The Galileo Project and Possible Opportunities for the Czech Space Industry

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Zásady pro vypracování:

Popište historii evropské kosmické spolupráce.
Popište základní trendy Evropské kosmické kanceláře.
Stručně nastiňte vývoj GNSS s důrazem na strukturu evropského programu Galileo.
Uveďte možnosti zapojení českého kosmického průmyslu do projektu Galileo.
Rozveďte vybranou aplikaci projektu Galileo včetně ekonomického rozboru.
Vyhodnoťte získané informace z pohledu možnosti zapojení pracovišť UTB do studované problematiky.

Rozsah bakalářské práce:

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ABSTRAKT

Tato bakalářská práce se zabývá evropským globálním navigačním satelitním systémem Galileo. Nejdříve je popsána historie a současné trendy Evropské kosmické kanceláře, informace nutné k pochopení projektu Galileo. Poté se práce věnuje systémům GPS a GLONASS a následuje podrobný popis Galilea. Druhá polovina práce je zaměřena na možnosti zapojení České republiky a Univerzity Tomáš Bati do projektu Galileo a do jiných kosmických aktivit.

Klíčová slova: Evropská kosmická kancelář, globální navigační satelitní systém, Galileo, GPS, Česká kosmická kancelář, UTB

ABSTRACT

This bachelor thesis focuses on the European global navigation satellite system called Galileo. In the beginning, the history and current trends of the European Space Agency are explained in order to understand the background of the Galileo project. Then the thesis deals with GPS and GLONASS systems followed by a detailed description of Galileo. The second part of the thesis presents possible opportunities for the Czech industry and Tomas Bata University brought by Galileo and other space projects.

Keywords: European Space Agency, global navigation satellite system, Galileo, GPS, Czech Space Office, TBU

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CONTENTS

INTRODUCTION

In 1611 Galileo Galilei discovered four moons of the planet Jupiter which proved to be unquestionably useful when determining longitude. For many years his discovery helped travellers to find their ways and navigated them to places they wanted to reach. Four hundred years later Europe proudly named its first global navigation satellite system after this great astronomer.

The Second World War pushed science to new explorations. Nazi Germany succeeded in development of Vengeance Weapon 2 rockets and after the war's end the wining powers, the United States of America and Russia, used German research to start missile development and later to explore the space. During the second half of 20th century these Superpowers massively worked on their space programmes making it impossible for small European countries to compete against them alone. In 1960s the idea of European cooperation on space activities was born and led to what the European Space Agency is now. Currently, ESA, an international organisation consisting of 19 European states, is able to compete with Americans and Russians but also to cooperate with them on various space programmes.

However speaking of global navigation satellite systems the USA and Russia have been ahead of Europe leaving us dependent on American GPS. European citizens unconsciously use satellite positioning in their everyday lives and the fact that GPS could be banned for civilian use made the European Union start developing Europe's GNSS called Galileo. The development stimulates the European industry and Galileo has a potential to bring economic benefits based on positioning products.

The Czech Republic, once involved in soviet space activities, is now a full member of ESA and therefore it is directly influenced by its activities. To get the most out of this membership, the space sector should not be longer considered as a pure science but it should be viewed as an economic chance to enhance competitiveness of the Czech Republic. The Galileo project and the transfer of the European GNSS Agency to Prague is a great opportunity to boost the Czech industry and to stimulate research and development of Czech academia.

1 FIFTY YEARS OF THE EUROPEAN SPACE COOPERATION

Galileo is not the product of one country but it has been developed in very close cooperation among European countries. The whole idea of the Galileo project is built on benefits for European community and therefore it is necessary to start with the history of the European space cooperation.

After WW2 the US and the Soviet Union started to build aggressive space programmes with the help of German scientists who surrendered either to American soldiers or to Soviet ones. During the 50s European countries such as United Kingdom, France and Italy tried to develop space programmes on their own. They succeeded in launching in orbit satellites. However, they could not compete with programmes developed in the United States or the Soviet Union. (Krige and Russo 2000, 1-11)

The first idea of creating an organisation that would concentrate on space programmes in cooperation is traced back to 1959 and 1960. There were two men who brought this idea alive - Edoardo Amaldi and Pierre Auger. If they did not present and justify their believes in joint European space programme the history of ESA could have been very different. Due to the fact that many scientists left Europe to do researches in more promising land, the USA, the need for such organisation was clearer and clearer. However, Europe was reluctant to follow American and Soviet paths and their military characters and did want to build a strictly civilian space programme.

1.1 The Pioneers – ESRO and ELDO

The Italian scientist Edoardo Amaldi and the Frenchman Pierre Auger are responsible for the creation of the European Space Research Organisation. They both worked on a successful CERN project and wanted to build a space organisation similar to CERN. In 1960, several discussions were held among the representatives of France, Italy, Germany, Belgium, Holland, Sweden, Switzerland and the United Kingdom. During those discussions the main bodies of ESRO were established. They were: "a headquarters; an engineering centre for integration, testing and preparation for the launching of satellites and rockets; a network for satellite tracking and telemetry stations; a centre for data analysis; a small research laboratory; a launching base" (Bonnet and Manno 1994, 5). From the beginning, the main intention of representatives of those European countries was to keep ESRO out of politics because of the threat of its possible military use and therefore the question of launching was viewed negatively. It posed that mentioned threat to the purely civilian organisation. However, having Europe's own space programme without the ability to launch space rockets was not a desire of the founders either. Despite of these problems, on 14 June 1962 Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom signed the Convention and the 8-year budget protocol meaning that ESRO was officially instituted.

At the same time, France and the United Kingdom did not want to rely on the US launchers and they were considering developing the European ones. Even though the discussions about creating ELDO were held after those ones about setting up ESRO, the European Launcher Development Organisation (ELDO) was instituted 3 months prior to the institution of ESRO. Although it might seem that the organisations worked together they did not. The purpose of these organisations are demonstrated in words of Bonnet and Manno (1994,12), "while ESRO was created by scientist in order to meet scientific needs, ELDO was created by governments interested in taking advantage of their technological expertise and of their earlier financial investment, either in the military or in the civilian sector."

ESRO was very successful and it followed set objectives. It built the launching base in Sweden called ESRANGE and with American launchers by 1968 ESRO managed to send around a hundred sounding rockets and first three European satellites. However very soon it hit the first crisis. Never able to stick to the budget, ESRO started to be view as the organisation pumping money and not bringing the larger projects like lunar satellites to close. It was fully dependent on NASA launchers and unfortunately did not want to bring the real value for Europe.

The same situation occurred in ELDO from the very beginning. The lack of real cooperation and management responsibilities led the organisation to its doom. Its programme seemed fine and the first and main aim was to build a European launcher. However each stage was given to one member state agency to be developed on its own. Due to the inability to work together the launcher neither reached the orbit nor launched a satellite. Furthermore, the set budget was not sufficient either. ELDO completely failed its mission.

The mistakes of both organisations were judged and viewed as an opportunity for a new start. Just few years after their institutions in 1968 a report from a group of experts recommended a fusion of the organisations into one agency that would have a proper management and would avoid wrong steps of its predecessors. Even though ESRO was against it could not follow its original path and later in 1975 merged with ELDO into one organisation now known as the European Space Agency.

1.2 The establishment of the new Agency

Establishing such organisation and especially building it on previous failures seemed to be very difficult. Several conferences had to be held in order to decide what steps need to be followed and to set a future programme that all member states would approve. The program called The Second Package Deal defined in December 1972 was proposed as follows:

- A European Space Agency would be established which would combine the functions of ESRO and ELDO and whose role would be to coordinate and progressively integrate into a single European space program the various individual national space activities.
- The French rocket design, then called L3-S, later renamed Ariane, was adopted as the future European launcher in preference to Europa, developed by ELDO.
- The Europeans would cooperate with NASA in the development of their Space Transportation System, the Space Shuttle, by developing Spacelab.
- A maritime navigation satellite would be developed as part of the applications program. (Bonnet and Manno 1994, 20)

As it was viewed very positively, in 1973 the package deal was approved by all ten member states followed by the approval of the Convention of the European Space Agency on 15 April 1975 which was later ratified on 30 October 1980. The framework of the Convention defined the management of ESA and its projects.

1.2.1 The Convention of the European Space Agency

In the beginnings of the Agency, setting of governing principles was a must and these written rules in the Convention still apply today. The Article 1 of the Convention (2005,12) explains the ground principle of the Agency and it says that "all Member States shall participate in the mandatory activities and shall contribute to the fixed common costs." Moreover it explains the main purpose of ESA. "The purpose of the Agency shall be to provide for and to promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space applications systems" (ESA Convention 2005, 13). These words are also reminded in every number of ESA's quarterly ESA Bulletin. Although ESA's main activities focus on research and development in space technology, the main purpose of this Agency could be interpreted differently. It is not wrong to say that ESA was established to promote close cooperation and to show that this cooperation can bring good.

1.2.2 The Organs of the Agency and their role

The Convention created main organs of ESA. These are the Council and the Director General. Both organs are assisted by a staff.

The Council is composed of delegates of the member states and it is the sovereign body. All delegates have the right to vote. It approves all programmes and future activities, defines and adopts policy or decides on the admittance of new member state. As the Convention mentions the Council does not meet on regular basis but when required. These meetings can be held at ministerial or delegate levels. If not stated otherwise they are held at the headquarters of the Agency in Paris. (ESA Convention 2005, 25-33).

The Director General is elected by the Council by two-third majority. This executive officer is directly responsible to the Council, he attends the Council meetings however without the right to vote. His responsibilities have international character and he is forbidden to take any instructions from local governments of the member states. The Director General is assisted by senior staff also appointed and approved by the Council. All responsibilities and duties of The Director General also apply to this staff. (ESA Convention 2005, 33-36).

1.3 The Member States

The member states build the Agency and its existence relies on them. In words of Bonnet and Manno (1994, 60) “ESA belongs to its Member States and is entrusted with the task of defining a space policy and of developing systems to be made available to the scientific community and to the users of space application programs.” By signing the Convention in 1975 Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom are considered as the founding member states of the European Space Agency. However, at the present ESA has 19 permanent members and 9 states have Cooperation Agreements with the Agency. Here is the admission process of new member states after 1975:

- On 31 December 1975 Ireland became 11th member state.
- On 1 January 1987 Austria and Norway signed the Convention and became 12th and 13th member states.

- In January 1995 Finland joined the Agency.
- In January 2000 Portugal became 15th member state.
- In 2005, ESA welcomed two new member states – Greece in March and Luxembourg in June.
- On 12 November 2008 the Czech Republic became the first member state from the formal Soviet bloc.
- On 22 December 2011 Romania became the last member state of ESA.

ESA signed Cooperation Agreements with Estonia, Latvia, Lithuania, Poland, Slovakia, Slovenia, Hungary and Bulgaria. Canada has been working with ESA on several missions and signed the agreement too.

2 CURRENT TRENDS OF THE EUROPEAN SPACE AGENCY

To understand the Galileo project there is a need for defying ESA's activities first. The European Space Agency concentrates its activities into several programmes. These programmes are: science and robotic exploration, Earth observation, telecommunications and integrated applications, development of new technology and launchers, human spaceflights and explorations, Galileo and navigation-related activities. With these programmes ESA is able to respond to global challenges.

2.1 Science and robotic explorations

Space science and technology is a core of ESA. Since 1970's ESA has focused on the Solar system and the Universe exploration. Within this field, ESA successfully observed the Sun with joint NASA/ESA Ulysses mission, it managed to launch space-based telescopes such as Hubble and Integral, or get samples of Saturn's moon Titan with the Huygens probe. European scientists must think of new challenges and therefore ESA has prepared the Cosmic Vision plan which draws activities connected to the Space exploration for next twenty years.

2.1.1 Solar missions in operation

At the present there are many missions in operation which give scientist new information about the Sun and its impact on the Earth. ESA claims that these missions are the most important at the present:

- Ulysses is a project done in close cooperation between NASA and ESA. It was sent in orbit on 6 October 1990 from Kennedy Space Centre in Florida. For the first time it studied Sun's poles. ESA claims that, "with Ulysses, scientists obtained the first-ever four-dimensional map of the heliosphere – the bubble generated by the solar wind that defines the sphere of influence of the Sun" (ESA, Space Science).
- SOHO, the Solar and Heliospheric Observatory, is another joint ESA/NASA project exploring the Sun. It reached its orbit in December 1995. Its main objective is to answer essential scientific questions about the Sun's structure and dynamic, the existence of solar corona and its ability to heat up to 1 000 000°C, and source of solar winds.
- Four spacecraft flying around the Earth are named Cluster project. They are identical and are used in a cluster pattern. Cluster maps solar winds and therefore

the scientists can use collected data to define how those winds effect our planet. Solar winds have bad influence on connection between satellites and power stations on ground. ESA thought that Cluster project would be ended in 2009 but it is still in full operation.

2.1.2 Planetary explorations

ESA states that it focuses on exploring Earth's closest planets Mars and Venus. It was Mars Express that found water and has been mapping the surface of planet Mars. Venus Express has been trying to explore the cause of the greenhouse effect on Venus. ESA's Huygens has been exploring one of Saturn's moons, Titan, and should be able to obtain information about its composition. In 2014, Rosetta will land on Comet 67P/Churyumov-Gerasimenko and this mission should possibly answer the question whether comets brought life to Earth or not. The BepiColombo is on its way to explore the closest planet of our Sun and it might give scientists the insight into formation of planets in such close distance to stars. ESA cooperates with NASA on ExoMars programme which will keep exploring Mars. It is the most ambitious scientific programme of NASA/ESA cooperation and should find whether the life on Mars ever existed or still exists. (All about ESA 2011, 4)

2.1.3 Cosmic Vision Plan

Cosmic Vision is a strategic planning tool for years 2015 – 2025 created in 2005. It provides all information for current and future ESA projects. It replaced the Horizon 2000 plan prepared in 1984 which was very successful and therefore ESA decided to continue with a long-term planning. These plans have enabled scientists and engineers to commit to the projects that take years to develop. Cosmic Vision focuses mainly on finding answers to these questions:

- What are the conditions for planet formation and the emergence of life?
- How does the Solar System work?
- What are the fundamental physical laws of the Universe?
- How did the Universe originate and what is it made of? (Cosmic Vision 2005, 6)

2.2 Earth Observation

Satellites are needed to get valuable and important data about the Earth. They are essential in providing all kinds of information about the changes of our planet. This information must quickly reach ground-based observatories to be available for direct use. In 2001, ESA launched the biggest satellite ever built called Envisat which monitors the atmosphere, the Earth's surface, our seas and location of icebergs. For meteorological purposes Meteosat satellites map the weather conditions in the air and on the ground. As mentioned in ESA's 2009 Annual report (2009, 13) "GMES is the most complex and ambitious Earth observation programme to date with the goal of delivering operational information services for environment and security in five main areas: land, marine, atmosphere, emergency response and security. The overall programme and the Services Component are led by the European Commission while ESA has the role of coordinating the GMES Space Component."

2.3 Telecommunications and integrated applications

Telecommunications satellites were the first applications sent into orbit and since 1960s they have been helping humans to communicate and share information. In the 2009 Annual Report ESA states that "the European space industry could not exist without a healthy satellite telecommunications industry, which accounts for over 60% of the total satellite industry turnover and about 90% of commercial launches. Satcoms provide more than 200 000 jobs directly and indirectly to highly qualified European citizens" (Annual report 2009, 27). Telecommunications satellites vary in their shapes and sizes according to what purposes they are used for, they circulate on different orbits and they will always be one of the most important applications for scientists, industries and us humans.

2.4 Development of new technology and launchers

Developing new technologies has always been ESA's top priority. Since 1970s enormous progress can be seen because without constant development and research ESA would not be able to compete with the USA or Russia. All European industries take part in developing processes, from microscopic particles to huge launcher. At the present ESA has been using Proba satellites which are sent in orbit in order to test the efficiency and usefulness of new technologies before launching real satellites.

Launchers play a key role in sending satellites into space. ESA uses two launchers built and developed under its name: Ariane and Vega. Ariane launchers are capable of carrying up to 10 tons into orbit. Ariane 1 was used in 1979 for the first time and could carry maximum weight of 1,83 tons. Ariane 5 shows very successful and fast development as in 1997 it could carry up to 9,5 tons. (ESA, Launchers) In this field ESA cooperates with Russian Federal Space Agency and therefore it is able to use Russian Soyuz launchers which can carry not only satellites but humans into space as well. ESA is proud to have its own launch base in Kourou in French Guiana where the Soyuz launch base was also built and is available for RFSA launches.

2.5 Human spaceflight and explorations

European astronauts have been taking part in space actions since 1980s. The first European astronaut was Ulf Merbold who flew into space in 1983. In 1990 ESA established the European Astronaut Centre in Germany, a facility for astronauts' selection, training and medical support. (Feustel-Buechl 2003,8) Without this base ESA would not be able to send astronauts under its name. However, human spaceflights are in general based on close cooperation of Europe, the USA, Russia, Japan and Canada. Together they have built the International Space Station (ISS) which construction started in late 1998 after Russian launch its first part, the Zaria module. ESA provides this information about the ISS:

- it is as heavy as 400 tons and as big as a football pitch,
- it was impossible to launch the ISS at once and due to that fact the building of the ISS has been done in-orbit,
- the ISS flies around 400km above the Earth,
- it is the most ambitious scientific and technological programme done in such joint partnership. (ESA, International Space Station)

ESA has contributed to the ISS with two very successful modules:

- The first one is the Columbus laboratory. It provides scientists with the ability to do researches and experiments in zero-gravity conditions. Researches in Columbus ground can easily reach the data from in orbit experiments.
- The ATV (Automated Transfer Vehicle) is a space ship built to supply the ISS with food, fuel and other supplies needed. This spacecraft is unmanned and navigated to be precisely attached to Zvezda module. The third ATV is planned to be launched in the first half of 2012. ESA is currently working on the evolution of the ATV which would be able to come back from the orbit to the Earth and bring the research results which could be examined by scientist on ground.

2.6 Galileo and navigation related activities

The United States has the GPS or so-called NAVSTAR, Russia has been modernizing its GLONASS and therefore EU represented by ESA could not stay behind. Since 2001 ESA jointly with the European Commission have focused all efforts on creating their own global navigation satellite system (GNNS), Galileo. However, Galileo is not ESA's first effort to enter GNSS field. At the present ESA operates the European Geostationary Navigation Overlay Service (EGNOS). It decodes GPS signals and provides Europe with less than two meter accuracy. With EGNOS and fully operational Galileo not only Europe but the whole world will be able to use first GNSS targeted to civilians and not developed mainly for military purposes.

2.7 ESA budget for years 2011 and 2012

Every year ESA publishes its budget for an upcoming year. The amount of invested money into each programme basically says what fields are currently ESA's priorities. However, none of these programmes could exist without development and funding of others. Observing of the Earth seems to be the most significant one but second place has been taken by the Galileo project and navigation-related activities in the year 2012. At the moment ESA is trying extremely hard to place Galileo in orbit by 2015 otherwise it might lose the space planes reserved for the European navigation system. The money spent on all ESA's programmes can be seen in this table:

Table 1. ESA budget for 2011 and 2012

M €	2011	2012
Science and robotic exploration	592.2	602.7
Earth observation	843.9	861.4
Telecommunications and integrated applications	341.3	330.0
Development of new technology and launchers	717.6	659.0

Human spaceflights and explorations	410.9	413.3
Galileo and navigation-related activities	665.7	720.7

Source: Data collected from All about ESA 2011 and ESA, Funding.

3 GNSS – GPS AND GLONASS

Global Navigation Satellite System (GNSS) is the system which uses ultra-precise clocks placed in orbit satellites to obtain the information about a position of an object on or near the Earth surface. At the moment there are several satellite-based positioning systems. The most ambitious systems are GPS, GLONASS and Galileo. Before defying Galileo there is a need for understanding other GNSS systems. There are also other regional navigation systems like Chinese Pej-tou (Compass) or Japanese Quasi-Zenith Satellite System but these are not going to be described into any detail.

The predecessors of present GNSS systems were American Transit system and Russian Tsikada. They were developed in 1960s and 1970s and both systems used low orbit satellites (about 1 100 meters above Earth's surface). They were used mostly for military purposes. However, they encountered two problems. They lacked accuracy especially in the determination of height and due to the low number of satellites users could obtain the information about the position only when having the satellite visible to the receiver. It might have taken up to 90 minutes. Transit was closed done in 1996 but Tsikada is still operational. (Hofmann-Wellenhof, Lichtenegger and Wasle 2008, 4-5)

These older systems' weaknesses certainly helped while developing present systems. GPS, GLONASS and Galileo share similar structure and are operational through three segments: space segment, control segment and user segment.

The space segment is a constellation of in-orbit satellites which circulate around the Earth approximately 20 000 km above the surface. At least four satellites must be visible to the ground receiver. These satellites have to carry atomic clocks, radio transmitter and receiver and computers. Each of them should be equipped with solar panels in order to gain the energy from the Sun.

The control segment, sometimes called ground segment, takes the control of the whole system. It consists of ground bases, antennas and master stations which continuously receive data from all in-orbit satellites and transmit them back. This segment carries the biggest responsibility as it has to monitor and maintain the satellites as well as keep this service available only for authorised users.

The user segment can be easily defined as the last destination of the signal transmitted from a satellite. Direct users and receivers both belong to this segment. The users can be military or civilian depending on what authority the users obtain. The huge selection of receivers with the ability to decode signals is currently available on the market for the direct use of civilians.

3.1 GPS

The Global Positioning System (GPS) or sometimes referred as NAVSTAR (Navigation System using Time and Ranging) is a GNSS programme developed and maintained by the United States of America. At the present days it serves for both military and civilian use even though it was previously targeted at American military purposes only. It has been in full operation since July 17, 1995 and it is available for users all around the world.

The Cold War was a great justification for such a huge project which cost billions of American dollars. The initial development started in 1973 and after five years the first satellite was ready for being launched into orbit. However these early satellites were only in their testing phase. The launch of the first operational satellite was ready many years later in 1989. In the process of development the US Congress made the important decision and classified GPS as the dual-use system and therefore two levels of service are provided: the standard positioning service for civilian use and the precise positioning service for authorised users and military purposes. Since 1999 it has been going through the process of modernisation to satisfy military and civil interests and to stay competitive to future European Galileo programme. (Hofmann-Wellenhof, Lichtenegger and Wasle 2008, 309-319)

These days the GPS space segment consists of 27 operational satellites circulating about 20 200 km about the Earth’s surface and they are orbiting on six spaced planes. Each satellite is able to do two circles a day. This constellation should ensure that minimum of four satellites are visible to on ground receivers anywhere on the planet. GPS in-orbit satellites are either legacy or new ones. However, all of them are upgraded second generations of GPS Block II. Ten GPS Block IIA satellites are in-orbit with 7,5-year lifespan and provide codes for civil and military use. Twelve GPS Block IIR satellites orbiting around the planet have new on-board clock monitoring. GPS Block IIR(M) satellites have enabled civilians to use second GPS signal and also two military ones have been transmitted from seven of these satellites. Twelve IIF satellites are ready to be launched having 12-year lifespan, third civilian GPS signal and extremely precise atomic clocks. Two of them are already in-orbit. Note that 4 of these 31 satellites are decommissioned and are not transmitting signals at the moment. (GPS.Gov 2012)

The GPS control segment has one master control station at Schriever AFB, Colorado Springs, and four ground antennas at Cape Canaveral, Ascension Island, Diego Garcia Island and Kwajalein Island.

3.2 GLONASS

The Russian GLObal NAvigation Satellite System or GLObalnaya NAvigatsionnaya Sputnikovaya Sistema is satellite navigation system run by Russian government. The main purpose of this GNSS is stated in interface control document: "the purpose of the Global Navigation Satellite System GLONASS is to provide unlimited number of air, marine, and any other type of users with all-weather three-dimensional positioning, velocity measuring and timing anywhere in the world or near-earth space" (Coordination Scientific Information Center 1998, 5).

Its development started in 1976 and first three satellites were sent to orbit in 1982 but they never became operational. In 1993 twelve operational GLONASS satellites were in orbit but it took another three years to reach 24 operational satellites. On 18 January 1996 full operational capability was declared but the number of healthy satellites started to drop soon after this date due the short life-span. In full operation, GLONASS signals were available both for military and civilian users although their rights were restricted. In 2001 only six GLONASS satellites were able to transmit signals and the desperate need for modernisation arose. The process of modernisation took 10 long years but successfully, in October 2011, 24 satellites were again orbiting and transmitting healthy signals. These satellites circulate approximately 19 100 km above the surface in three spaced planes. Such constellation provides visibility of at least five satellites anywhere on the Earth. (Hofmann-Wellenhof, Lichtenegger and Wasle 2008, 341-363)

The GLONASS control segment is not distributed worldwide but control centres, synchronizers and TT&C stations are only within the Russia.

The biggest difficulty GLONASS is facing at the moment is in the user segment. Even though it is in full operation the commercial use is increasing very slowly. Most receivers are still only compatible with GPS and especially car navigations receiving GLONASS signals are costly in comparison to GPS ones. The brighter future could be seen in smart phone industry as Nokia, Sony-Ericson or Apple have been working on products that should benefit from both GPS and GLONASS satellites (Abraham et al. 2011, 50-59).

4 EUROPEAN GNSS – GALILEO

Galileo is the European GNSS currently being under construction. It is a joint effort of the European Space Agency and the European Commission (EC) to provide Europe and the whole world with satellite navigation developed not for military purposes like GPS or GLONASS but directed to civilian use. The European Commission plays an important role because it is responsible for the political, legal and financial backup for navigation oriented activities. ESA covers development phases, development of technologies and processes of validation. Dated back to 1990s the EC and ESA set two main objectives. Firstly they wanted to increase the precession of existing GNSS and secondly they emerged a need for European own GNSS which would be independent from GPS and GLONASS. The EU established special authority called GSA which deals with public interests in European GNSS programmes.

4.1 EGNOS

It is important to define the first ESA/EC goal before continuing with Galileo. In 1996, works on satellite based augmentation system of GPS open public service signals began and later in 2005 EGNOS (European Geostationary Navigation Overlay Service) was officially made operational. Since then it has been continuously sharpening the accuracy of GPS to 3m enabling Europe to use the Safety-Of-Life service (e.g. airplane landing) which would be impossible due to lack of high accuracy (approximately 20m). EGNOS space segment consists of three geostationary satellites and its control segment counts four master control centres and a network of ground stations all over the Europe. At the moment these ground stations are being deployed into Africa as well. EGNOS has showed the desire for Europe’s own GNSS and it proved Europe’s commitment to Galileo. (Hofmann-Wellenhof, Lichtenegger and Wasle 2008, 425)

4.2 Defining the need for Galileo

Satellite positioning already plays incredibly important part in our everyday lives. People might not realize this fact but the use of satellite navigation has been affecting air, road and marine transport, agriculture, finance, telecommunication or civil protection just to name few. “The European Commission (EC) estimates that 6-7% of European GDP – around 800 billion by value – is already dependent on satellite navigation” (ESA, Galileo Navigation). However Europe is fully dependent on GPS which can easily raise a question of what

Europe would do if GPS was shut down. It creates concerns about reliability and availability of GPS signals in general because the GPS service is not guaranteed to be freely accessible all the time. The EC claims that if GPS signals were interrupted just for two days the consequences would be extremely costly and "it would cost Europe's transport and financial sectors about EUR 1 billion, if Galileo would not be operational" (Hofmann-Wellenhof, Lichtenegger and Wasle 2008, 366). Generally, Galileo will bring Europe political security and technological independence supported by ESA's statement that "European independence is the chief reason for taking this major step [for building Galileo]" (ESA, Galileo Navigation).

Galileo interoperability with GPS and GLONASS will also bring unquestionable advantage for both professional and everyday users. Increased number of orbiting satellites should provide even better coverage in urban and remote areas. Furthermore, Galileo will be fully compatible with EGNOS and the estimated accuracy should be counted in centimetres.

Moreover, Galileo is a huge economic opportunity for EU countries. At present, the majority of GNSS related applications have been developed in the United States but building Galileo such development might start here in the EU. Basically, everybody can be involved in this fast growing market including mainly industry sectors but also academic and scientific sectors should be mentioned. European Commissioner Loyola de Palacio (2001, 3) also highlighted the number of created jobs by stating that by 2020 satellite navigation will have created around 100 000 jobs.

4.3 Galileo project phases

The Galileo project is divided into four stages:

- the definition phase;
- the development and validation phase;
- the deployment phase;
- the operational phase. (Hofmann-Wellenhof, Lichtenegger and Wasle 2008, 367)

During the definition stage (1999-2000) main objectives and goals were set. The EC and ESA contacted the majority of European space industry and potential users to see their point of view. In this period several studies and cost benefit analysis contributed to the success of the first phase and the jump into the development phase.

The development and validation phase (2002-2008) dealt with development and manufacture of all components needed for orbit validation counting satellites and their parts as well as building ground bases. The success of this stage was demonstrated by launches of GIOVE-A (Galileo In-Orbit Validation Element) in 2005 and GIOVE-B in 2008. Both of them have been transmitting healthy signals.

The deployment phase has been in delay. The original plan was to launch all satellites until 2010 and Galileo should have been fully operational by today. However, first two operational satellites were placed in orbit on October 21, 2011 and because ESA claims that the deployment stage should take around 24 months the operational phase can be expected to start in 2014 (European Commission 2012). Just recently the EC has signed the contract with Arianespace and therefore Ariane 5 launchers which can carry 3-4 satellites at once will replace Soyuz launchers. This could hopefully speed up the deployment process.

4.4 Galileo services

Galileo as a civilian GNSS will offer different services than military ruled GPS and GLONASS. These services are designed to be available for wide range of users and therefore the whole approach of Galileo can be seen as service-oriented. The services are as follows:

- open service;
- commercial service;
- safety-of-life service;
- public regulated service;
- search and rescue service

The *open service* will be free and available to all users and it is targeted mainly at mass usage. It has not been confirmed yet how many signals will be provided. The open service signals will be available to anybody with a compatible receiver worldwide. This service should also combine both Galileo and GPS signals (possibly GLONASS too). However, due to its massive potential it will not provide any signal guarantee. The *commercial service* adds a greater value to the open one. With two more signals it will be able to provide better accuracy and timing but due to this “added value” the commercial service will be paid. The service will be run by authorized providers and Galileo operators which will give access to final users. It will possibly work on protection key bases. The *safety-of-life service* will work on the same principle as the open service but it will provide a needed guarantee. As previously mentioned this service is already being provided through EGNOS but with Galileo it will ensure the users with time-ahead warnings in case the signal went out. To be more concrete about the users of the safety-of-life service these include aeronautic and maritime users including both private and commercial sector. The *public regulated service* will be available all the time but it will follow special protection rules which should keep the service from hacking. This should serve governments and special authorized bodies like police or customs for safety purposes or investigations but also it will help citizens in critical situations. The *search and rescue service* will have a global impact on life saving operations. It is not a real navigation service but it will support the current COSPAS/SARSAT, “[which] provides accurate, timely and reliable distress alert and location data to help Search and Rescue authorities assist persons in distress” (COSPAS/SARSAT). Not only will Galileo shorten the time for detection and increase the accuracy but its main contribution will be a sent confirmation to a distress alert sender. For clarification, now if a boat is lost at sea and asks for help it never gets the feedback but that “feedback” is what Galileo will provide. (Hofmann-Wellenhof, Lichtenegger and Wasle 2008, 370-373)

4.5 Galileo segments

As already mentioned Galileo has a similar architecture like GPS and GLONASS. However ESA presents it differently and divides it into global, regional and local components. The enclosed picture shows the structure of Galileo architecture.

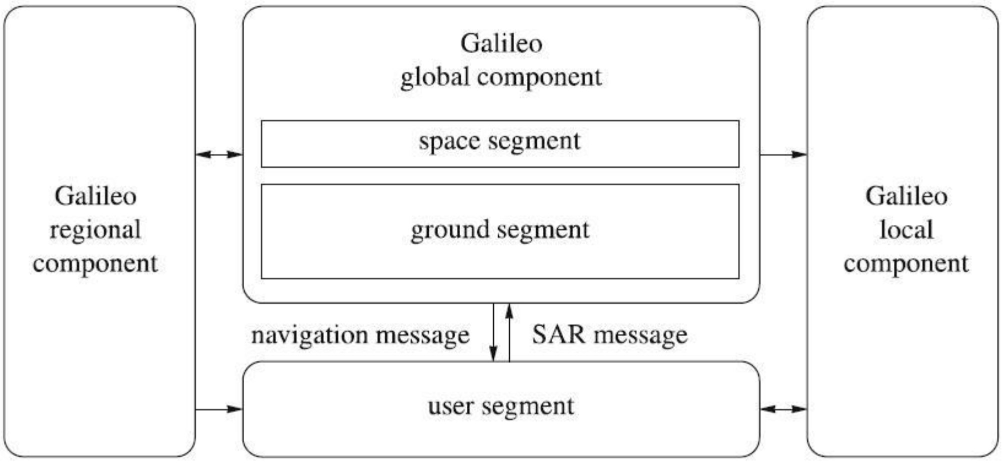

Figure 1. Galileo architecture. Hofmann-Wellenhof, Lichtenegger and Wasle 2008.

The global component is the most important part of the architecture because it consists of space and global segments having impact on the user segment as well as on the regional and local components. Being fully operational the space segment will consist of 30 Galileo satellites, 27 active and 3 spare, circulating approximately 23 000 km above the Earth's surface. Ten satellites will run on three orbital planes and the height and the constellation should guarantee at least 6 visible satellites anywhere on the planet. These satellites should have 12-year lifespan. The ground segment will be deployed into different places around the world with two main control centres, in Oberpfaffenhofen, Germany and in Fucino, Italy, five TT&C stations, nine uplink stations and forty Galileo sensor stations. This segment has two main parts: the ground control segment being responsible for satellite maintenance and the ground mission segment controlling the navigation systems. *The regional component* will serve for non-European countries or organisations etc. in order to provide full integrity of Galileo in regions outside of Europe and also to meet legal requirements of non-EU countries. *The local component* is designed to help locally and to supply better accuracy and precision. It will be employed for example at airports or harbours. (Hofmann-Wellenhof, Lichtenegger and Wasle 2008, 373-375).

4.6 Applications and market

Galileo applications will be focused mainly on civilian customers. The number of possible applications is countless and it only depends on imagination of developers. Many existing apps will be possibly improved in order to work with Galileo but the market for new applications is huge. The major part will be probably taken by the transport domain including road, air and maritime. Of course, it is important to realise that applications for road transport will mostly emerge from the open or commercial services, therefore a massive production of apps can be expected, whereas air and maritime transport will benefit from the safety-of-life service and apps for this market will count a lower number. Apart from the transportation GNSS technology is also used in location based services, agriculture, energy networks, environment control, finance or banking, fishing industry, civil engineering, security and health sectors, telecommunications and many other fields which might surprise regular users. Many events connected to development of new applications are being held such as Galileo Masters or Galileo Application Congress.

Considering the development of applications for GPS the market forecasts for Galileo are very promising. The current development is mostly being done in niche markets but the move into massive production is expected. Talking about real numbers, the turnover of GNSS related activities rose from 10 billion € in 2001 to nearly 60 billion € in 2005 and this growth was mainly in hand devices (smart phones, PDAs) and road navigation devices. The turnover forecast for 2020 is that satellite navigation products will increase to 180 billion €. (European Commission 2006)

A closer examination of one concrete application is not possible at this stage of Galileo as no further data or information about such applications are available yet. Furthermore, my technical background is not sufficient to explain given problem in detail and the range and concept of the thesis does not provide enough space and time to fully cover the application problem.

5 OPPORTUNITIES FOR THE CZECH INDUSTRY

The Czech space industry has a long tradition dating back to 1950s when the Military Academy Brno worked on development of 2-stage sounding rockets. More or less the majority of space activities were connected with Soviet interests. This political cooperation also led to Vladimir Remek's flight to the space in 1978 meaning that Czechoslovakia was the third country whose citizen entered the Universe. In the past, Czechoslovakia also developed several artificial satellites (Magion), laser spectrometer to explore Mars's moon Fobos or stabilised platform to study Halley comet for Vega spacecrafts. However after 1989 there was no significant space activity. The change might hopefully come after joining ESA and with the development of the Galileo project.

5.1 Major steps of the last decade

Since the year 2000 several milestones have happened and these may help and influence the growth of the Czech space industry. To name the most significant: the foundation of the Czech Space Office, becoming the member of the European Union, signing the Plan for European Cooperating States, becoming the member state of the European Space Agency, the release of the first National Space Plan, establishment of the Coordination Council for space activities, the development of Galileo and the transfer of the European GNSS Agency (GSA) headquarters to Prague.

In 2003 the Czech Space Office (CSO) was established as a non-profit organisation and it serves as a contact point for all space related activities. The Czech Space Office also provides opportunities for Czech institutions and companies to cooperate or join international space activities. The CSO also manages the relationship between ESA and the Czech Republic. It tries to inform the public about the space activities and opportunities and therefore organizes various seminars and workshops. Moreover it serves as the database of all Czech space projects and it keeps records of all institutions and businesses involved in space programmes. (Kolář 2011)

In 2004 the Czech Republic joined the European Union and since then it has been sharing EU's space objectives. These objectives count:

- the development of space applications which serve EU citizens in fields of development, environment and climate changes;
- meeting the security needs in all space related activities;

- contribution to the EU society by investing into space programmes and activities and therefore keeping the space industry healthy;
- provision of unlimited access to crucial technologies and systems in order to contribute to European space industry. (Ministry of Transport 2010)

The Plan for European Cooperating States which the Czech Republic signed in 2004 enabled our country to join ESA's programmes without being the proper ESA member state. This was the leading step for gaining the full membership latter on. During those four years under the cooperation, the Czech Republic spent almost 10 million € and for example the Academy of Sciences was given an opportunity to be involved in Cluster or Integral projects.

After conducted surveys of Czech industry in 2007, later in November 2008 the Czech Republic became the first ESA member state from former Soviet bloc. This membership binds our country to actively participate in ESA mandatory programmes and a financial contribution is also required. Such participation and contribution will return in the form of a contract with ESA on a certain activity. Apart from mandatory activities the Czech Republic can join optional ones according to interests. Mostly, cooperation on ESA's space activities is offered through open tenders and all these tenders in which Czech bodies can take part in are published on the portal called EMITS. Until 2014 our state is the member under special transitional group called the Task Force. This group helps with the adaptation process of our industry, scientific field and others in order to become an efficient partner for ESA and to gain some competitiveness. During the 6-year period (2008-2014) the Czech Republic contributes to ESA budget with only 45% of the mandatory share. This Task Force takes active part in preparation of tenders in which Czech institutions, companies and academic sector might participate. Under Czech Industry Incentive Scheme Czech bodies can submit their projects in order to get funding from ESA. The Task Force group closely cooperates with the Czech Space Office. Until 2011 the Ministry of Education, Youth and Sport funded all activities under ESA with the professional help of the CSO. (Ministry of Transport 2010) The participation in Galileo will be discussed later on.

These mentioned steps led to the publication of the first National space plan in the Czech history. It was prepared by the Ministry o Transport in close cooperation with the Ministry of Education, Youth and Sport, Ministry of Trade and Industry and Karel Dobes, the Government Commissioner for Galileo, and professionals from Czech industry and academic world were also consulted. This document represents a basis for the potential progress of the Czech Republic, it determines fields and programmes in which our state could participate and it proposes guidelines to maximise returns on investments. The National space plan was approved by the Czech governmental body for the EU in May 2010. The National space plan has a significant meaning for our country because it sees the future in space related activities and their importance for national and industrial growth. The detailed National plan with economic analysis of future space activities including the funding should have been submitted to the Prime Minister of the Czech Republic by the end of 2011. However, it is expected to be published within next few months.

The approval of the National space plan led to the establishment of the Coordination Council of the minister of transport for space activities (Coordination Council) approved by the Czech government on April 20, 2011. Since then, the Czech Minister of Transport jointly with ministers of education, youth and sport, industry and trade and environment have been fully responsible for coordinating space activities of the Czech Republic. The minister of transport has also become the representative for space activities on the international scene and he chairs the Czech Task Force group. (Czech Gov. 2011) Apart from the Coordination Council the Ministry of Transport also operates the Department of space technologies and satellite systems through which it informs the general and professional public about current situation of European space programmes and activities.

5.2 Current situation of Czech space entities

Currently, the Czech bodies both academic and industrial have to change the perception of space activities. Space should not be longer viewed only as a scientific field. The attention should be paid to its economic, strategic, political and safety benefits. The main problem of Czech academia and industry is the low number of entities that are able to compete on European space scene in order to be successful in wining tenders. Another issue is the lack of awareness among Czech institutions.

5.2.1 Academia

Czech academic institutions have been always interested in space projects and very often they are involved in projects jointly with companies. In the first Czech Industry Incentive Scheme Czech Technical University and the Academy of Sciences were the most successful and were given 5 contracts (Projekt 43 2011). However, it is important to mention that there are other academic institutions that CSO registers including several departments of Brno University of Technology, Charles University in Prague or the University of Pardubice. Regarding the National Space Plan (2010) Czech academia plays an important role in providing analytical and experimental background before projects are developed and in end phases it is the academic sector that validates collected data. However, the research and development of Czech academic institutions still has its reserves, the universities do not pay enough attention to ESA tenders but on the other hand they should be better informed about such opportunities by CSO and the Coordination Council. They also need to establish cooperation with business and industry and then jointly try to take part in space programmes.

5.2.2 Industry

Similarly to academia the Czech industry has a great potential to be involved in space activities. Czech companies are able to produce high standard technologies which contribute to the prestige of the Czech Republic. Even the ESA survey, which led to the admittance of our country as the ESA member state, proved that Czech industry has a lot to offer and it can compete on European market. Currently, Czech companies are successful as subcontractors in several ESA programmes but it means that they only support larger and better companies from other countries. Such cooperation is a good start but it will not raise the competitiveness of the Czech Republic. The National Space Plan (2010) analyses main hardware and software competences of Czech industry which include development of:

- design and manufacture of high-precision mechanical parts and assemblies
- design and manufacture of electronic components
- terminal equipment (aircraft)
- opto-mechanical and opto-acoustic device
- advanced materials technologies
- precise X-ray cameras
- embedded software, satellite control systems and other ground segment, as well as flight software
- satellite positioning technologies and infrastructure (EGNOS, Galileo)
- basic technologies for Earth observation, data processing and applications
- satellite communications

- satellite navigation user applications.

Recent trends also show that Czech companies do not know how to participate in ESA tenders but moreover, mainly due to the lack of information, they are reluctant to apply for them. The National Space Plan (2010) also explains that despite advanced technologies, which could relatively easily participate in space programmes, companies lack motivation to overcome initial obstacles and they have difficulties dealing with high requirements. Big companies are discouraged by ESA profit margins because such contracts allow maximum of 8%. It is a minimum profit for huge companies but it might be interesting for Small and Medium Enterprises (SMEs) which are however too often pushed back and not taken into account. It is a vicious circle which should be eliminated as soon as possible in order to improve the status of Czech industry. ESA activities should be seen as an opportunity to develop new technologies, services and products that will be then commercialized bringing the return-on-investment.

5.3 The Czech industry and Galileo

As previously mentioned the definition phase of the Galileo project, during which all important decisions were made, took place before the Czech Republic joined the EU and ESA. Therefore the Czech industry could not participate in the development stage of the space segment. Still there is a possibility to get Czech entities involved in development of other segments. Czech industry can participate in Galileo's final stages as a subcontractor in ESA's optional programmes. However, the biggest opportunity for Czech companies and academic sector has been identified in the development of new applications for GNSS.

The Czech Republic as the member of ESA is well aware of importance of getting involved in Galileo but it is crucial to inform Czech professionals as well as general public. Therefore in 2008 the Ministry of Transport initiated so called Galileo User Forum (GUF) Workshops. Eight workshops have been held so far and they took place in the Prague House in Brussels and in Prague. As mentioned by Space Technologies and Satellite Systems Department operated by the Ministry of Transport, the main objectives of these workshops are to identify end-users needs in order to use collected information for development of new applications for Galileo. These workshops involve professionals who usually have discussions with ESA, EU and GSA representatives for GNSS matters.

Another important step which shows the dedication of the Czech Republic to become more space oriented is the candidature to host the seat of GSA in Prague. The 6-year effort ended up successfully in January 2012 when the Minister of Transport of the Czech Republic Pavel Dobes and the Executive Director of GSA Carlo Des Dorides officially signed the transfer of the European GNSS Agency from Brussels to Prague (Kosmický projekt 2012). GSA should start operating from Prague during this summer. This transfer has a huge potential for the Czech industry and academia mainly because:

- most certifications of future applications will be done in the Czech Republic,
- information will be obtained directly from GSA offices in Prague,
- conferences will be held in Prague.

Having GSA in Prague will bring a competitive advantage for Czech entities and especially for Information and Telecommunication Technologies (ICT) sector. Development of Galileo applications will be a fast growing market in next few years with almost no limitations and if Czech entities did not start now it might be too late to catch up especially for Czech SME.

5.3.1 Czech applications

In spite of the fact that Galileo is still in process of deployment, development of potential future applications has already started. Since 2004 the European Satellite Navigation Competition has been raising awareness among professionals interested in GNSS applications by selecting the best ideas from 20 different world's regions including the region of the Czech Republic. (The Galileo Masters team 2012a)

Regarding the Czech region the most successful company is PRINCIP, a.s. represented by Vladimir Vejvoda. The company won the Regional price in 2006 for its Non-Discrimination and Value-Added On-board Telematics and Tolling Unit[1]. This company participated again in 2011 introducing MEFID – the Mobile Epileptic Fit Detector[2]. Apart from being the regional winner it gained a global recognition by winning the third place in the world round. However these applications are currently in the process of testing.

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[1] A toll collection system based on communication between an on-board unit and electronic toll collection which should reduce building of toll gates (The European Satellite Navigation Competition 2007).

[2] "The Mobile Epileptic Fit Detector (MEFID) is a mini-sized, mobile, remote unit that can rapidly detect signs of an imminent epileptic attack in children patients, and thus help save their lives" (The Galileo Masters team 2012b., 42).

Regarding the domestic interest in the European Satellite Navigation Competition only eight projects participated in the last year (The Galileo Masters team 2012b, 9) which again shows the lack of general attention paid to Galileo related activities. Currently, new projects can be registered until June 30, 2012 to participate in this year round and the question is whether the transfer of GSA offices increase the number of Czech participant or not.

5.4 Awareness

Throughout this chapter the lack of awareness was mentioned several times as the main cause of low number of space activities in our country. In the National Space Plan (2010), the Czech Government admits that the low recognition of space activities is the biggest downside and this has to be improved. Informing the professional community goes in hand with the need for fostering the cooperation and exchange of information between all involved entities.

Public knowledge on space activities of the Czech Republic is very limited and building awareness will be the major step towards public's interest and support. Using the instruments which help to promote space problems such as media will help to attract the public. In the case of space activities, it is important to focus on the potential of space activities and on what they could bring to the whole society. In order to catch the initial attention, already existing products or applications which are beneficial to everyday life must be used for promoting future ones. These days media however cover mostly international space activities, they inform about space events which are not held in the Czech Republic but domestic ones are those that need to be pinpointed. (Projekt 43)

During the research, I have encountered several problems myself while exploring web pages of institutions that should provide detailed information about the Galileo project. Firstly, I need to mention the Czech Space Office. It has been 10 months since I entered the section about Galileo on their web pages but apart from few paragraphs and unavailable picture the page still says "under construction, more information coming soon." Secondly, the Ministry of Transport plays the key role in space activities but when searching for Galileo on their web sites no articles were found and it does not even direct you to their Space Technologies and Satellite Systems Department web page. This site gives readers some information about space activities but these are again very limited. However, the Space Technologies and Satellite Systems Department informs about current and future events connected to space activities.

All in all raising public awareness is the key aspect that needs improvement and if done precisely it might change the future of the Czech industry, its competitiveness and global status. The guide could be seen in the project called *Space activities of Czech companies - Strategy for international competitiveness of the Czech Republic for the period 2012 – 2020* which was approved by the Government in 2011 and which explains in detail which steps have to be taken in order to make the Czech industry more competitive.

Although few opportunities are brought directly by Galileo the development of such huge European project and having GSA offices in Prague should change the perspective of Czech industry and academia on space activities and should help while raising desperately needed interest in space activities.

6 OPPORTUNITIES FOR TOMAS BATA UNIVERSITY

The research has shown that currently Tomas Bata University is not significantly involved in any space oriented activities which I find very unfortunate. However, I consider the state of research and development for innovations to be on a very high level which gives the university possible opportunities to participate in space programmes offered by the EU and ESA. The recent development of CEBIA-Tech, the regional research centre, will provide the university with new research and development capabilities in fields of applied informatics, security technologies and alternative energy sources. This centre will certainly help the university (especially the Faculty of Applied Informatics) to succeed in potential space projects and to work on development of Galileo applications. CEBIA-Tech should be opened in June 2012. The list of CEBIA-Tech equipment in the Czech language can be found in appendices.

Further opportunities might be brought by the Laboratory Centre of the Faculty of Technology which will be finished in September 2013. This new technology park will focus mainly on the polymer research and development.

6.1 Cooperation with business and industry

Unfortunately, there might be one specific obstacle. In order to successfully participate in space projects more attention has to be paid on cooperation with business and industry. The easiest way might be to concentrate on establishing cooperation with companies, which reside in the close distance to TBU, and then foster such collaboration. Companies might not be aware of research and development capabilities of TBU and therefore the burden of contacting professional sector is carried by the university. Attracting regional companies involved in space activities could be easier if the promotion of CEBIA-Tech is done effectively.

The Czech Space Office gathers private companies and research institutions which work or are interested in space activities. There are three companies in close distance to TBU, namely 5M in Kunovice, MESIT pristroje in Uherske Hradiste and Meopta – optika in Prerov, which would be worth cooperating with. All of them might show an interest in CEBIA-Tech R&D facilities.

The main area of 5M is production and development of structural composite parts, pultruded profiles, structural epoxy adhesives, sandwiches, epoxy resins, aluminium honeycombs, foil adhesives, preimpregnated fibres, precise sandwich surfaces for optics, etc. (CSO 2011, 4)

MESIT pristroje spol. s r.o. concentrates on instrumentation for measuring physical variables with aircraft applications, and static single-phase and three-phase voltage converters up to 7200 VA, 3x 36 V/400 Hz, 3x 115 V/400 Hz. It also focuses on instrumentation for controlling generators and control boxes for starting and controlling the operation of air generators. (CSO 2011, 100)

Meopta – optika has a field of expertise in optical and mechanical production, assembly, research & development, optical systems design, thin film rating design, mechanical components design, measuring methods design, spectral and interferometric measurements. (CSO 2011, 98)

6.2 CSO seminar

During my research I cooperated with Mr Milan Halousek, the Head of Education of CSO, who provided me with valuable information about how could our university participate in space programmes. Mr Halousek offered to conduct a seminar preferably for academic staff and students interested in space activities. Such seminar would be the most efficient way of learning how to get involved in space activities. The seminar will take approximately 10 hours and in the first part CSO representatives will inform participants about the Czech Space Office and European Space Agency mentioning concrete opportunities for involvement in both ESA educational projects and ESA research and development programmes. The second part will be dedicated to the Standards of ESA, the National Incentive Scheme, the Basic Technology Research Programme, the Science Programme and PROgramme de Développement d'EXpériences scientifiques (PRODEX).

Mr Halousek’s contact details were given to doc. RNDr. Vojtech Kresalek, CSc. for further consideration of possible realization of such seminar under CSO conduct at TBU.

CONCLUSION

Nearly everybody knows what GPS means. People use this abbreviation in their everyday lives but more or less they mean car navigation devices rather than the satellite navigation system. However, people do not realise how much they are affected by GNSS and furthermore they cannot see the consequences of not being able to use it. The dependence on American GPS and the possibility of banning its signals for Europe made the European Union start developing Galileo, the European satellite navigation.

The Galileo project is currently in its deployment phase and European citizens cannot see its benefits yet but from all corners of Europe one specific question can be heard. Why do we need Galileo? Unfortunately, people see the expenses without considering the bigger picture. Galileo is expensive but it will improve position reliability and precision. It will stimulate the economy and improve EU's competitiveness in GNSS field. Galileo will create new jobs and boost industry in European countries, including the Czech Republic. The biggest opportunity is seen in the development of applications mainly due to its limitless character. Simply said, each one of us, if having an idea, can profit from Galileo.

Even though the Czech Republic is the member of ESA space activities are mostly viewed as a scientific field. However, Galileo and all space related programmes have to be seen as an opportunity for our industry. They are strategic tools that might help Czech companies and academic institutions to become more competitive. Therefore, it is fundamental to inform the Czech community about space activities and programmes which affect our country. In order to succeed in ESA tenders the Czech authorities have to raise awareness among business and academic professionals and foster cooperation between all involved entities. Being aware goes hand in hand with understanding and upon understanding support can be built.

It might be too early to predict whether Europeans start using the word Galileo instead of GPS or whether Galileo meets all expectations. Huge and expensive projects are hard to justify before they actually work but in the words of Galileo Galilei "facts which at first seem improbable will, even on scant explanation, drop the cloak which has hidden them and stand forth in naked and simple beauty."

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LIST OF ABBRIVIATIONS

ATV	Automated Transfer Vehicle
CERN	European Organization for Nuclear Research
CSO	Czech Space Office
EC	European Commission
EGNOS	European Geostationary Navigation Overlay Service
ELDO	European Launcher Development Organization
EMITS	Electronic Mail Invitation to Tender System
ESA	European Space Agency
ESRO	European Space Research Organisation
EU	European Union
GIOVE	Galileo In-Orbit Validation Element
GLONASS	Globalnaya Navigatsionnaya Sputnikovaya Sistema
GMES	Global Monitoring for Environment and Security
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSA	European GNSS Agency, formerly European GNSS Supervisory Authority
GUF	Galileo User Forum
ISS	International Space Station
MEFID	Mobile Epileptic Fit Detector
NASA	National Aeronautics and Space Administration
NAVSTAR	Navigation Signal Timing and Ranging
RFSA	Russian Federal Space Agency
Satcoms	Satellite Communications
SME	Small and Medium Enterprises
SOHO	Solar and Heliospheric Observatory
TT&C	Telemetry, Tracking and Control

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APPENDICES

APPENDIX I: CEBIA-TECH EQUIPMENT

Pořadové číslo	Přístroj	Rok pořízení	Cena bez DPH (Kč)	Výzkumný tým
1	Vakuová pumpa	2011	95 920,00	3
2	Titrátor	2011	199 100,00	3
3	Tavicí analyzátor	2011	83 630,00	3
4	Viskozimetr	2011	144 000,00	3
5	Analyzátor spalin	2011	133 266,00	3
6	Skenovací mikroskop atomárních sil	2011	7 862 337,30	2
7	Spektrometr mm a submilimetrových vln	2011	7 474 551,00	2
8	SW pro návrhy elektronických obvodů	2011	232 752,00	2
9	Generátor GHz signálů	2011	648 430,00	2
10	Násobiče kmitočtu až do 325 GHz	2011	819 480,00	2
11	Měřicí technika	2011	3 249 530,00	2
12	A Zařízení pro měř.obruš.polymer.mat. a kompoz. B Přístroj pro pádové zkoušky C Nanotvrdoměr	2012	8 950 900,00	1
13	3D souřadnicový měřicí stroj	2011	2 404 673,00	1
14	3D dvoukomponentní tiskárna	2011	6 375 000,00	1
15	Mobilní laserový scannovací systém	2011	3 383 391,00	1
16	Průmyslový robot	2011	756 600,00	1
17	Měřicí a diagnostická technika	2012	1 139 247,51	1
18	HW vývojové prostředky	2012	550 846,00	1
19	Programové vybavení pro embedded systémy	2012	601 840,00	1
	Celkem		**45 105 493,81**	

Souprava pro měření tlaku a teploty	v plánu 2012
Kapalinový chromatograf	v plánu 2012
Vektorový obvodový analyzátor s příslušenstvím do 325 GHz	v plánu 2012
Generátor pro EMC odolnost včetně anténních systémů	v plánu 2012
Satelitní spoje	v plánu 2012
Dvoukomponentní vstřikovací stroj	v plánu 2012
Optické stoly s vybavením	v plánu 2012
Vstřikovací stroj	v plánu 2012
Kombinovaná měřicí komora	v plánu 2012 - 2013
Akustické zařízení	v plánu 2013
Zařízení k VaV regulačních systémů	v plánu 2013
Kalibrační zařízení	v plánu 2013
Testovací manuálně měřicí zařízení	v plánu 2013
Zařízení k měření proudění	v plánu 2013