# EVALUATION OF THE AIR TRANSPORT EFFICIENCY DEFINITIONS AND THEIR IMPACT ON THE EUROPEAN PERSONAL AIR TRANSPORTATION SYSTEM DEVELOPMENT

**Prof. Dr Jozsef Rohacs**
Department of Aircraft and Ships
Budapest University of Technology and Economics

## 1. INTRODUCTION

The large US SATS (Small Aircraft Transportation System [1, 2, 3] and EU supported EPATS (European Personal Air Transportation System [4, 5]) projects target to develop and introduce new transportation system based on the newly designed small and smart aircraft mostly personal used in completely redesigned and rebuilt airport and ATM systems [2, 3, 5, 6, 7]. Introduction of such innovative system can be characterized by innovation diffusion process [8, 9, 10].

The diffusion of innovation is the process by which an innovation is communicated through certain channels over time among the members of social system [11]. The penetration of the new innovative system into society and economy can be characterized by "S" curve [12]. In case of earlier time of diffusion, when only the relatively small number of users, called innovators and early adaptors are applying the new system, the evaluation of efficiency of the new system plays a determining role.

Generally, it seems the efficiency can be defined and applied for evaluation of the new technology easy. However, the efficiency means different meaning for different group of people, like designers, operators, users, owners, stakeholders, or simple "neutrals", namely for those who does not belong no one from the named groups. So, the new system must be evaluated with use of different terms, different methods, as technical or energetic efficiency, benefits, etc.

This short paper tries to summarize the different definitions of efficiency and their use for evaluating the EPATS and their impacts on the EPATS development process.

## 2. THEORETICAL CONSIDERATIONS

In the EU a one % growth of GDP generates increasing in passenger and freight transport about 0,4 and 2,2 % respectively. The transport is one of the Europe's strengths contributes more then 13 % of EU GDP and it is giving job up to 18 million persons [13].

The air transport is the major contributor to the transport employment. In Europe 1.5 million jobs induced directly by air transport [14].

Air transport as a capital-intensive business, productivity per worker is very high – indeed it is three and a half times the average in other sectors (Fig. 1.).

It is true, too, the transport uses the 30 % of energy consumption, 98 % of which is depend on oil. The transport is the largest sector of economy that pollutes the carbon-dioxide, playing determining role in climate change [15].
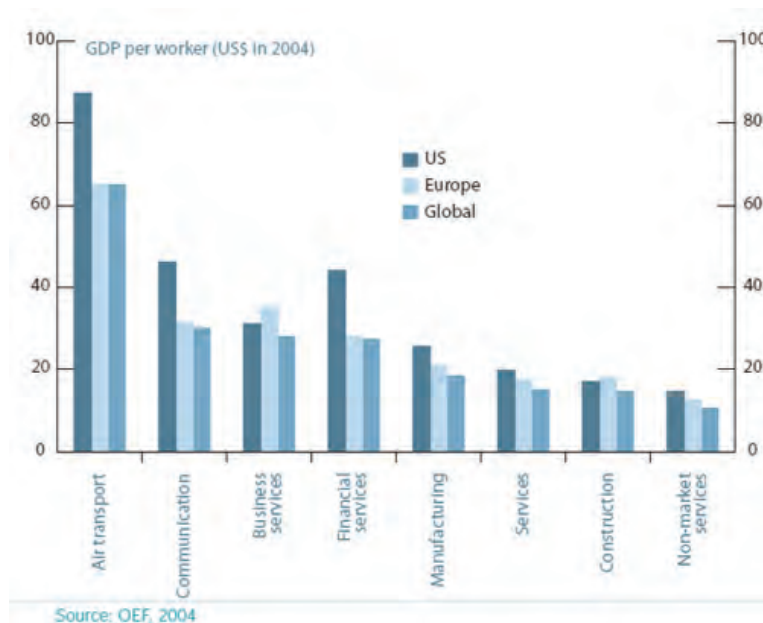


*Fig. 1. Transport as a capital intensive business*

The EU has a strong plan for developing the effective, affordable and sustainable transport systems and European transport networks [16]. However, the established transport systems tend to their capacity limits. Even the air transport has a problem of airport and air traffic management capacities [17]. The future transport systems should make possible the people and goods mobility with increasing the affordability, accessibility, efficiency, sustainability and security. The future transport must use the air more widely. The some part of personal transport must be climb to the third dimension, into the air [2, 5, 6, 7, 18].

The PATS is a new system changes our mind about the air transport, bringing to us a new vision on the personal used aircraft that can be own, rented and piloted by common people having limited training and knowledge in aeronautics [2, 3, 5]. We can say that the PATS is the US Ford T, French "Duck" or VW Beetle for the future aviation that will bring the high technology, on-demand, fast and effective transport to public. However the PATS has influence not only on the society, but on the economy and on the future of our community, too.

From the engineering point of view the systems, products, events can be characterized with use of ratio of the effective or useful outputs to the total input that is called as efficiency [19]. Generally speaking, the efficiency describes that what we can have for which.

The efficiency can characterized by using the different indicators. For example, the price efficiency is the degree to which the prices of assets reflect the available marketplace information. It is easy to understand, there are too many different indicators can be applied to evaluation of the efficiency.

It seems that the efficiency can be defined easy as the state, quality or grade of being efficient. The efficient means performing or functioning in the best possible manner. With use of another words, efficiency is the competency in performance. So, it is the ability to accomplish any task with a minimum expenditures (use of time and efforts). Shortly, the efficiency is the degree to which a system or component performs its designated functions with minimum consumption of resources.

On the other hand it is a difficult task to evaluate the efficiency, because this term has different means for the different peoples, while transportation system itself has determining role in economy and society [20].

The efficiency depends on the:
- performance, characteristics chosen for its grading,
- needs and requirements defined by individuals, society and economy,
- available scientific results, technology and
- possible alternatives (comparison to other systems).

The efficiency of the new transportation system can be investigated on the different levels, i.e. levels of interest and levels of dimensions. In first case the evaluation of efficiency depends on the target goal, namely the future transportation system can be evaluated from energy, cost, individual (or personal requirements), society and community point of views (Fig. 2.). In second case, the dimensions of the systems can be classified as the vehicles, given transportation system (EPATS), general transport, sector of economy and economy.
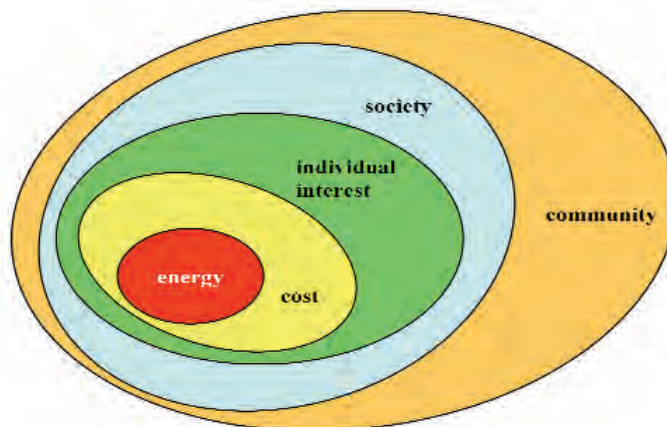


*Fig. 2. Fields of interest in evaluation of the future transportation system*

The comparison of the different transportation modes can result to different ranking depending on the levels of interest and dimensions. Even the efficiency is not the simple term.

As it can be seen, the efficiency depending on the competence in performance, can not be defined and determined easy, because too many characteristics having influences on it. Therefore the efficiency must be defined for different levels of interest and dimensions, and can be described by quantitative and/or qualitative characteristics. Even instead of term efficiency some others, like influence, impact, demand, accessibility, affordability, acceptability, etc. can be defined. In some case only the benefit analysis can be performed.

## 3. EFFICIENCY DEFINITIONS

The general definition of the efficiency has given already, since it is the state, quality or grade of being efficient. At the same time, there are not references trying to determine and evaluate the efficiency generally. A series of papers deals with the energetic efficiency, efficiency of operation, etc. [21 – 24], analyses the trends of air transport developments [25 – 27] and applies the special models [8, 10, 18, 28 – 33] for investigation of the different characteristics of the air transportation system.

Our preliminary studies show that, in practice, the efficiency can be defined differently for each subspace shown in Figure 3.

The elements of the cub of efficiency evaluation can be defined with use of some references or dictionary (like [19, 33].

Impact is the striking of one thing against another. It is well known from innovation theory that the introducing the new system always generates conflicts with the earlier established, so called conservative systems. In our case it means that the PATS has impact on the general aviation, airport systems, applied ATM and other transportation means (like road transport) by changing the way of using the personal transportations, etc.

The influence is the capacity or power of persons or things to be a compelling force on or produce effects on the actions, behavior, opinions, etc., of others. The influence is wider effect on the others then impact. While impact can be evaluated as the conflict with other system, the influence includes all the effects. It is easy to understand that, the PATS will initiated many positive effects on the other transportation means, too. New airport networks will be established, general aviation should be increased radically, new ATC/ATM system must be developed, etc. even the road and railway transport development will be redefined after introducing the PATS.

The demand characterizes the state of being wanted or sought for purchase or use. So, the PATS performance that covers the requirements of possible users of the new air transportation system in ratio for which the users are willing to pay can define as the demand. So, the demand model must evaluate the new PATS as the new system for which the users are ready to pay. Of course, such characteristics are depending on the affordability, accessibility, etc. describing the user friendly system.

The benefit is something that is advantageous or good. The investigation of the benefits of PATS deals with the advantageous of introduction of the new transportation system. Often, when the efficiency, namely grading of the goodness, can not be realized, or can be determined with use of too much information, only, the benefit analysis can apply.

Figure 3. shows that all the effects, as impact, influence, demand, benefit and efficiency depend on the point of view and size.
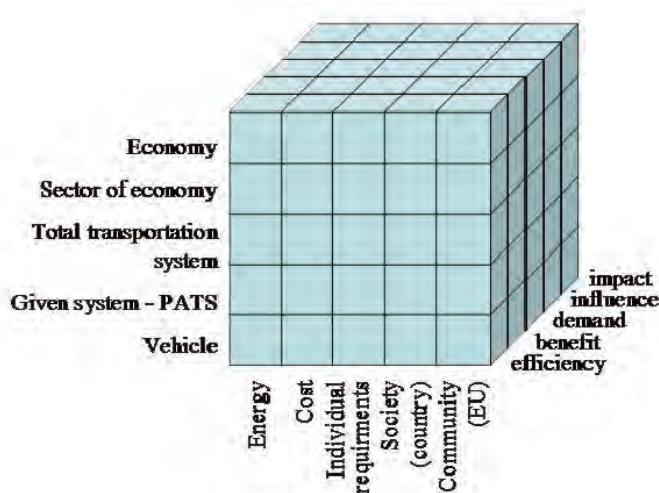


*Fig. 3. Cub of the efficiency evaluation*

With use of energy or energetic point of view, the new system PATS must be investigated and evaluated on the grades of energy consumption.

The cost is the most common used characteristic for evaluating the different systems. It is well understood by people, and mostly use by companies for evaluating their works, their results.

The individual interest of people mostly depends on the cost. However, the individuals are evaluating the transportation systems on the safety characteristics, time effects (as from door to door speed), affordability, accessibility, etc.

Accessibility is a general term used to describe the degree to which a system is usable by as many people as possible without modification. Accessibility is about giving equal access to everyone. Affordability means that the given system covering the minimal needs of users can be afforded, i.e. it is within the one's financial means. The grade of capable or worth of being accepted figures by acceptability.

Of course from the definitions of terms accessibility, affordability and acceptability it is clear the using of the new system like PATS depends on the design performance, needs in such systems and cost of offered service and incomings of people, or better to say the amount of money (expenditures) that can be used by people for transportation purposes.

The interest of society is slightly different from interest of individuals. For example use of land [25, 35], externalities [36] associated with new system, etc. can characterize society requirements. Here, an external cost is a cost not included in the market price of the goods and services being produced, i.e. a cost not borne by those who create it. It means that, the price of using the PATS, like air taxi ticket price or rent a plane price are not includes any expenses may born on society levels like expenses induced by health problems caused by effects of transportation systems on the people.

For the society the most important quality of the new transportation system under development may be the sustainability. Probable the most used term of sustainability is given by WCED: „...*we must meet the needs of the present in ways that do not compromise the ability of future generations to meet their needs*" [37].

The sustainability can be characterized by using the sustainability performances indicators and sustainability performance index [38 – 40].
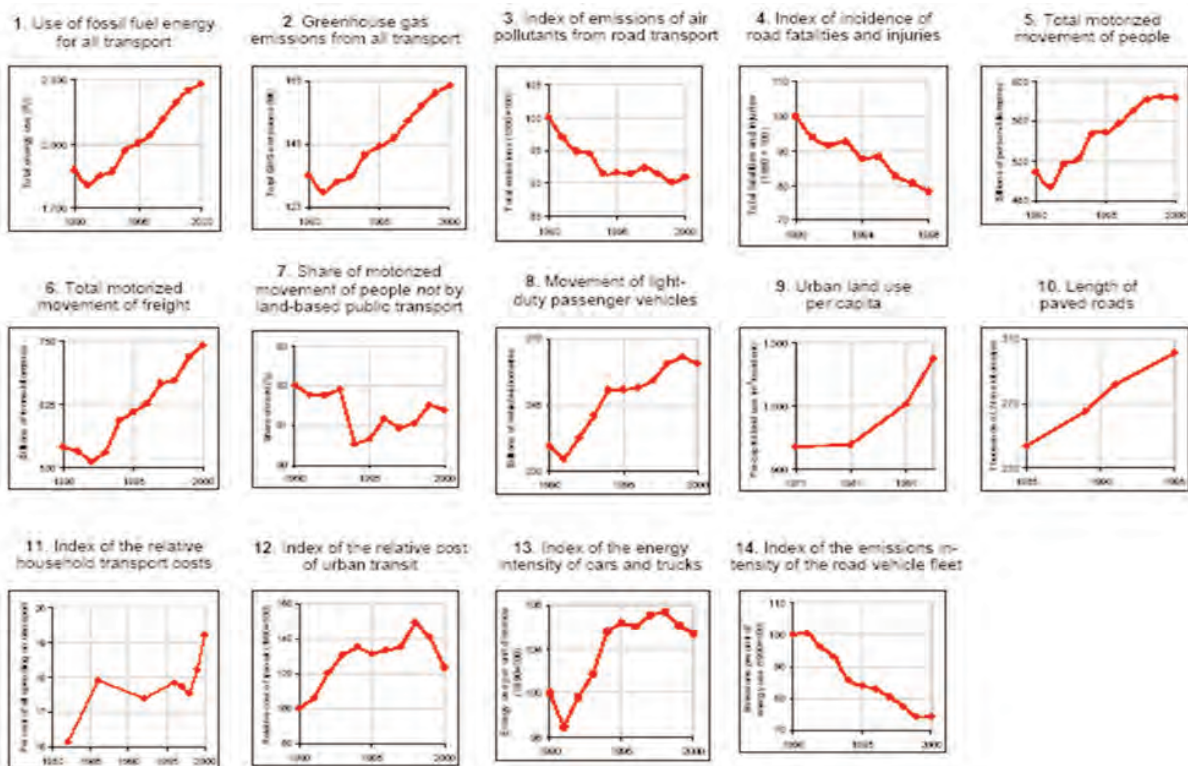


*Fig. 4. The 14 indicators in the initial set of STPI made by Gilbert at all [41]*

*Indicator* – a variable selected and defined to measure progress toward an objective [41]. *Indicator data* – values used in indicators. *Indicator type* – nature of data used by indicator (qualitative or quantitative, absolute or relative. *Indicator system* – a process for defining indicators, collecting and analyzing data and applying results. *Indicator framework* – conceptual structure linking indicators to a theory, purpose or planning process. *Indicator set* – a group of indicators selected to measure comprehensive progress toward goals. and *Index* – a group of indicators aggregated into a single value.

In our study the society as term is used as country level. It is not only the group of people, but it includes economy, environment, etc., too. With applying this approach the community is the group of countries, like EU. The community is a greater population then society and less then humanity. The community can generate special needs and requirements. For example the community would like to be a first in introducing of the new systems, like PATS.

The efficiency of the PATS can be investigated depending on the size of effected field of interest. With use of most simple approach, the vehicles are investigated, only.

The operational system of PATS includes the small airport nets [5, 42], operational and maintenance organisations and facilities [6], as well as the ATC/ATM applied [7].

The given system of new innovative transportation system, as an subsection of economy contains the design and production organisations, logistic support, etc. So, the given system includes all things having influence on the affordability, accessibility, operability.

The sector of economy in our case means transportation system generally. The total transport system can be characterised by inter-operability, inter-modality, etc. [43, 44].

Interoperability refers to ability of given system to use in different countries in different technical and economical conditions.

Transfer of persons and goods between modes of transport to obtain the maximum advantage is known as inter-modality. Competition has generally been a force against inter-modality in the past. Moreover, vertical management of the sector by each mode has exacerbated the situation. Finally, the biggest size of area in which the PATS may use is the economy generally. Of course, the real biggest area is the community economy, in which the economical, sociological and political goals of the community may determine the grading of the transportation systems.

The community view can be defined by a special scientific groups, like it was done by ACARE [43].

## 4. CRITERIA AND THEIR EVALUATION METHODS

With use of approach shown in Figure 3., the new innovative system can be evaluated with using of the several hundred characteristics, performance indicators and criteria. Our goal is to evaluate the efficiency of the EPATS. Therefore, the investigation of the sub-matrix describing the efficiency only is targeted. This means there are 25 sub-elements must be studied. So, at least 25 criteria must be defined. Here, we try to summerise the definitions of the criteria recommended for application. The possible ways of measurement or determination of the criteria are described, too.

### *Energetic coefficients*

*Sub-space: vehicle - energy*

*Criteria*: energy used for one flying hours, transporting a unit commercial load, one passenger or the transport work solved by using one unit of energy.

$$C_{e1} \rightarrow \frac{l\,(\text{or kg}) \text{ of used fuel}}{\text{flying hour}},$$

$$C_{e2} \rightarrow \frac{kWh}{tkm} = \frac{\text{energy used}}{\text{transport work (transport of one tonna commercial load for unit distance)}},$$

$$C_{e3} \rightarrow \frac{kwh}{paskm} = \frac{\text{energy used}}{\text{transport of one passanger for unit distance}},$$

$$C_{e4} \rightarrow \frac{lkm}{kWh}, \quad C_{e5} \rightarrow \frac{paskm}{kWh}.$$

*Measurement:* these criteria can be determined with use of the general performance data of the vehicles. For example, the $C_{e4}$ can be determined with use of data maximum boarding fuel, $W_{bf}$ minus aero-navigation reserve, $W_{anrf}$, and over the maximum payload, $W_{kl}$, times by maximum range with full payloads, $R_{max\,kl}$:

$$C_{e4} = \frac{W_{bf} - W_{anrf}}{W_{kl} R_{max\,kl}}$$

*Sub-space: operational system – energy*

*Criteria:* the same criteria can be defined as for the sub-space vehicle – energy, but in these cases the energy consumption must include the energy used during the operation of the PATS systems, i.e. energy used during maintenance, running the ATC/ATM systems, etc.

*Measurement:* the energy used in operation of the PATS can be calculated as the annual use of energy at airport and maintenance facilities, $W_{op}$, for operation of small aircraft applying in PATS and related to the total annual transport work realized by the given number of small aircraft.

$$C_{e4o} = \frac{Nn(W_{bf} - W_{airt}) + W_{op}}{NnW_{kl}R_{max\,kl}},$$

For example:

Where $N$ – number of aircraft operated at the given airport, $n$ – is the number of average flight of one small aircraft.

*Sub-space: given system - energy*

*Criteria:* In this larger system of investigation the energy applied during production of the aircraft and other elements of the PATS must be added to the energy used for applying the total PATS.

*Measurement:* all the energy consumption must be related to the unit of transport work.

*Sub-space: economy sector – energy*

*Criteria:* Even in this field the same type of energetic coefficients can be defined as it was done earlier, however, the energy consumption should be calculated as the total energy used by this transport section of economy. So, the energy applied by road and rail transport used for traveling to and out of airports and any other extra energy need for applying the PATS must be included into the energy consumption. This means that all types of direct and indirect energy consumption must be taken into account. For example energy consumption of car used by administrative persons working for rent a plane system must be added to the total applied energy.

*Measurement:* the calculation of the total energy consumption associated by using the PATS is quiet difficult task. However it can be solved, if the system would be divided into more clear sub-parts that can be investigated individually.

*Sub-space: economy – energy*

*Criteria:* in this case the total energy consumption will be really totally calculated with taking into account the external energy, like energy used for constructions realized near the airports, built of connected road and rail transport systems, or energy used for built and operation of the hospitals, where those persons will be cured who will have health problems initiated by introduced new personal air transportation system.

*Measurement:* the energetic coefficients of this level of investigation can be calculated not so easy. The methods developing for external cost calculation or investigation of the real sustainability may apply on this level.

### Cost

*Sub-spaces: vehicle - cost, operational system – cost, given system – cost, economy sector – cost, economy - cost*

*Criteria:* The costs or cost coefficients are very similar to the energetic coefficients, when instead of energy the spent expenses must be taken into calculation. Of course, cost can be calculated by using the very different approaches as it shown in Figure 5. In case of investigation of the aircraft itself, the cost is the direct operational cost. Generally, the transportation system PATS can be grade on the total operational cost including direct and indirect costs. However, for users, the expenses of traveling are more important then any other characteristic of the

transportation mean. So, the users are choosing the transportation system, or completing their real travel as the combination of the different transportation means minimizing the traveling cost. The general transportation system as the logistic support of economy must be developed with using the minimum expenses. So, the external costs must be included into the evaluation of the transportation sector of economy. Nowadays, very often, the sector is evaluated with using terms of sustainability. Finally, the economy must be really sustainable, therefore all the costs associated with using the natural resources for realizing the transportation of goods and people must be taken into account.
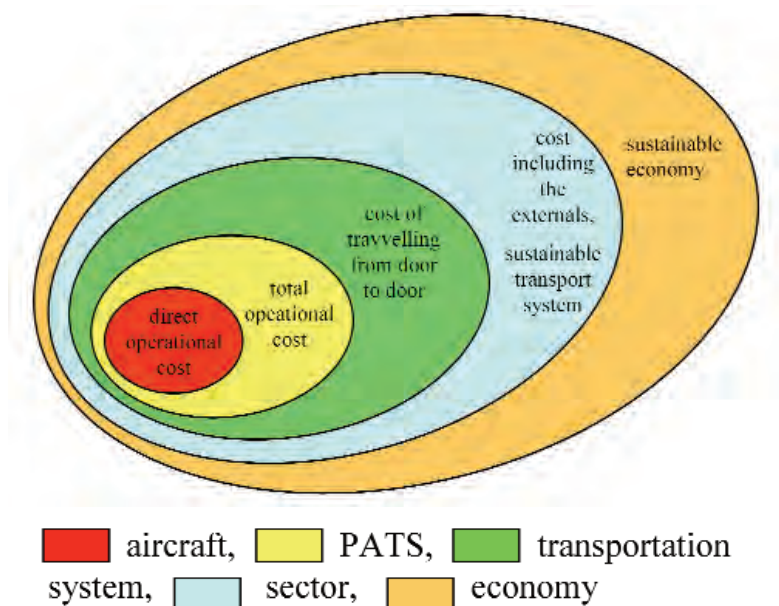


*Fig. 5. Cost evaluation hierarchy*

*Measurement:* All the earlier defined formulas of energetic coefficients can be applied for calculation of the cost coefficients on the supposition that the energy would be changed for cost determined for the same conditions.

### Individual requirements

*Sub-spaces: vehicle – individual requirements, operational system – individual requirements, given system – individual requirements, economy sector – individual requirements, economy - individual requirements*

*Criteria:* The EPATS system is based on the on-demand flights. However, the characterization and evaluation of the individual requirements are the very complex problems. The different groups of people have different priorities in grading the traveling possibilities. They are making decision on the traveling forms depending on the time effects, costs, accessibilities, safety, etc.. As it is well known from the innovation diffusion theory, the first users of the new technologies are the innovators and early adaptors. So, we have to centric our investigation on them. For them the time-effect may most important factor. Therefore the individual requirements can be characterized by time used for given travel, time of traveling.

EPATS from the individual requirements point of view can be evaluated by applying the time coefficients that may be calculated as the energetic coefficients with replacing the energy or power by time. Here the small aircraft direct flying time, time from airport to airport, time from door to door traveling, time used generally for travel or transportation and time associated with operation of transportation systems for supporting the economy.

Instead of the time effects the average speed can be defined and applied, too.

*Measurement:* principally the time used for traveling depends on the distance of traveling, too. On the other hand, the direct flight time depend on the aircraft performance, aircraft flying

characteristics, while time from airport to airport depend on the operational characteristics of the aircraft (like line-up maintenance), operational system (economical operation, ATC/ATM) and operational conditions (like weather conditions). Time from door to door includes the time–effects influenced by using the different transportation modes during the combined traveling or transportation. Generally the transportation time depends on the inter-operability (time used for adaptation of the transportation systems to the conditions of different countries), harmonization of the time-tables (giving slots), etc. Finally, the community can have economical, social and political priorities that can cause some extra time in use of the new transportation systems. These time-effects must be included in to time-coefficient calculation, too.

### Society

Sub-spaces: *vehicle - society, operational system – society, given system – society, economy sector – society, economy - society*

*Criteria*: for society, the development, establishment and operation of the sustainable transport may the most important, today. The sustainability can be characterized by using several different indicators, like use of fossil energy, emissions, greenhouse gas emissions, totals motorized movement of freight and people, urban land used, length of paved transportation systems, etc. These indicators show the given indicator related to the total or relative (determined for unit) transportation work. Often, the sustainable transportation systems are characterized generally by emissions. The sustainability of the small aircraft can be characterized by their emissions (weight of pollutants) during its direct operation (flights). The EPATS generates pollutants emitted by aircraft, technical systems applied at airports, waste of energy by ATC/ATM, etc. Of course, the covering of the individual requirements (as using the washing rooms, eating, etc) cause some extra pollutant distribution, too. On the total transportation system level, the pollutants born during the aircraft production, airport building, airport and ATM devices productions, etc. the transportation system generates pollutants not only their operation, but during construction of the infrastructure, mining the materials for aircraft and system elements production, and so on. On the community level the pollutants born because the people life must be taken into account, too.

*Measurement*: It is seems clear, how to define the sustainable transport indicators. They are the coefficient defining as the quantity of controlled emission related to the unit of the transportation work. On the other hand the calculations of the sustainability (emission) coefficients are very complex problems, because the real emissions

### Community

Sub-spaces: *vehicle - community, operational system – community, given system – community, economy sector – community, economy - community*

*Criteria:* in our approach to investigation of the EPATS, the community is the EU. So, the community is the group of countries, group of societies having the same common interest and goals. One of the most important goal of EU is to be a leader in technology development. Therefore, the EU must support specially the EPATS as the new, innovative transportation system opening new market and making possible the real free movements of people and products in Europe. The EPATS must be characterized by criteria grading the common interest of community and members (persons and enterprises, institutions) of community. Such criteria can be given as ratio of the criteria developed for evaluation of the society and personal requirements. So, the efficiency on the community level can be characterized by ratio of emission over time of using the system.

*Measurement:* The community interest coefficients can be calculated very simple as ratio of emission and time coefficients.

## 5. USING THE EFFICIENCY DEFINITIONS AND CRITERIA IN EPATS PROJECT.

As it was described the investigation of efficiency of the radically new, innovative projects is a very complex problem that can be solved depending on the goal, point of view and size. The applied efficiency coefficients are changing with use of the latest results of sciences and technologies. Therefore they must be calculated as calendar time functions.

On the other hand, the EPATS is a really new system that has not established, yet. Therefore, there are not available initial data for making evaluation. Even, there are not enough data for describing the establishing and development of the EPATS. So, the future development and use of EPATS, as the new system may evaluate with use of some forecast models of its impact, demand, etc. Such models are quit complex and depend on the applied scenarios.

Principally, there are many different performance indicators, efficiency coefficients defined earlier can be applied for investigation of the EPATS. Some of them like the different energetic and cost efficiency coefficients or some other indicators as impact of increasing in GDP on the air traffic, land used for given type of transportation means, number of airports and airfields in unit land area, etc. can play very important roles in understanding the EPATS demand.
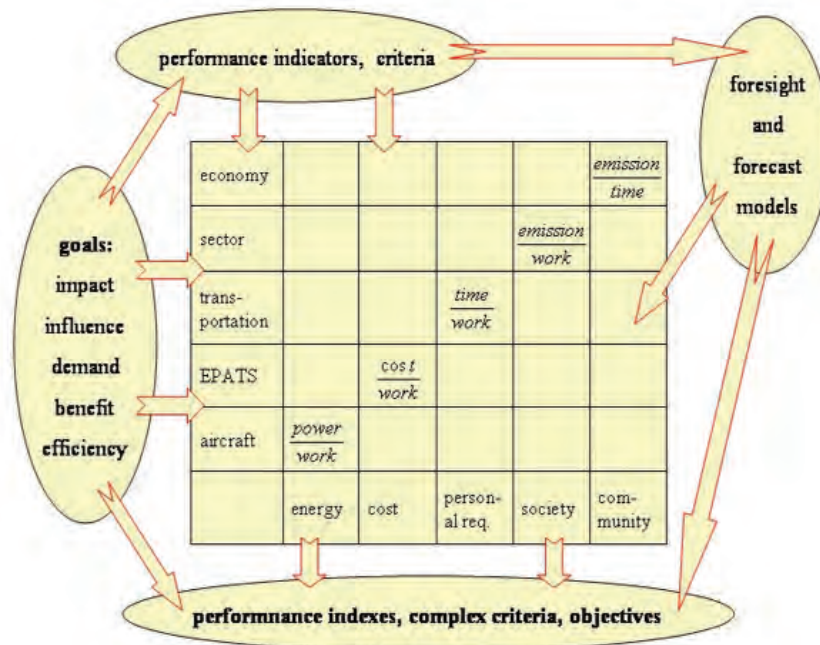


*Fig. 6. Rational choosing the efficiency coefficients*

Choosing the efficiency coefficients can be realized on rational way shown in Figure 6. The recommended method is based on the investigation of the cube of efficiency evaluation given by Figure 3. Choosing the most important indicators and criteria must based on the general investigation of the possible perfor-mance indicators, creating the perfor-mance indexes and6or efficiency coefficients with using the results of developed foresight and forecast models.

With accordance to our preliminary analysis, the most important efficiency coefficients are in the diagonal plane of the efficiency evaluation cube, namely:
  - efficiency coefficients recommended for the evaluating the small aircraft are the energetic coefficients, ration of energy and transportation work: (fuel or energy used for unit tkm or passkm work), Ce;
  - the PATS system can be qualified with use of cost coefficients (direct, total or total LCC for unit of tkm or passkm work), Cc;
  - the priority of chosen transportation mean must evaluated with use of time-effect coefficients (flight time, block time or door to door time used for transformation related to unit distance), Ct;

- from the economy sector and society point of view, the new transportation system can be graded depending on the emission coefficients (mass of pollutant materials related to unit of tkm or passkm), Cem;
- on the economy level and from the community point of view, the transportation system can be characterized by quality coefficients determined as multiplication of the emission and time-effect, coefficients, Cq = CemCt.

All these coefficients can be given in different form as it was discussed and shown in energy coefficients sub-point of the point 3.

## 6. SOME COMMENTS OF THE POSSIBLE EFFICIENCY EVALUATION

The previous chapter contains the definition of the different efficiency coefficients recommended for using in EPATS efficiency evaluation. However the calculations of these coefficients for different transportation means are very complicated tasks that can not be easy solved because a lack of information required for calculations.

Here are some recommendationsfor determining the defined efficiency coefficients.

### *Energetic coefficients*

In simplified case, when the fuel consumption in direct operation must be calculated, the energetic coefficient may be determine quit easy. There are several formulas especially had been developed for energy consumption evaluation (like[22]).

The aircraft fuel consumption decreases continuously (Figure 7.) Today, the conventional air transport has fuel consumption related to the pass.km not more then road transport (Figure 8.). With accordance to EPATS, we can declare that, the weight and drag of the new small aircraft will be much more smaller then analogical characteristics of the modern cars, because the use of the latest technology and developed aerodynamics.
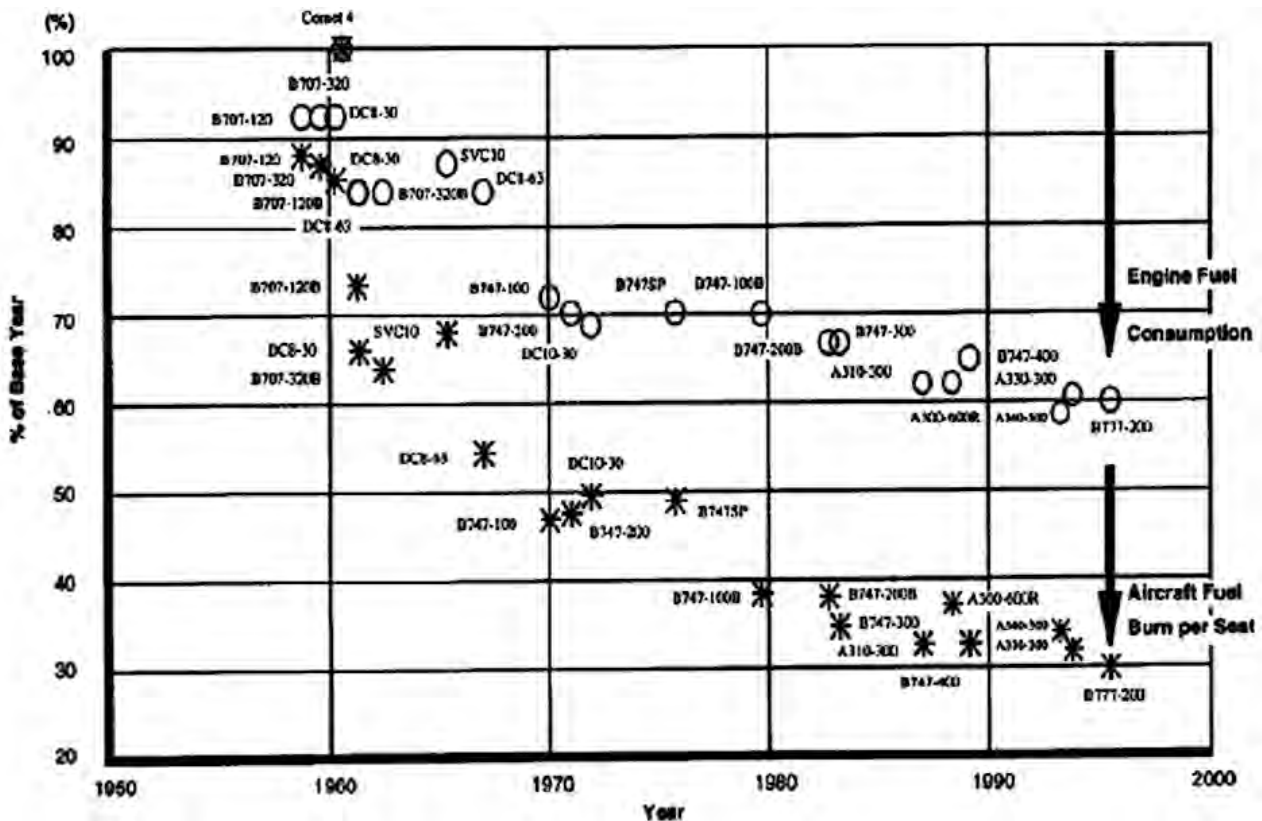


*Fig. 7. The original Rolls Royes figure representing the fuel efficiency of the modern aircraft [45, 46]*

If the energetic coefficients were determined for the total system, then calculations will be much more complex, because who, how and when has taken into account the use of energy during the infrastructure, for example road system construction in form of energy consumption related to one passkm.
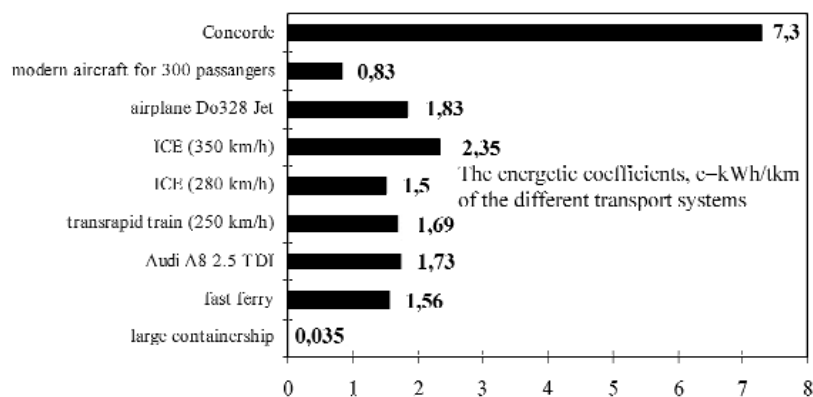


Fig. 8. Specific energy demand of different transportation means [25, 32]

## Cost evaluation

The modern air transportation engineering deals with the total life cycle cost related to unit of work. Such approach includes all the direct and indirect costs determined for total time of usage. Nowadays everybody can understand that the low cost airlines can carry the passengers at price level that is lower then using the car. However, the air travelers must pay for everything like it is shown in Tables 1 and 2.

Table 1. Real costs associated with flight

| Budapest – Berlin return flight may, 2005 | Payment | % from total |
|---|---|---|
| Air ticket (Air Berlin) | 32 EUR | 17.6 |
| Taxes | 127 EUR | 69.8 |
| Printing the ticket (travel buro) | 23 EUR | 12.6 |
| Total | 182 EUR | 100 |

Table 2. Lowest price for return journey London – Paris for travel between 2-5/12/2002. [47]

| Company | From | To | Euro (€)[1] | | | |
|---|---|---|---|---|---|---|
| | | | Fare | Tax | Price | Fare/2 |
| Eurostar[2] | Waterloo | Gar de Nord | 94.4 | 0.0 | 94.4 | 47.2 |
| British Airways[3] | LHR | CDG | 65.5 | 44.5 | 110.1 | 32.8 |
| Buzz[4] | Stansted | CDG | 29.3 | 38.0 | 67.3 | 14.7 |
| Easy Jet[5] | Luton | CDG | 26.1 | 29.5 | 55.6 | 13.0 |
| bmi British Midland[3] | LHR | CDG | 16.0 | 44.5 | 60.5 | 8.0 |

1 £1 = €1.6
Source: 2www.eurostar.co.uk (3/11/02) 3www.opodo.co.uk (3/11/02)
4www.buzzaway.com (3/11/02) 5www.Easy-Jet.com (3/11/02)

The latest available technology makes possible to develop EPATS on the cost level of the middle size car [29]. However, the cost of EPATS must cover absolutely everything associated with use this new system, while for example the road system construction only partly covered by car owners.

Of course, the costs can be evaluated on the total life cycle, or / and on the total system levels. In last case for example all the costs associated with the deployment and operation of the given transportation system must be taken into account. For example the infrastructure investment [48] or the externalities [36] must be evaluated.
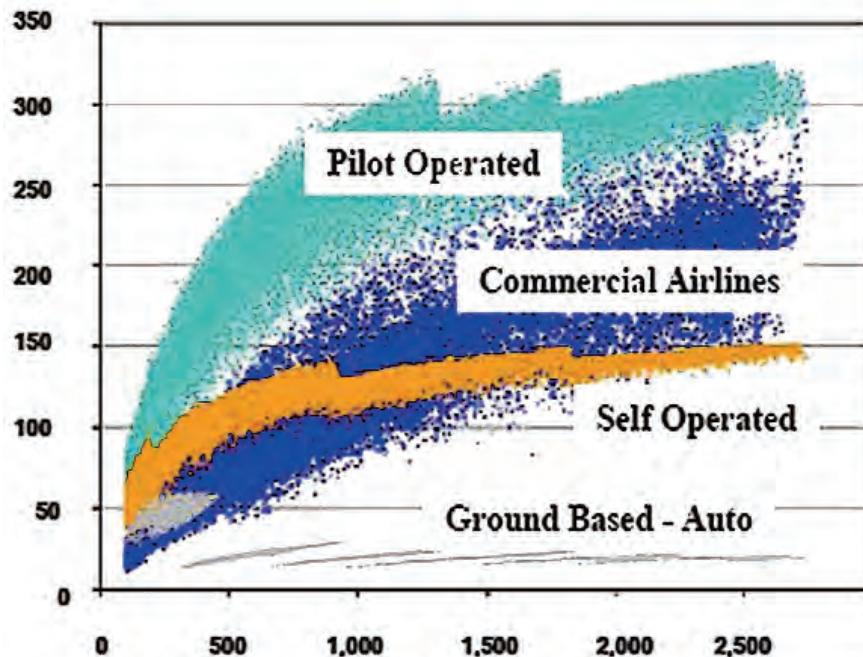


*Fig. 9. Door to door trip speed (MPH) as function of range (miles) [3]*

### Time effects

The comparison of the different means from the time effect point of view must based on the door to door speed, or total traveling time. In this case we will have something like it is demonstrated by Figures 9 and 10. From the Figure 9. from the figure 9, it is clear, the time spent on travel is approximately four hours for from 500 km up to 2000 km with using the different transportation systems, different vehicles.

Of course the time effect very depend on the accessibility, affordability and other similar performances [3, 48].

### Emission coefficients

In terms of performance measurement - as it is defined by [50] - indicators of sustainable development must comply with the followings:

- an explicit set of categories linking vision and goals of the future;
- a limited number of key issues for analysis;
- a limited number of indicators of progress;
- standardized measurement;
- indicators related to the spatial context;
- ongoing assessment integrated into the decision-making.

On the other hand the indicators for the investigation of the sustainable transportation must show to decision makers and authorities what they can do [51].
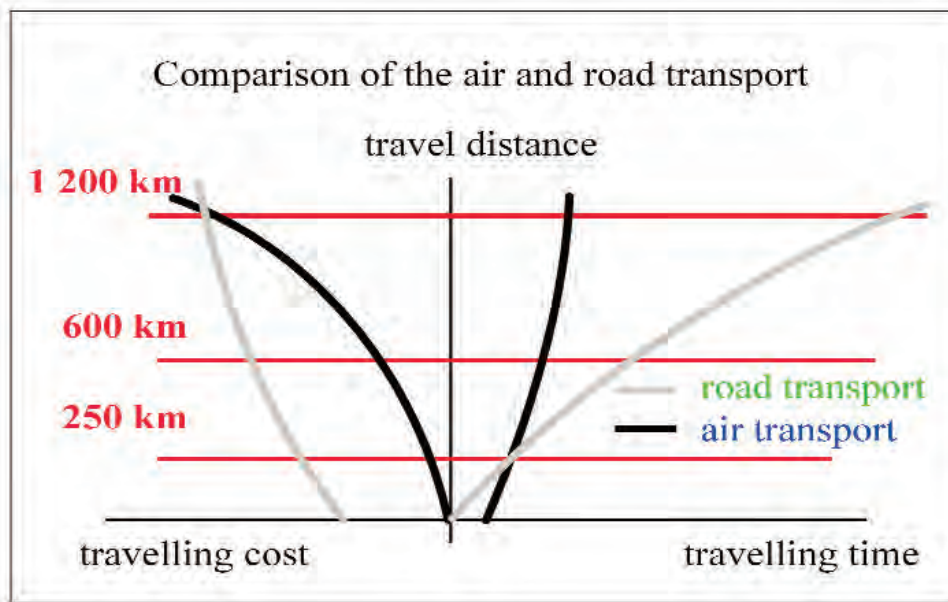
*Fig. 10. Comparison of the different transportations [32]*

Many different approach are described by references for generating the performance. All of them are based on the DPSIR (Drivers – Pressure – State - Impact – Response) principle, as it shown in Figure 5. Generally, many different indicators or performances can be defined (Fig. 11.). However, the large number of indicators make difficult to use them for comparison of the different transportation means. It would be better to introduce one index describing the transport sustainability, generally.
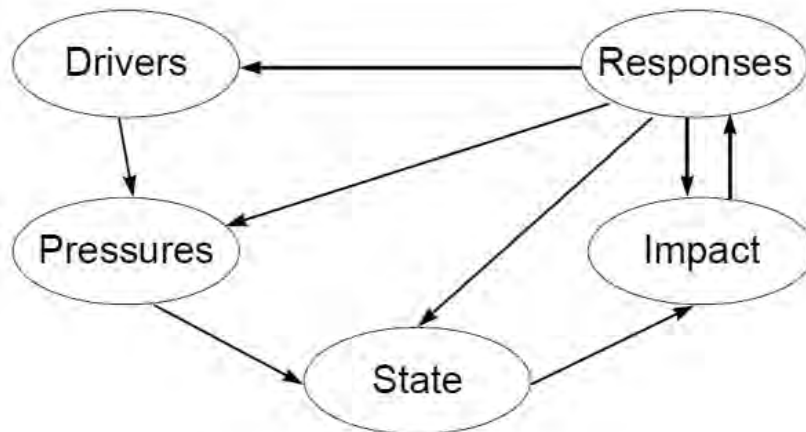


*Fig. 11. Framework for Reporting on Environmental Issues [52]*

If we will take into account all the effects having influences on the use of the resources, then we will have quit interesting results. For example one B747 can produce 18 billion psskm. during the, that is equal to production of the 12 thousand middle upper size car. The fuel consumption approximately is the same for air and car users. However, the empty (dry) weight of cars would be about 120 times more then aircraft empty weight. Even, if were calculated that the aircraft production uses relatively 10 times more natural resources, the production of the defined number of cars needs 12 times more resources. If we will take into account the infrastructure investment cost, or land used by different transportation systems (Fig. 12), we can make decision, the air transport can not be camper to the road one in case of long distance travel.
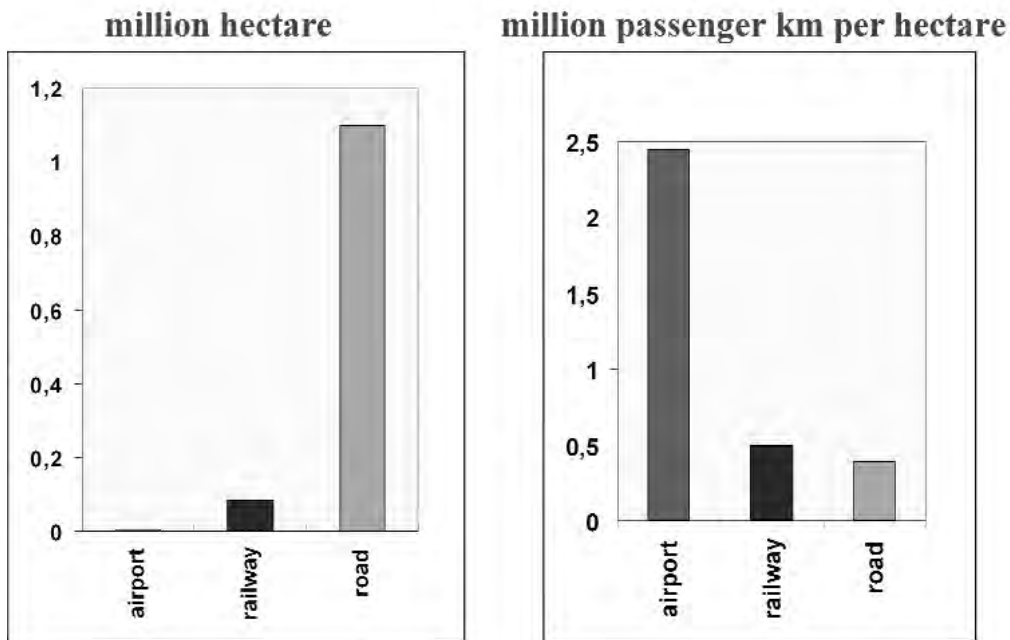
*Fig. 12. Land usage by different transportation systems [25]*

### Quality coefficient

The recommended quality coefficients summarize the society acceptance (emission coefficients describing the sustainability) and individual interest (time effect applying the golden rule of or era: time is money).

Of course, as it was outlined, many different characteristics can use for efficiency evaluation. The new US program PAVE (Personal Air Vehicle Exploration) project offering web based benefit analysis (Fig. 13.).
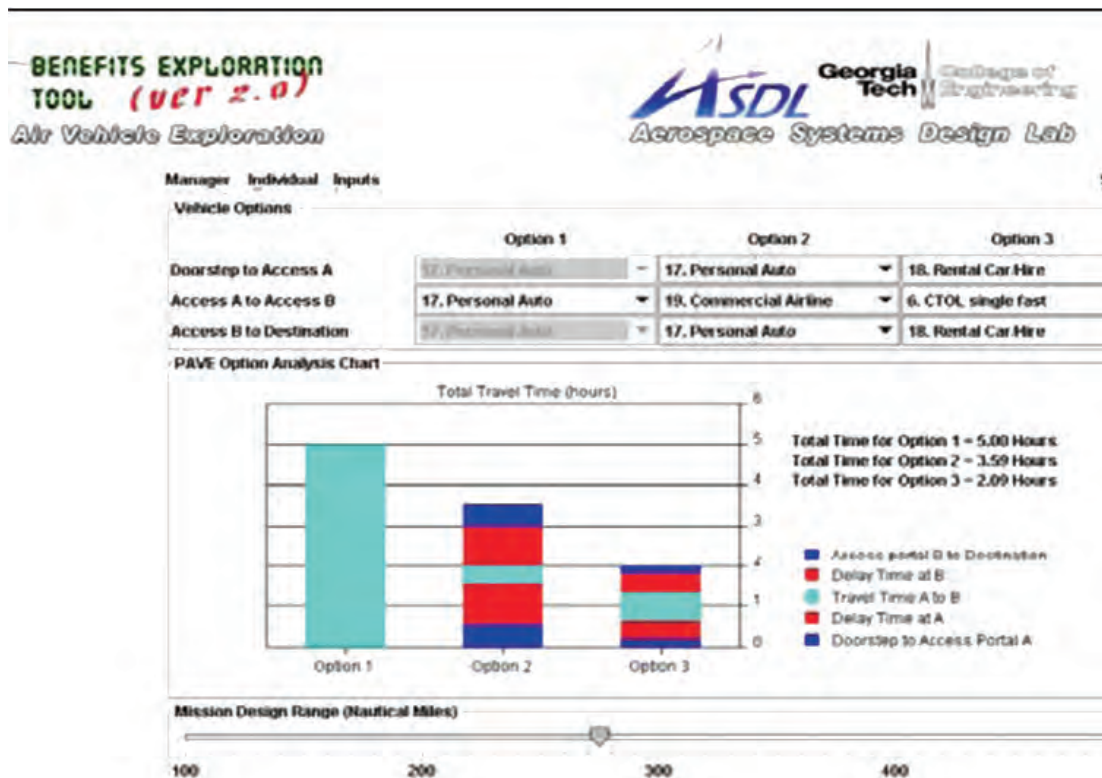


*Fig. 13. PAV Web based benefits Exploration Tool [3, 53]*

There is a big question, how to increased the efficiency and deployment level of EPATS? We can recommend to use the following methods:
- dissimination of the results of the given EPATS projects demonstrating the needs, technology availability, operational philosophy, establishing the system, profitability of services provided by companies strating their activities in new transportation system,
- taxation; loan financing schemes and partial loan guarantee schemes, operating either within the commercial banking system or as specialized development institutions or revolving funds for accelarating the EPATS deployment,
- use of advisory and consulting companies supported by EU for help in the companies starting their busines in this new areas,
- utility demand-side management (DSM) programs.

## 7. CONCLUSIONS

EPATS is the radically new, innovative transportation system making possible the on-demand transport giving real freedom in movements of goods and people. This system opens a new market, initiates a lot of new jobs.

The benefits and efficiency of the new system can be evaluated with using the different performance indicators, including the flight performance, operational characteristics, fuel and energy consumptions, expenses, use of natural resources, land, etc., influences on the economy, environment and so on. There is no one and most important indicator. However, a special hierarchy was found in system of performance indicator given in form of efficiency evaluation cub. This hierarchy makes possible the systematic investigation of the new transportation system EPATS that results to the reduction of the number of indicators in forms of indexes called as efficiency coefficients.

The efficiency coefficient are depending on the sizes of the investigated system (aircraft, EPATS, total transportation system, sector of economy and economy), point of view (energy, cost, personal requirements, society, community), scientific and technological level as well as time.

Finally, we have defined 5 different efficiency definitions, efficiency (energetic, cost, time effect, emissions and economic) coefficients that can be given in different forms depending on the evaluated form of transportation, size of system and time for which those coefficients would have calculated.

The results of shortly described analysis will be used in efficiency evaluation of the new transportation system, EPATS.

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