THE USEFULNESS OF THE THEORY OF TRANSPORT STREAMS FOR CIVIL AVIATION

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One of the essential conditions of an economic operation of the carrier techniques is to ensure their high daily usage. It is possible to achieve by applying the elements of mechanization and automation. All these elements need to be aligned within the framework of a scientific theory and the subsequently translated into practical solutions. Such a practical solution can be derived from the theory of transport streams.

KEYWORDS: the theory of currents, air transport network.

1 INTRODUCTION

The carriage of goods, baggage and mail on a global scale continues to grow. The introduction of high-performance aircraft gives the possibility of growth in air freight and in expanding the range of transported substrate. The biggest priority for air freight transport is transport speed. In order to maintain this priority to air carriers trying to constantly modernize and accelerate the process of movement to facilitate, in particular, of air cargo. The main emphasis will be on simplify and speed up the handling of air cargo from a technical standpoint and the simplification of customs clearance and documentation. One of the essential conditions of an economic operation of the carrier techniques is to ensure their high daily usage. It is possible to achieve by applying the elements of mechanization and automation. All these elements need to be aligned within the framework of a scientific theory and the subsequent translate to practical solutions. Such a practical solution can be derived from the theory of transport streams.

2 TRANSPORT STREAMS

It should be recalled that the transport streams represent the requirements for the operation of the transport network and at the same time on the variable portion of the transport system. We can say that it is a process of transport ensembles on the network. To meet the transport requirements, while the effective use of fixed and mobile parts of the transport systems, it is necessary to the steering system to deliver only the relevant information for deciding how to make optimal use of existing or proposed infrastructure. Retrieving this information, it is necessary to work with the networks, whose rating has the importance of distance or in some sense similar to variables. Common to these networks was that if there was a rating of sections of the minor, the boundary nodes sections to each other closer and the ties between them were tighter.

The practice is currently more often brings cases, when can you anticipate here the route in terms of minimum length allowed for any carriage of traffic flows of sufficient capacity and throughput. On the basis of prejudice are very important also positively evaluated the network, whose rating has the opposite sense, binding inside the network between two nodes is the closer, the evaluation section, which connects them, bigger.

Such evaluation is the throughput and capacity of nodes and segments, and it is obvious that for the task of optimizing processes on transport networks have value transmissions and the capacities of the elements of the network, of fundamental importance. In such networks can be valued on the basis of knowledge of these values to decide on how the requirements for the carriage of the network properly directed, or spread out. This layout is determined by the maximum amount of substrate, ensembles etc., which can be transported from their place of entry into the network to the location of their exit from the network per unit time.

Due to the fact that requirements for transport (i.e. transport streams) could be almost limitless possibilities are limited, and their networks to carry always has a meaning and therefore it is necessary that we in the transport network, the following requirements laid out in an appropriate manner. An example of the use of the theory of traffic flows in civil aviation is just a few, from the way the security the level aircraft, translating the goods from the aircraft, loading and unloading the luggage of passengers. Always at the beginning of shaping, planning and design solutions of the problem itself, it is necessary to define the variables that characterize the current ensembles.

For the tasks formulated on the transport networks is necessary in addition to the description of the fixed part of the transport system (i.e. its network) also know by the appropriate means to express the movement of transport elements and their ensembles in these networks. We pay attention to the variable part of the transport systems, in other words, we will deal with the movement of a sequence of sets $k = \{k_1, k_2, ...\}$ in a defined segment of the transport network. This movement we can express, for example, the increasing sequence of time moments $t = \{t_1, t_2, ...\}$, which represent moments of passing the ensembles the chosen point and some of the transport network. The sequence of moments of significant events of t_i, IE. passes ensembles to$_{(i)}$ point (A) is an ongoing process at the time. If it is with the transport network, on which this process, therefore the movement of the currents of ensembles, in progress and if it takes place in the direction from point A to point B, we can transport stream formally described as organized four of a kind, or socket these objects:

p = (S; (A); (B); $\bar{t}$) or p = (S; (A); (B);$\bar{t}$,$\bar{k}$).

For an explanation of the concept of a transport stream, we can use the analogy of flow of liquids, gases, or electric current. The status of the transport stream we can describe it´s state variables, i.e. speed, density and intensity.

Speed intraffic we understand his immediate physical speed, IE. the speed of the ensembles, which is observed in point and transport network.

(H) the Densityof traffic, we mean the number of sets per unit length of the network in the vicinity of the point of and.

Intensity (q)transport stream, we understand the number of ensembles that pass (pass) point and per unit of time.

Listed status variables generally depend on time, therefore we will differentiate its instant and average values. The introduction of these instant values of status variables of the transport stream is very important, because unlike the gases and fluids flow analogy, which we perceive as a continuous process, has a transport stream significantly discreet nature of the movement, our senses, recognizable means of ensembles.

To determine the values of the variables we'll use approximately instant status of the transport stream a sequence of times t ‾. Next, we'll assume that we can determine with sufficient precision the distance $(d)_{(i)}$of ensembles $to_{(i)}$; from A place and at moments of t_{i+1}; i = 1,2 ... If the speed of ensembles $to_{i \text{ and }}$ k_{i+1}around the place, and equal and constant, $(d)_{(i)}$is equal to the distance between the complets.

For the immediate value of the status variables of the transport stream in place and we will consider, for the presumption of conformity of the above definitions and assumptions already for i = 1,2, ..., the values of the following relations:

The speed of the transport stream $v_i = \frac{d_i}{t_{i+1}-t_i}$

The density of the transport stream $h_i = \frac{1}{d_i}$

The intensity of the transport stream$q_i = \frac{1}{t_{i+1}-t_i}$

We can see that among the state variables of the transport stream is this mutual relationship:

$$q_i = (h_i \,.\, v_i)$$

The average values of the state variables at time t_{n+1} t_{-1}, which means the stream when crossing streams and *n* ensembles point this stream consumes (by averaging at the time), they are

$$\bar{v} = \frac{\sum_{i=1}^{n} d_i}{t_{n+1} - t_1}$$

$$\bar{h} = \frac{n}{\sum_{i=1}^{n} d_i} = \frac{1}{\frac{1}{n}\sum_{i=1}^{n}\frac{1}{n_i}}$$

$$\bar{q} = \frac{n}{\sum_{i=1}^{n}(t_{i+1} - t_i)} = \frac{1}{\frac{1}{n}\sum_{i=1}^{n}\frac{1}{q_i}}$$

The introduction of average speed v is quite natural, since this speed is the proportion of the distance that offended ensemble to_1 per time t_{n+1} $-t_1$. The average density is the proportion of the number of ensembles and the sum of the measures of length n units $(d)_{(1)}$ + ... + $(d)_n$ transport network, which invades the at times t_1, t_2, ..., t_n (ensemble to_{n+1} , exception). As well, the average intensity indicates the number of ensembles, as recorded in the time interval t <$_1$; t_{n+1}).

The bulk of the other then apply that these variables are average for h and q is equal to the harmonic average instant variables. Both equality directly originate from definitional formulas for $(h)_{(i)}$ and $(q)_{(i)}$. Furthermore, we can observe that for the average values at the time of true equality:

$$\bar{q} = \bar{h}.\bar{v}$$

As longas we have the opportunity to watch a group of ensembles that pass through a point and we can introduce other instantaneous status variables, and that their average values along the route. At a given moment $t_0$willbethedistanceofensembles to the$_1$, ...,$_{n+1}$ from the point and straight: x_1, ..., x_{n+1} and after the expiry of any period, IE. at the moment $t_0+\tau$ these distances will be equal to: x_1 + r x_1, ..., $x_{n+1} + r_{n+1}$
(see fig. 1)

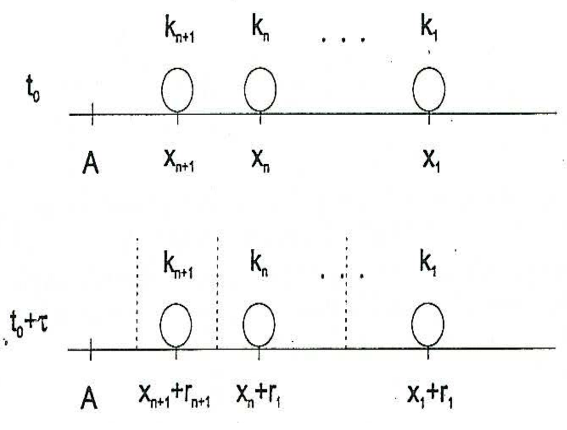

Fig. 1: Location of the ensembles of the transport stream in two moments after overrunning the point and

On the basis of the above data, we can introduce the speed of the i-th Ensemble and density in the vicinity of point (A) as follows:

$$v_i{}' = \frac{n}{t}$$
$$h_i{}' = \frac{1}{x_i - x_{+1i}}$$

We define intensity so as to be valid equality:

$$q_i{}' = h_i{}'.v_i{}'$$

then:

$$q_i{}' = \frac{r_i}{\tau(x_i - x_{i+1})}$$

The corresponding average value along the routes are then defined by the following equalitys:

$$\tilde{v} = \frac{\sum_{i=1}^{n} \mathrm{r_i}}{\mathrm{n\tau}} = \frac{1}{\mathrm{n}}\sum_{i=1}^{n} \mathrm{v_i}{}'$$

$$\tilde{h} = \frac{n}{x_1 - x_{n+1}} = \frac{1}{\frac{1}{n}\sum_{i'1}^{n}\frac{1}{h_i{}'}}$$

$$\tilde{q} = \sum_{i=1}^{n}\frac{x_i - x_{i+1}}{x_1 - x_{n+1}} q_i{}' = \frac{\sum_{i=1}^{n} r_i}{t.(x_1 - x_{n+1})}$$

Evidence of these variables in the expression shape gradually, harmonious and weighted average arithmetic is easy. It should be noted that the expression of q in the form of a weighted average is quite natural, because q is constant after sections (straight values q $'_i$) at long intervals differently (length x_1 -x_{n+1}). For the average values applies again the basic relationship:

$$\tilde{q} = \tilde{h}.\tilde{v}$$

If there is a transport stream of a stationary and if is the set of possible ensembles singleton (various types of ensembles each other we do not distinguish), we call such a stream of homogenity. Finally, it is a means of current periodicals, if the value is the same for all probabilities in defining the stacionary nature of the transport stream (i) shape:

$$i = j + mp, m = 0, 1, \ldots$$

Streams can be divided:
Stationary – such as when the probability of that point, and since the beginning of the measurements is dependent only on the pervious spent n ensembles, time, not at the moment (for its position on the timeline), when we started to measure

Homogen– such as when we do not need to distinguish the different types of ensembles;

Current independent increments -such as when the number of ensembles, which missed the point and in a timed interval does not depend on how much was spent in the previous point, point and ensembles before this moment, such a stream we refer to as "stream with no memory" (such time intervals between clash points and currents will be exponentially distributed).

Independent stream – such as when objectively there is no cause, which would have resulted in the steady stream of ensembles that would have been determined, the stream is on ensembles do not affect other streams. Independent stream is a random process, which is the most widely used mathematical model of traffic flows and for it has for modeling in the transport systems of fundamental importance, it is called. Poisson current (flow), also referred to as the free stream. We can tentatively say that traffic stream characteristics Poisson stream the morethe less the various exhibits on other elements of the bindings of the transport system, which could affect its properties arising from the random nature of the process, which implements the stream (stationary, independence, homogeneity, as well).

If we start from the fact that the individual streams of moving, we need to find out how they affect. It serves the kinematics of the transport stream. Kinematics of the transport stream deals with the movement of the currents, without being examined and dealt with is the cause of this movement. To do this you need to derive an important relationship between the waveforms of state variables of the transport stream, called. the equation of continuity of the transport stream, which has its analogy in the theory of the ideal flow of the liquid.

For Δ t → 0, Δ x → 0, where t is time and x is distance, we get the equation of continuity of the transport stream:

$$\frac{\partial h}{\partial t} + \frac{\partial q}{\partial x} = 0$$

From experience it is known that in increasing the density of traffic, as long as the distances between the sets and ensembles are large enough to affect each other, do not hinder you, increasing the intensity of linear density in accordance with the relationship q = h. v. At the moment, when the density to rise above a certain threshold, the interaction leads to a reduction in speed and in ensembles called. presýtenom stream may come up to its stop. Empirically observed curve current strength on its density has a shape as in Fig. 2:

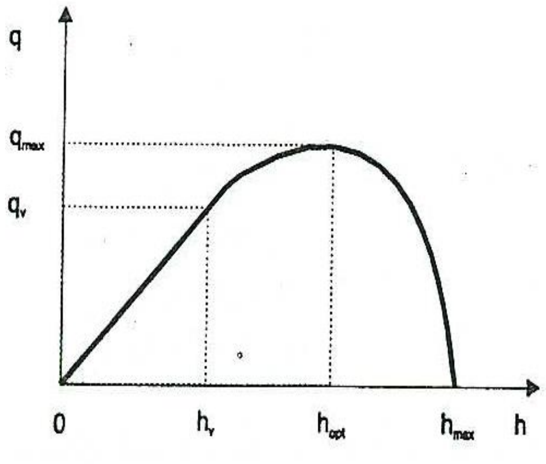

Fig. 2: the dependence of the intensity of the traffic stream on density

In the event that the density (h) enters in values from interval (h) € < 0, h_{in}>, regarding the free stream, the ensembles are mutually affected and in so far as there is no prevention of ensembles, the speed of the stream is constant. (H) values $_{in\ a}$ and q are limit values $_{in}$ density and intensity of the free stream. (H) (h), for € <$_{in}$>h $_{opt}$ is q (h) growing, but derivatived q/dh drops to zero at the point h = $h_{opt}$for which intensity reaches its maximum value:

$$q\ (h_{opt}) = q_{max}$$

which is equal to the throughput of the segment of the route.

For h >$h_{opt}$to stream called supersaturated. With the increasing density of the flow rate drops sharply and at the same time decreasing the intensity until after reaching density h = h_{max}flow completely stops.

From experience we know that the density of the traffic stream is modified so that sites with the same density is transmitted along the length of the transport stream in the direction of movement in the opposite direction of ensembles or even.

In transport networks are mostly moves a group of traffic flows and not only a single stream. Streams are port, divide, touching or crossing, thus experiencing their interaction, to their mutual influence. As a result of these interactions is to change the characteristics (properties) of these streams. This way the traffic streams of influence and what will be the outcome of this influence depends on three factors:

(S1) on the characteristics of individual streams,

(S2) simultaneously on the arrangement of the transport network (topology)(S3), and on the way the Steering currents in the transport network. It should be noted that the problem of the optimal management of entry traffic flows into the transport networks is one of the troubled areas, traffic engineering, whose task is to design transport systems in a comprehensive sense of that Word. In its range are the activities of planning, design, organization and regulation of traffic, transport systems, further forecasting transport performance assessment and evaluation of the effectiveness of communications nodes, and other activities.

3 AIRLINE NETWORK

An example of the use of the theories of tradic flows in aviatik is even a direct comparison of air networks of the type "hub-and-spoke" and "point-to-point". Here is a preview of possible traffic flows and directinputs affecting the creation of air transport networks. One of the unexpected phenomena that drastically changed the structure of air routes was the introduction of the wide "hub-and-spoke" system. In combination with the “point-to-point” tzpe of transport and its links to the central hub, are airline companies able to offer a greater selection of alternative destinations and also increase frequencies.

The concentration of transport in the transport node allows airlines to economies of scale. The situation on the European aviation market, compared with the U.S. market differs and the European aviation market is under the influence of different factors:

-travel distance within Europe (EU-25) are shorter: from this it follows that the number of large and important transport hub is significantly lower, and also that the use of these nodes is no longer as profitable as in the past,

- competition from other modes of transport: the European high-speed rail network is in selected services more competitive air transport on the European continent,

- between the continents bilateral regulation versus the European deregulation.

The advantage of network "hub-and-spoke" is its greater efficiency, the disadvantage is the possibility to easy to distort her vulnerability, as well as the risk of delay as a result of the absence of Center of direct connections. Network type "hub-and-spoke" allow greater flexibility through concentration streams transport system – eg. on fig. 3 network type "point-to-point" includes a total of 16 independent paths that need to be serviced by its own infrastructure and transportation vehicles.

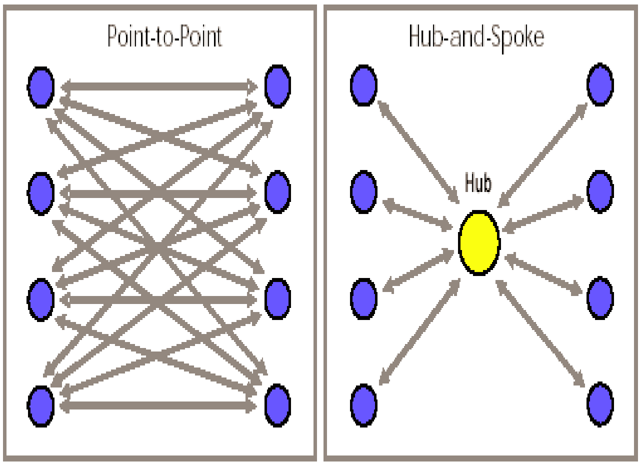

Fig. 3. differences in the transport network of the type "point-to-point" and "hub-and-spoke"

Network type "hub-and-spoke" to the same purpose it is sufficient to only 8 independent paths. A limited number of sessions can lead to an increase in the frequency of services operated by the remaining sessions (application of the principle of economies of scale), for example. instead of one pair of connections between each pair of nodes in the network type of point-to-point, may be offered to the five connections from each node to the selected "shut up". Other benefits of network type "hub-and-spoke" can be characterized as follows: the introduction of more efficient ways of hub check-in, which in this hub allows you to handle at the same time a larger quantity of transport (transfer passengers). But on the other side of the network type "hub-and-spoke" exhibits a certain potential drawbacks. The necessity of transfer passengers, which in some ways may mean delays and extension of time travel. Also there is the threat of potential congestion to shut up, because most of the transfers taking place right in this node. currents transport networks of the type "hub-and-spoke" have always been the domain of national carriers. As they were the owners of the national airports have always been closely linked to national airlines, so should the national carriers and still have greater privileges to these airports. This fact, as well as on the basis of the development of the theory of transport is one of the many of the anti-competitive measures in the fight against competition from low-cost airlines, in particular, against the carriers, who are in accordance with the theory of traffic flows are forced to use secondary airports. However, this does not mean that low the budget of theno operate carriers at major European airports, but the main hinges in their activities are just secondary or regional airports. Detachment from the exploitation of the network "hub and spoke-–" it is necessary to take as a subtle deviation from the classical development of air networks. Airline network type "hub-and-spoke" are from the perspective of the number of passengers certainly stilluses as much as possible. Network type "point – it – point" However, creating new destinations, mostly in conjunction with the low-cost carriers.

BIBLIOGRAPHY

[1] PASTOR, o., TUZAR and: Theory transport system. 1. ed. Prague 2007, 312s.

[2] ČORNY, I.-MAGPIE, Ľ.-MIHALČOVÁ, J.: Convection Models and their application in simulation programs in a technology environment. In: mechanical engineering-ISSN 1335-extra 2938 – Č5 (2009), p. 6/1-6/4

[3] HRICOVÁ, r.: Optimisation of Labelling of Tapered Roller Bearing with. In: TSO07 Proceedings-International Scientific Conference on Technology Systems Operation, 8. vintage, HERE in Kosice, KPTZ Prešov, 21. -23. november 2007, p. 77-79. ISBN 978-80- 8073-900-3

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