability was additionally verified by answering for the additional question: *Does your disability has been formally established?* The answer is important in those situations, when disability is not obvious. The sample of professionals was chosen by Internet research of services that repair electronics. First, the phone call to the service point

was made and then, after expressing one’s willingness to participate in the study, the proper link to the questionnaire was sent via mail.

The final answers have been aggregated and counted. Then, the analysis were performed to get to know the important results of the questionnaire and to catch the similarities of opinions between professionals and the disabled persons themselves, who are not familiar with the subject of embedded systems.

4. RESULTS AND DISCUSSION

The aggregated results of the questionnaire distributed among disabled people are presented in the table 2 -6.

Table 2

Aggregated results of the questionnaire distributed among people with disabilities – questions 1-4. Each person gave one answer only. Sum of yes and no answers equals to 30

QUESTION \ SUM OF ANSWERS:	YES	NO
1. Do you think that modern embedded systems have the potential to become the assistive technology to work management solution for disabled individuals?	30	0
2. Do you know and recognize any embedded system? If so, put its name.	7 (gave the name)	23 (did not give the name)
3. Do you think the embedded system will lower costs of preparing a position or a disabled person to work?	28	2
4. Do you think you could afford a solution based on embedded system today?	24	6

Table 3

Aggregated results of the questionnaire distributed among people with disabilities – question 5. Each person gave at least one answer. Sum of all answers is greater than 30.

QUESTION \ SUM OF ANSWER:	Type of disability				
	hand movement problem	not able to walk	problem with keeping balance	problem with speech	with limited perception problem
5. How do you think, what sort of disability may embedded system help with?	28	20	8	2	7

The result of questionnaire distributed among disabled people is as following: all of respondents see the potential of modern embedded systems to become the assistive technology for work management solution in case of disabled individuals. Only 7 disabled persons were able to give the name of at least one embedded system. 23 of asked disabled persons did not know any name of the embedded system. 28 disabled persons think that embedded system will lower costs of preparing a position or a disabled person to work, while 2 of disabled people have opposite opinion. 24 persons with disabilities think they already (today) could have afford some solution based on embedded system. 6 person of 30 questionaired disabled people state they cannot afford the solution based on embedded system now (at the day they were asked). With regard to question number 5. *How do you think, what sort of disability may embedded system help with?* 28 of disabled persons indicated hand movement problem to be solved through usage of embedded system. 20 of them pointed out that embedded systems could be able to help those disabled persons who are not able to walk. 8 people had written that problem with keeping balance can be solved by modern microcontrollers. Almost the same – 7 disabled persons state that embedded systems may help persons with limited perception. Only 2 disabled persons indicated that embedded controllers may help in case of problem with speech.

Table 4

Aggregated results of the questionnaire distributed among professionals having knowledge in electronics – questions 1-2. Each person gave one answer only. Sum of yes and no answers equals to 30.

QUESTION \ SUM OF ANSWERS:	YES	NO
1. Do you think that modern embedded systems have the potential to become the assistive technology work management solution for disabled individuals?	30	0
2. Do you think the embedded systems will lower costs of preparing a position or a disabled person for work?	28	2

For the first question asked to professionals having knowledge about electronics, all the professionals think that modern embedded systems have the potential to become the assistive technology work management solution for disabled individuals. In terms of question number 2, 28 of professionals think that the embedded systems will lower costs of preparing a position or a disabled person for work. 2 individuals have opposite opinion.

Table 5

Aggregated results of the questionnaire distributed among professionals having knowledge in electronics – questions 3-4. Each person gave one answer only. Sum of yes and no answers equals to 30.

QUESTION \ OF ANSWER:	SUM	Producer of embedded system			
		STM	R.PI	SONY	NVIDIA
3. According to you, what embedded system has the highest potential in the above mentioned area?	12		8	8	2
4. Why do you think so? What are the most important traits, that make specifically this system most suitable to this solution?		Small-sized, energy-saving, having many uses, very cheap	Small-sized, energy-saving, easy to service, cheap	Small-sized, energy-saving, having many uses	High computational power

In terms of questions number 3 and number 4, 12 professionals think that solution developed by STM has the highest potential due to its small size, energy-saving aspect, many possible uses and they additionally think that STM solution is very cheap. In case of Raspberry PI (R.PI in the table) and SONY solutions, ex aequo, 8 professionals think those systems have the highest potential of being the most useful for disabled persons. The most crucial indicated traits of Raspberry PI are: small-sized, energy-saving, easy to service and cheap. In case of SONY system, respondents pointed out many potential uses of such system, but do not think this is a cheap solution. Finally, in terms of NVIDIA, only 2 asked professionals recognize its potential as the highest one. The reason is high computational power of the system. On the other hand, it is neither enough power-saving nor cheap.

Table 6

Aggregated results of the questionnaire distributed among professionals having knowledge in electronics – question 5. Each person gave at least one answer. Sum of all answers is greater than 30.

QUESTION \ OF ANSWER:	SUM	Type of disability				
		hand movement problem	not able to walk	problem keeping balance	with problem speech	with limited perception problem
5. How do you think, what sort of disability may embedded system help with?	30	28	20	28	22	

The aggregated answers of the question number 5 asked to professionals who have knowledge in electronics show the very high rates for the embedded system to potentially help with disability – 30 people indicated, that embedded system may help with hand movement problem, 28 that such solutions may help with disability to walk or problem with speech, 22 have indicated the capability of embedded systems to help with limited perception problem. Finally, 20 of respondents saw the opportunity to use micro-controllers to fight with problem with keeping balance.

5. CONCLUSIONS

In the beginning, it must be emphasized that there is available many embedded systems on the market by now. The reason of such situation is their high potential and significant level of specialization of each embedded system. Now, embedded systems (also called micro-controllers) are common to be used in many bigger solutions, f. ex.: control panels in cars, vehicle infotainment systems, mobile phones, toys, air condition control panels, and many others. Previously, the challenge was to design one embedded system that could serve in many places. However, last years brought the new trends in embedded systems that are easier to transform signals from many new types of sensors, which are easier to program and more and more power-efficient. From the perspective of the entire society, it is also important that the modern embedded systems may support the fulfillment of requirements for employees by legislators thus make employment of disabled people easier. The conducted study has proved that not only disabled persons see the potential of modern technology (embedded systems) in becoming work supportive solution but also the professionals who have deep knowledge in electronics and understand the complexity of the embedded systems themselves. It must be emphasized that according to professionals the embedded systems have the potential to help with almost each type of studied (analyzed) disability: hand movement problem, lack of ability to walk, problem with keeping the balance, problem with speech and even limited perception problem. The disabled persons were significantly less optimistic in terms of problem with keeping balance, limited perception problem and problem with speech – less then 20 respondents (in total, less than 10 when treated each position separately) indicated those groups of problems as in their opinion expected to be solved by embedded systems. Moreover, the professionals indicated that the

embedded system designed by STM has the greatest potential to become work management supporting solution. The reasons are it is small-sized, energy-saving, allows many uses and is additionally very cheap. Second choice were ex aequo Raspberry PI and SONY solutions. In terms of Raspberry PI, the following traits were indicated: small-sized, energy-saving, easy to service and cheap. While in case of SONY solution the crucial traits were: small-sized, energy-saving and having many uses. Only two professionals indicated products of NVIDIA as best suitable for such solutions. Respondents pointed out the one advantage only: high computational power of NVIDIA embedded system. The aggregated results of the questionnaire distributed among people with disabilities showed that all of disabled respondents consider embedded system as having potential of being work management supporting solution. However, the majority of disabled respondents does not know any embedded system of its name – only 7 out of 30 people were able to give at least one name of the system. Also, almost all of questionnaired disabled think the embedded system will lower costs of preparing a position or a disabled person to work. Moreover, with little less optimism they consider about what they can afford – 24 out of 30 respondents finds solution based on embedded system affordable now.

The author believes that analysis basing on above-mentioned both sides approach is coherent and exhausting – first, the disable side, the side of demand one may say - and the second one – the side of professionals is the side of supply. This approach seems to be sufficient to predict the success of further development of embedded systems to become the strong element of work management supporting solution for disabled persons. However, because of the delicate nature and many types of disabilities, further research is needed in this area.

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