DESIGNING RESOURCES IN AGRICULTURAL SERVICES PROJECTS

J. Bartoška, T. Šubrt

Czech University of Life Sciences Prague, Faculty of Economics and Management, Department of Systems Engineering, Prague, Czech Republic

Nowadays, project management reallocation of resources occurs still more often. The reason for this phenomenon usually lies in multitasking, overloading human resources, and the increase in under-pressure work on project tasks. Most commonly used methods are based on delaying the tasks or resource work on a task. However, these methods usually prolong the project' due date. Other group of methods is based on resource substitutions and/or changes loading resource allocations. Such methods are very often ineffective due to the lack of substitutable under allocated resources in a project team. Another group of methods resolves resource conflicts by changing resource's work contour on a task. Usually front/ back loaded contours, or early/ late peak contours are combined. This approach is quite effective but usually it does not affect human behaviour – human's (resource's) inclination to the Student Syndrome and to the behaviour based on Parkinson's Law. In our paper we propose to exploit the Student Syndrome to resolve resource conflicts, to combine work contours based methods with variously shaped Student Syndrome derived from resource properties/characteristics. The quantification of various Student Syndrome shapes has already been given in previous papers. Now we try to improve and utilize this approach to reduce resource reallocations in projects.

project management; resource conflict; work effort; work contour

INTRODUCTION

Agricultural services projects are usually short-term contracts of agricultural enterprises in the area of agricultural services, with restrictions as to the date of delivery and performance intensity. Where services are pesticides, a restricting factor is time and effective resource allocation. Those services are strictly bound to weather and season. Time and effective allocation is priority in this specialized segment. Failure in spraying against pests being performed by a certain date and at a specific spot may lead to financial losses. Allocated resources for agricultural services are usually technical devices, farm machines, and their staff. A contribution to this services segment may be the use of project management approach, in particular considering the variability of resource and human factors in projects.

Projects are very often described as unique and complex. The concept of complexity in project management is dealt with for instance by Baccarini (1996) and Castejón et al. (2011). Whereas Baccarini (1996) distinguishes between project organizational and technological complexity, Castejón et al. (2011) view complexity as the interaction of seven parameters of a project which lead to different amount of total effort. Among the seven project parameters they rank: technological level of immaturity, commercial level of immaturity, technological number of sources/elements, commercial number of sources/elements, complexity of interaction, amplitude of responsibility, technological customization and uniqueness. Project complexity can be further divided into external complexity (conditioned by the environment in which a project will be carried out) and internal. In their theoretical starting points authors mention that the project complexity is given by the number of participants in the project, i.e. the number of participating resources with human agent. The human agent is therefore one of the complexity resources in project management. Whereas Castejón et al. (2011) offer the use of linear model or the model of neuron networks to estimate how laborious the project is, König, Kleinmann (2005) or Bartoška, Šubrt (2011b) focus in particular on mathematical modelling of human agent and his/ her work effort in projects.

Work effort of an allocated resource has very often been investigated in projects from the area of information technologies and software development, as these projects contain a high level of indefiniteness, and even common and routine activities are unique. At the same time, it concerns the area where it is possible to find a great number of approaches to estimate how laborious the project will be or how long the activities will take, and also case studies. The proposal for mathematical apparatus for planning the course of activities within a case study is dealt with for instance in Özdamar, Alanya (2001), or Barry et al. (2002). The authors Özdamar, Alanya (2001) propose a particular pseudo-heuristic approach to

doi: 10.7160/sab.2013.440409

estimate the activities course where the indefiniteness in the project is expressed by fuzzy sets. Barry et al. (2002) concentrate on the existence and expression of the relation between project duration and total effort and in their theoretical starting points they point out the dynamics of the relation between the effort and project duration when a self-strengthening loop can be expected. Others researchers studying the project complexity and work effort are for instance Clift, Vandenbosh (1999), who point out a connection between the length of life cycle and project management structure where a key factor is again a human agent.

The influence of the human agent is vital for the realization and completion of the project. If we disregard the forming of a project team and creating project organizational structure, the place where there occurs the first significant influence of the human agent on the project and project complexity growth is the estimate of duration and how laborious partial activities are. Determining duration time of partial activities and thus estimating the deadline of the project is conditioned by the subjectivity and unreliability of the human agent. Possibilities how to restrict this influence and how to improve duration time estimates are dealt with for instance in Premachandra (2001), Hanh (2008) or Bartoška, Šubrt (2011a).

The project complexity is further contributed to by a number of organizational units and allocated resources within these units. The project complexity also grows with the amount of estimates how laborious a project is and duration times which emerge during resource allocation. In projects of agricultural services the complexity of resources allocation and their heterogeneity influences work effectiveness and often leads to a failure in meeting customers' needs. At higher complexity, the resource allocation becomes less successful and resource conflicts arise. The resource allocation should always proceed from the resource effort which is not constant during activity performance. The work effort will be different for various resources and activities. The aim of the paper is the analysis of resources allocation in agricultural services projects and proposition of resources allocation designing which would take into account an expected effort of resource and which would prevent failures during its deployment.

MATERIAL AND METHODS

Scheduling the work of resources

Internal complexity of the project is given by the number of organizational units, the number of resources, and the number of carried out estimates how laborious it will be during the allocation of resources. The indefiniteness of the project is inversely related to the quality of effort estimates (Clift, Vandenbosh, 1999; Özdamar, Alanya, 2001). This presupposition is valid for the area of services, building industry as well as agriculture. Together with growing project complexity there also grows the probability of resources' multi-tasking the growth of which during the realization of the project leads to its delay and threatening the goal of the project. The closer is the effort estimate to the real need, i.e. the more closer is the work contour to the real work effort, the lesser we can expect resource conflicts and the level of project indefiniteness within its complexity.

Resource conflicts can be resolved by many means – from overtime work allocation, postponing the beginning of work to resource substitution. In the present paper we will focus on the method connected with the change in the work contour.

The contour of resource work for activity is given by at least three influence factors, which are as follows: (a) attitude to succumbing to the Student Syndrome (Bartoška, Šubrt, 2011b);

(b) real need for carried out work depending on the nature of activity with the resource working according to standard work contour, of the type flat, back loaded, front loaded, early peak, late peak, double peak, bell, and turtle (see Figs. 1–3); (c) need to adjust one's work speed to key resources of activity because it can be expected that during the realization of various types of activities various resources will exert different work effort. By combining these factors we can expect that even complex activities will have a different contour.

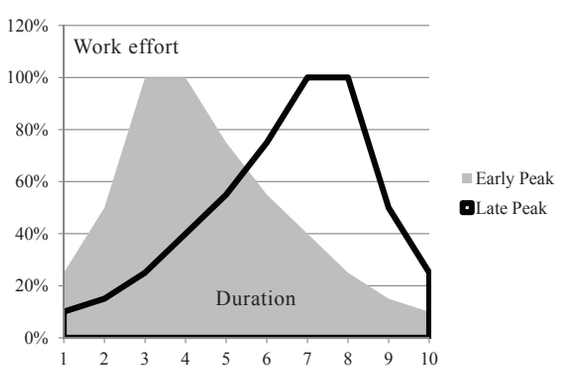

Fig. 1. Work contours: Early Peak, Late Peak

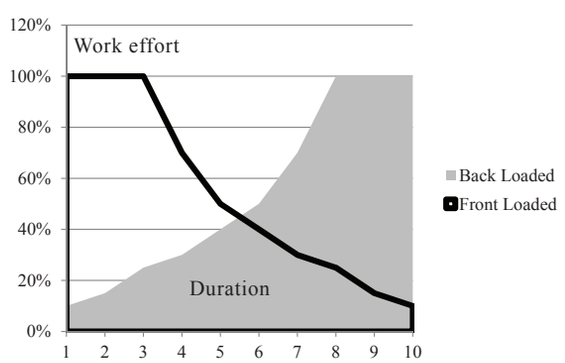

Fig. 2. Work contours: Back Loaded, Front Loaded

Table 1. Work effort in agricultural services projects during selected months of 2012

	'Hovádek' work group		'Bříza' work group	
	Hectares treated	Worked hours	Hectares treated	Worked hours
10 April 2012	112.5	10.45	112.5	11
11 April 2012	98	11.5	98	10
12 April 2012	116	10.5	116	11
13 April 2012	105	9.5	106	10
18 April 2012	123	11.75	98	9.5
19 April 2012	138.5	11.75	138.5	12.5
20 April 2012	71.5	7.5	91	11
23 April 2012	45	5	62.5	6
24 April 2012	105.5	11.75	104	12.75
25 April 2012	116	11.5	58	6
26 April 2012	139.5	12.5	116	12.5
27 April 2012	46	6	69.75	9
02 May 2012	80	10.5	108.5	10
03 May 2012	116	12,75	122	11,25
04 May 2012	122	13.5	122	11.75
05 May 2012	135.5	12.25	133.5	11
14 May 2012	106	12.75	122	11.25
15 May 2012	96.5	9.25	105.5	11.25
16 May 2012	28.5	3.75	16.5	2
17 May 2012	110	10.75	95.5	10.75
18 May 2012	99.5	11	94	10.5
19 May 2012	70	7.75	99	10.25
21 May 2012	133	13	84	8
22 May 2012	102	11.25	84.5	9
23 May 2012	47	5.5	46	5.5
24 May 2012	97	10.75	111	12.5
25 May 2012	47.5	5	47.5	5
28 May 2012	44	4.5	44	5
29 May 2012	94	11	95	11
30 May 2012	86.5	11	86.5	11
31 May 2012	85.5	11	85.5	8.75

If we consider possible contours from the viewpoint of the resource's Student Syndrome, then only two courses can be taken into account (Fig. 4). The first (1) corresponds with the pre-conditions of the Student Syndrome (C o o k , 1998; L e a c h , 1999), where the resource performs the work at the last moment, i.e. just before the deadline. The second (2) possible course proceeds from the First Parkinson's Law (P a r k i n s o n , 1991) where the resource spreads work unevenly across the whole duration time even though she/he could finish it earlier.

The real work contour of the task is the combination of basic contour (Figs. 1–3) and inclination to succumb to the Student Syndrome or Parkinson's Law (Fig. 4). When resolving resource conflicts, in contrast to prevailing experience, we propose the combination of basic contour with real resource effort which includes the impact of the human agent.

Experience with agricultural services projects

Approaching agricultural services and services in general as projects is not common. The reason is low knowledge of project management in the segment of agriculture and its services in the Czech Republic. To define several follow-up agricultural services within one contract to the form and structure of a project is not only convenient but also necessary. If a higher number of subsequent work tasks are to be performed in a short term, it is necessary to use devices and approaches of project management. Determining a specific goal of the application of agricultural services with technical parameters at the very beginning helps allocate resources in the right direction during the performance and it unequivocally determines a manner and necessities for handing over the contract. Planning services in time in the form of establishing a timetable can minimize the risk of delay. A difficult area for providing agricultural services is using resources at a particular time. Resources work timetable ceases to be a prescription of a possible work timetable, and it becomes an important device for the allocation and monitoring of resources. The use of basic principles and procedures of project management in short-term

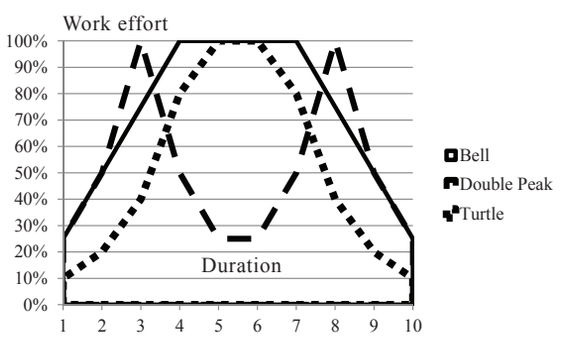

Fig. 3. Work contours: Double Peak, Bell, Turtle

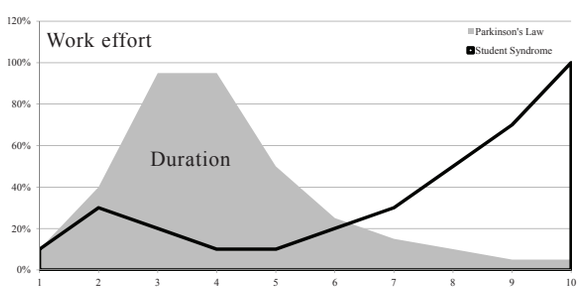

Fig. 4. Real work effort of the resource during the activity

contracts has its justification even in the case of other segments of national economy. As an example, let us mention a project lasting for several days with high intensity of resources allocation and emphasis on quality and season.

The example of the company applying resources allocation in agricultural services as a short-term project is AGRO Žamberk, a.s. in East Bohemia. Responsible workers of the company allocate and monitor resources while providing services to agricultural enterprises in the form of projects with the emphasis on project management principles. A goal and timetable for a contract is always determined as a short-term project. Thanks to the cooperation with this company, the following data on utilizing two work groups for pest spraying were provided (Table 1).

The data given in Table 1 reveal that the variability of hectares corresponds with the variability of worked hours. The effectiveness of resources, expressed by a number of treated hectares per one work hour in the observed project on agricultural services does not bring any new information about the resources' behaviour during work on tasks. The resource behaviour, i.e. his/her variability in the work effort, is expressed in worked hours. The number of treated hectares supports the output of the performed work only. The behaviour of resources and the variability of work effort can be considered in terms of worked hours. Hectares cannot be regarded as a sufficient figure.

If the data from Table 1 are transferred into the graph towards a time axis (see the beginning of the season in April 2012, Fig. 5), a growing deviation in the effort of allocated resources is evident. The project of agricultural services, intense pest spraying at the locality and time is not realizable in winter months. Therefore the data detect the first implementation of the project in 2012 no sooner than in April. The data presented in Table 1 are for calendar months April and May 2012 and they describe several implementations of the agricultural services projects for agricultural enterprises in the Czech Republic. These were always 4- to 5-day contracts concerning the application of pesticides and other technologies against pests. Within the short-term contracts an extreme emphasis was put on the deadline and intensity of resources use during the implementation.

At first a balanced effort of resources with a frequent allocation is sinking into constantly more significant deviations. Although the project and its tasks are repeating, the risk of a possible delay is growing. The resources are exposed to the load by a frequent repetition of technically and physically demanding tasks. The reallocation of human resources can be recommended. The change of work load of human resources and targeted stimulation could reduce the load and thus the risk of a possible delay of the agricultural services project.

RESULTS

The method for resources' allocation

The complexity of the project is given by the number of allocated resources in the project where the influence of the human agent is present. The project complexity is further increased by the variability of work effort for individual resources. This fact may have a two-fold impact on the resource admissibility of the project: (a) for obvious resource conflicts it is possible to seek their removal and solution in the variability of allocated resources work effort; (b) variability of allocated resources work effort may lead to resource conflicts that can be concealed and might not be revealed till the very realization of the project.

If we allow for the human side of individual members of the project team or responsible workers who are to execute work, we can eliminate resource conflicts using a suitable combination of contour with real resources effort. The resource admissibility can be for instance compensated by the allocation of two

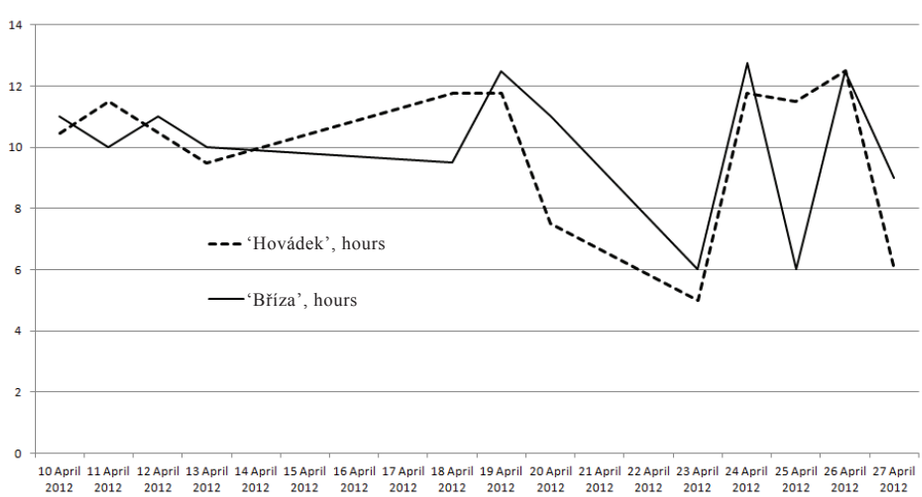

Fig. 5. Resources' work effort in agricultural services projects at the beginning of the season

resources where the former succumbs to the Student Syndrome in his/her behaviour while the latter to the Parkinson's Law. The peaks of both courses of real work effort complement one another in time (Fig. 4). As the work on the activity is spread into more peaks, we can expect a lower risk of delay or not fulfilling the task.

The consideration on how to compile work contour for various resources in order to eliminate resource conflicts can be further supported by the use of basic work contours (Figs. 1–3). Some basic work contours are mutually in contrast, i.e. they match one another from the point of view of work effort (Fig. 6). The basic contours express what project (task) managers expect from resources work effort, however, in a form enforced by the manager. The more the real work effort of the resource resembles in due course the allocated and required basic work contour, the more the risk of resource conflict decreases.

Based on this consideration it is possible to express the inclination to the Student Syndrome or the Parkinson's Law directly or partially by a suitable work contour. A starting point for the definition must be the knowledge of the nature and character of the allocated resource. The definition can be applied to one allocated resource or mutually, among several resources (Fig. 6).

Possible combinations of work contours for parallel performed activities are: (a) routine work × unique activity (Flat × Early Peak or Late Peak); (b) unimportant activity ×activity with high priority (Front Loaded × Back Loaded); (c) planned activity × unexpected activity (Double Peak × anything).

If we do not take into consideration the human side of individual members of project teams or responsible workers who represent allocated resources, we can dread a concealed resource conflict. If an activity is allocated to for example two workers whose behaviour corresponds with the Student Syndrome, we can expect an extreme growth in work effort towards the end of activity performance (Fig. 7). The risk of delay or not fulfilling the task is growing. A concealed resource conflict can appear towards the end of the task performance by not performing the expected work. The resource conflict can result in delay. Therefore it is necessary to take into account increasing stress and exhaustion of the resources towards the end of activity. The last time-sequence of the activity in this case represents a weak point in respect to endangering quality and work safety.

Usually the work contour for the activity is created regardless of the work contour of other activities. The experience is conditioned by the fact that resources are in their work effort a priori balanced and homogeneous. In everyday practice, very often neither the Student Syndrome nor the Parkinson's Law is taken into account. Therefore it is presupposed that work contours for different activities are seemingly not related. However, when we include real resource work effort of the resource who succumbs to the impact of the human agent, then, obviously, during the work contour it is necessary to consider also the work contours of other activities. If during the work planning more activities, more allocated resources are taken into account, then the phenomenon of multitasking is involved in the problem as well.

Multitasking, which appears during the project performance almost every time, often leads to resource conflicts or to delaying the activities or even the project. Multitasking is determined by the fact that the same resource is often allocated to more activities in series or parallel. However, if we subordinate the work planning for activities to real work effort of the resource, we can still eliminate the over allocation of the resource within multitasking. In the activities where the same resource is allocated with a particular type of human agent influence, it is convenient to create the itinerary of the project totally or largely in series. By such arrangement of activities an extreme work growth in one-time moment and concealed resource conflict are avoided (Figs. 8 and 9). Thus the itinerary of the project is changed and later resource conflicts are prevented.

If we do not take into consideration the real course of the resource work effort and work contour is ex-

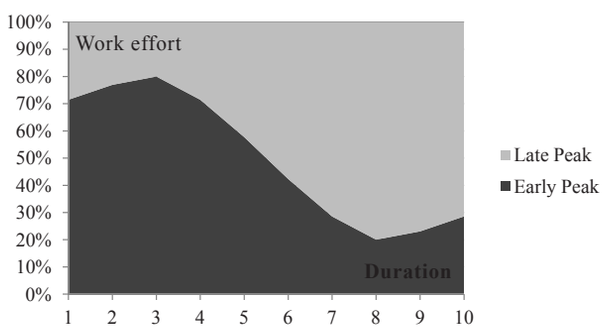

Fig. 6. A contrary course of work effort for basic work contours

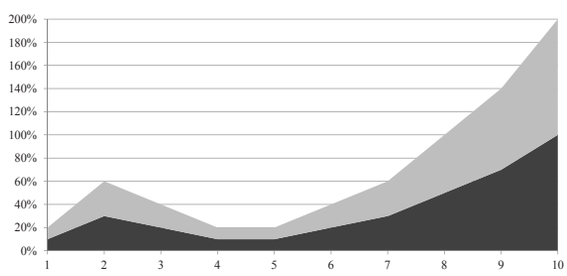

Fig. 7. An extreme growth of work effort for the activity where the resources with the Student Syndrome prevail

pected as balanced and the activities in the itinerary are arranged parallel and the allocated resource is affected by the Student Syndrome or Parkinson's Law, then during the project performance a concealed resource conflict can occur which did not have to be visible at the moment of the itinerary formation. There is no expected continuous over allocation of the resource due to performing more activities, the resource is over allocated during the performance of work either at the beginning or towards the end of the activity performed – the resource conflict arises. There may occur no concealed resource conflicts during the performance of the project provided the work contour for the activities is planned with respect to the course of the real work effort of the resource, with respect to the human agent.

Practical application of the proposed method

The agricultural services project implementation in time deepens the variability of work effort of human resources. During the repetition of physically and technically demanding tasks, the resources relent in their effort. Fig. 10 shows an apparent swing of work effort and work performance. Neither of the groups complements the other and both are oscillating. The delivery of services by deadline could be at stake.

The risk of the project delay is increasing with a number of deviations of work effort for both groups. If, time wise, both work groups complemented one another in their effort, the risk of the project delay would decrease. The reallocation of resources for both groups can achieve a mutual complementation during the project services implementation and a decrease in work effort deviations. The reallocation of resources can be carried out by a suitable personnel exchange of resources and by a suitable stimulation of resources.

The elicited observations were submitted to the executive workers of AGRO Žamberk, a.s. in the frame of an expert consultation. On the basis of the recommendations, appropriate changes of resources were performed and stimulation mechanisms were set. The resources' reallocation was successfully carried out prior to the implementation of the agricultural services project (spray against pests) in July 2012 (Table 2).

If we transfer the data concerning work effort and work performance of the resources in both groups from Table 2 to the graph (Fig. 11), we can observe the completion of work effort during the project within both resource groups. At first, work effort of 'Hovádek' resource group completed a quickly decreasing performance of 'Bříza" resource group.

Table 2. Work effort of resources in the project after reallocation

	'Hovádek' work group		'Bříza' work group	
	Treated hectares	Worked hours	Treated hectares	Worked hours
09 July 2012	149	11.5	149	10.75
10 July 2012	133.5	12.5	111.8	9.75
11 July 2012	123	10.5	60	6
12 July 2012	71	6.5	102	9.5
13 July 2012	98	9	81.5	8
14 July 2012	74	7	60	5

Then, after relaxation and targeted resources' stimulation, a growth in the work effort of 'Bříza' work group balanced a drop in the effort of 'Hovádek' group. We can speak about the composition of resources' work timetable. The intensity of services delivery was, thanks to the complementation of one group by another, without any significant deviances and drops.

The result of combining reallocated resources' groups is the delivery of services ahead of time. The delivery was performed about three hours earlier then it was expected. The risk of delay threatening AGRO Žamberk, a.s. employees in charge was reduced in the agricultural services project. The work of resources on the project was performed evenly with a mild peak in the beginning. Thanks to the resources' reallocation and resources groups' combination, growing deviations in the effort of resources in previous agricultural services projects thus could be reversed.

DISCUSSION

In every day practice the work contour for activities is often determined mechanically. It proceeds from the possibilities offered by software applications for project planning and which present routines: contour flat, contour back loaded, contour front loaded, contour double peak, contour early peak, contour late peak, contour bell, and contour turtle. Applied work contours do not correspond with the observed effort of resources. Work is performed differently thanks to the influence of a human agent who is present while using the resource. The course of real effort of the

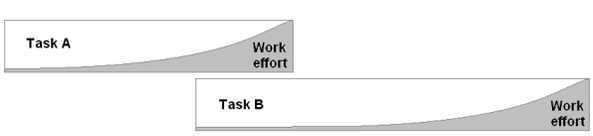

Fig. 8. Work contour corresponds with real work effort – resource conflict is avoided

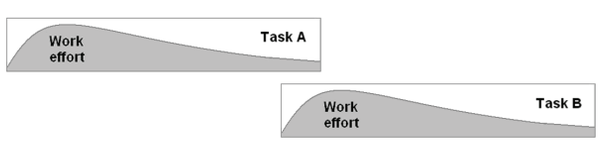

Fig. 9. Work contour corresponds with real work effort – resource conflict is avoided

resource does not correspond to the required work contour expected by a project manager.

The work contour which is required for the project performance should, to a large extent, express the course of real resource effort which corresponds in its extreme form to the Student Syndrome or Parkinson's Law. We can expect that the resources will never be able to meet flat contour in their behaviour. This is discharged by the nature of a human agent. On the basis of knowledge and experience, it is therefore necessary to determine when in time during the project performance an extreme growth in work effort will occur and consider this expectation in the work contour. Moreover, during totally parallel work of the resource on more tasks it is also possible to combine the tasks with respect to the relation of the resource to those tasks or which external or internal circumstances influence its completion. Possible task combinations according to the expected Student Syndrome with the goal of maximum effective use of the resource are as follows: (a) interesting × uninteresting work for the resource; (b) easy × complicated work for the resource; (c) work well secured × information-wise badly secured; (d) willing to cooperate with other resources × not willing to cooperate.

If the circumstances of the parallel course of activities of project tasks allow, the manager can use his/her knowledge of the behaviour of a particular resource (his/her relation to the tasks performing) and combine succumbing to the Student Syndrome, Parkinson's Law and forced contour – with for instance for the resource interesting work and task with a high priority during the tasks concourse.

The use of principles and broadened findings of project management and resources allocation can positively contribute to the area of specialized services, in particular to agricultural services projects. By resources' reallocation and combination of resources' groups it is possible for a company to achieve a decrease in the risk of delay. The risk of delay grows with an increase in work effort of resources due to repeating demanding tasks. When considering the nature of resources and modification of work groups, it is possible to work with composing work timetables. The composing of

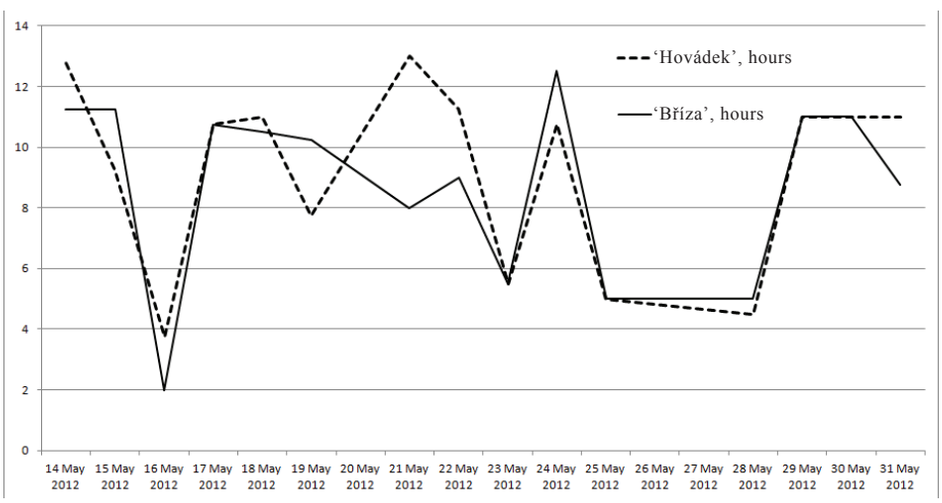

Fig. 10. Resources' groups in their work effort do not complement one another

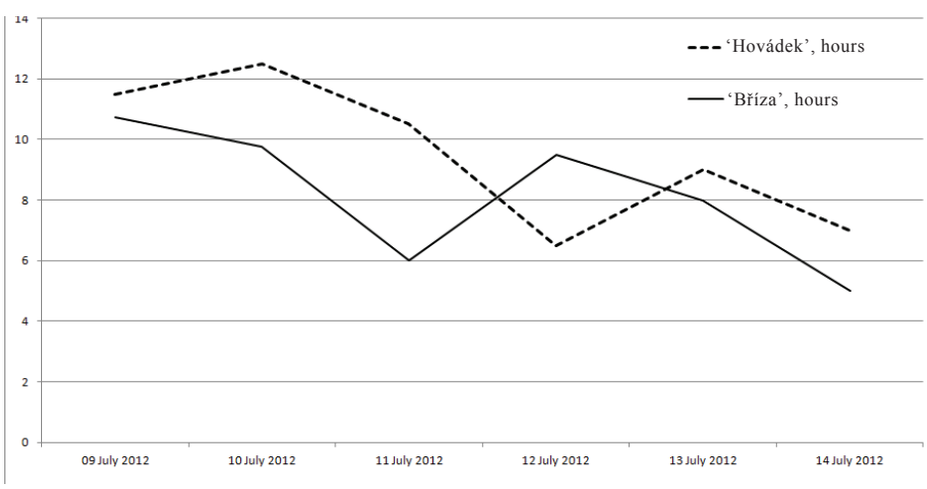

Fig. 11. The resource groups after reallocation complement one another in their work effort

work timetables can lead to a significant decrease in the risk of delay.

CONCLUSION

The results presented herein lead to the recognition of the internal complexity of the project, which can be the cause of failure. Resource conflicts, obvious or concealed, are the consequence of not including the human agent influence in the project planning and management. Even though the significance of the human agent in the internal project complexity is not directly and openly admitted (Baccarini, 1996; Castejón et al., 2011), the human agent plays a concealed, yet vital role in the project management. The recognition of the internal project complexity in the form of the human agent influence on the resources work effort should be fully used in project planning and management.

Theoretical results of the paper were used in a particular case of resources' modification for a short-term agricultural services project. Thanks to a convenient resources' allocation and the composition of work timetables, a decrease in the risk of the project delay was achieved.

REFERENCES

Baccarini D (1996): The concept of project complexity – a review. International Journal of Project Management, 4, 201–204. doi: 10.1016/0263-7863(95)00093-3.

Barry E, Mukhopadhyay T, Slaughter AS (2002): Software project duration and effort: an empirical study. Information Technology and Management, 3, 113–136.

Bartoška J, Šubrt T (2011a): Modification of the Three-point PERT Estimate for practical use. In: Proc. 29th Internat. Conference on Mathematical Methods in Economics, Janska Dolina, Slovakia, 23–28.

Bartoška J, Šubrt T (2011b): The effect of human agent in project management. Central European Journal of Operations Research, 3, 369–382. doi: 10.1007/s10100-011-0209-4.

Castejón M, Ordieres J, Gonzalez A, Gonzalez V (2011): Effort estimates through project complexity. Annals of Operations Research, 1, 395–406. doi: 10.1007/s10479-010-0776-0.

Clift T, Vandenbosh M (1999): Project complexity and efforts to reduce product development cycle time. Journal of Business Research, 45, 187–198. doi: 10.1016/S0148-2963(97)00227-0.

Cook SC (1998): Applying critical chain to improve the management of uncertainty in projects. MBA Thesis, Massachusetts Institute of Technology.

Hanh ED (2008): Mixture densities for project management activity times: a robust approach to PERT. European Journal of Operational Research, 2, 450–459. doi: 10.1016/j.ejor.2007.04.032.

König CJ, Kleinmann M (2005): Deadline rush: a time management phenomenon and its mathematical description. Journal of Psychology: Interdisciplinary and Applied, 1, 33–45. doi: 10.3200/JRLP.139.1.33-45.

Leach LP (1999): Critical chain project management improves project performance. Project Management Journal, 2, 39–51.

Özdamar L, Alanya E (2001): Uncertainty modelling in software development projects (with case study). Annals of Operations Research, 102, 157–178.

Parkinson CN (1991): Parkinson's law and other selected writings on management. 1st Ed. Federal Publications (S) Pte Ltd., Singapore.

Premachandra IM (2001): An approximation of the activity duration distribution in PERT. Computers & Operations Research, 5, 443–452. doi: 10.1016/S0305-0548(99)00129-X.

Received for publication on November 4, 2012

Accepted for publication on August 9, 2013

Corresponding Author:

Ing. Jan Bartoška, Ph.D., Czech University of Life Sciences Prague, Faculty of Economics and Management, Department of Systems Engineering, Kamýcká 129, 165 21 Prague 6-Suchdol, Czech Republic, phone: +420 224 382 352, e-mail: bartoska@pef.czu.cz