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# Task Assignment as a Crucial Factor for Project Success (Probabilistic Analysis of Task Assignment)

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## **Abstract**

Task assignment is one of important problems of project management. Moreover, it can become a crucial factor for project success or failure. For a successful task assignment project manager has to know not only the subject under development, but the capacities of each team member too. Tasks are characterized by their sizes and difficulties. In their turn people are characterized by their capacities to overcome these sizes and difficulties. Therefore the correspondence between the people capacities and assigned tasks can have a serious impact on the whole project success. All task assignment related decisions are based on the manager's experience, knowledge and intuition and therefore they can be erroneous.

This paper presents a new quantitative approach to the assessment of the project's success probability depending on the quality of task assignment. Also it contains two new differential equations for human action duration and human productivity analysis.

**Key words:** Human action dynamics, schedule risk analysis, Heavy (Fat) tail distributions, linear and non-linear work, deterministic and stochastic work, bursts of human actions, project failure, differential equations of human action dynamics, probabilistic analysis of task assignment.

## **Introduction**

All aspects of project failure are very important and should be studied comprehensively. Even if a small progress in this area can have significant consequences because of the huge number of failed projects and corresponding financial losses.

There are many causes of project failures. They can be external, related to spec change, market change, and others and internal, related to the endless unnecessary team meetings, low productivity of team members, improper task assignments and many others. At first glance seems that task assignment cannot have a crucial impact on the project failure but the detailed quantitative analysis indicates that it may become one of invisible causes of micro failures in the course of projects.

In many cases project failures are characterized by the following situation. Project works are in progress and there is no reason for concern. Everything looks like it will be completed on time and in budget. Suddenly during the ordinary everyday discussions people reveal serious

errors and unexpected problems in the project. Sometimes it seems that the problem came out of a clear blue sky. But it only seems that way. In reality the revealed problems always were there. Simply they remained invisible because the power of contemporary project diagnostic tools is far from being satisfactory.

The main conclusion from here is that in a majority of cases the main reasons of the sudden worsening of project situations are the invisible errors or unsolved problems. In this sense task assignment is a potential source of unexpected work delays and schedule related problems. Task assignment related decisions can contain invisible errors and potential threats that later may become serious problems and ultimately can lead to the project failure.

The very early causes of such a phenomenon might be uncertainties and disparities between difficulties of the assigned tasks and people abilities to solve these tasks.

## 1. Method of Human Action Dynamics

We can analyze the lack of conformity between the difficulties of tasks and the capacities of people using human action duration models from [1]. According to the approach developed in that paper it is possible to describe human performance characteristics quantitatively (Fig.1) and use them for schedule risk analysis. In this picture it is shown the human action duration as a function of task difficulty, where  $D_w$  is the maximum possible difficulty of an action that is feasible for a specific developer.

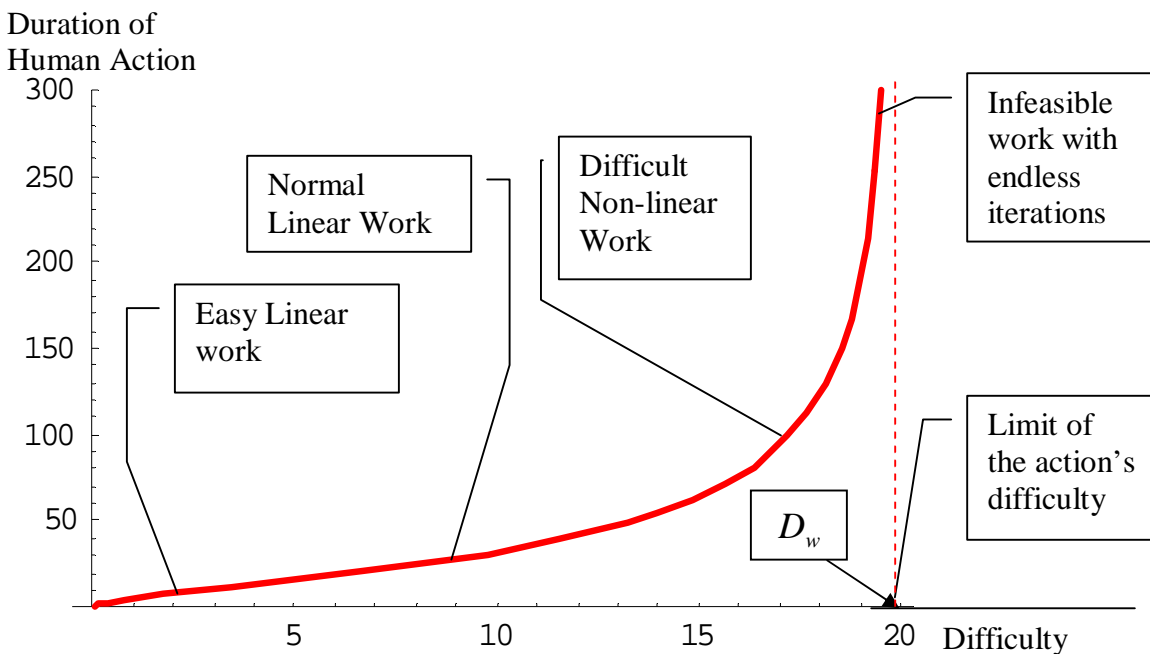


Fig.1. Non-linear relationship between the duration of human action and action's difficulty

Besides human sequential actions have random difficulty. So the mapping of difficulty of tasks over time can represent itself a random process with certain distribution functions (Fig.2.). In that picture we have two random difficulty processes  $D_1(t)$  and  $D_2(t)$  with distribution functions  $f_1(D)$  and  $f_2(D)$ . The average values of these two random difficulty processes are  $D_{av1}$  and  $D_{av2}$ .

Likewise the human productivity is a random process too. In the Fig.3 we have two productivity random processes  $P_1(t)$  and  $P_2(t)$  with distribution functions  $\varphi_1(P)$  and

Difficulty of Sequential Human Actions as a Random Process

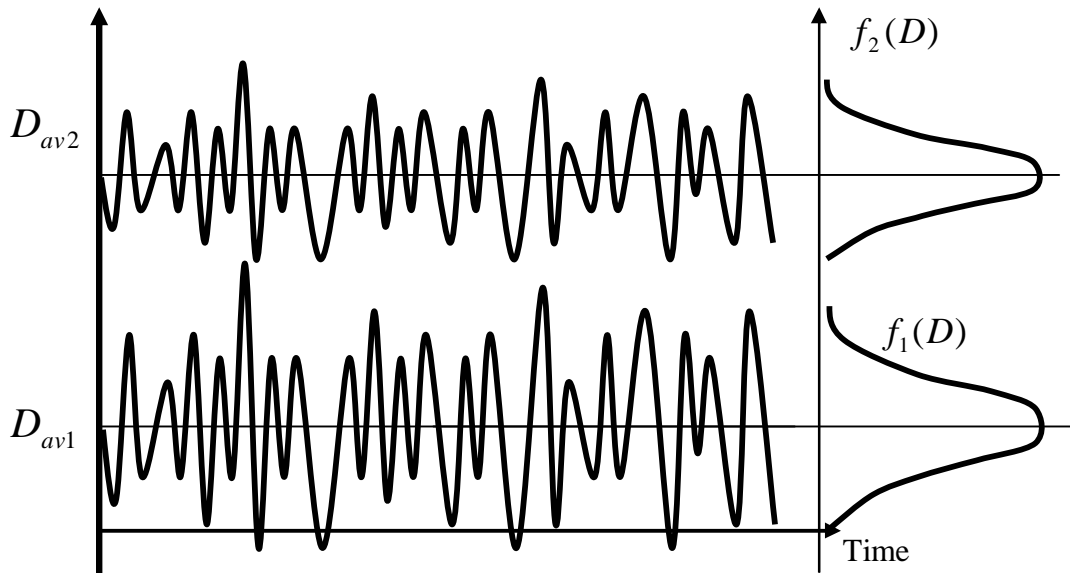


Fig.2. Two random processes that reflect the difficulty of human work

$\varphi_2(P)$ . The average values of human productivities are  $P_1$  and  $P_2$ . Besides the accomplishment of a task with size  $S$ , difficulty  $D$  and human productivity  $P$  can have duration  $T$  [1]

$$T = S \frac{D}{P} . \quad (1)$$

Randomness of task difficulty and human productivity, combined with the non-linear character of the relationship between time duration  $T$  and task difficulty  $D$  can generate a bursty behavior for action durations.

Human Productivity

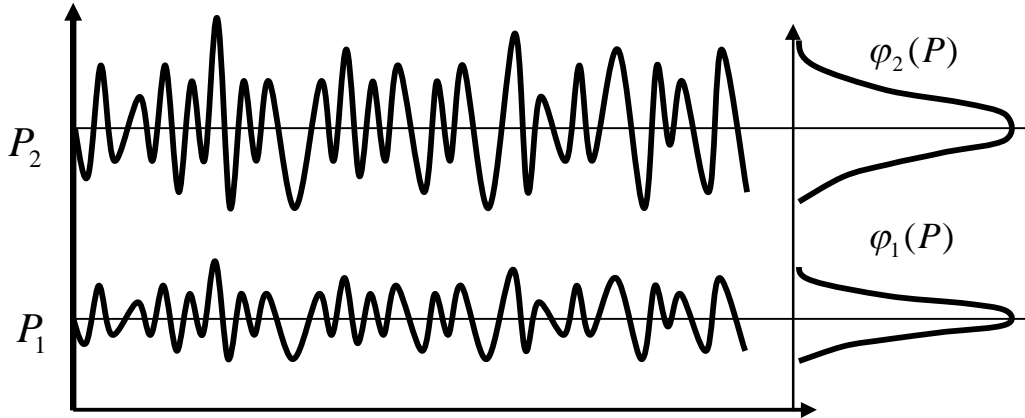


Fig.3. Two random processes that reflect the human work productivity

In fact the human work process is a non-linear transformation of two random input processes (task difficulty and human productivity) into an output random timing process of the duration of human actions. This transformation process is presented in Fig.4.

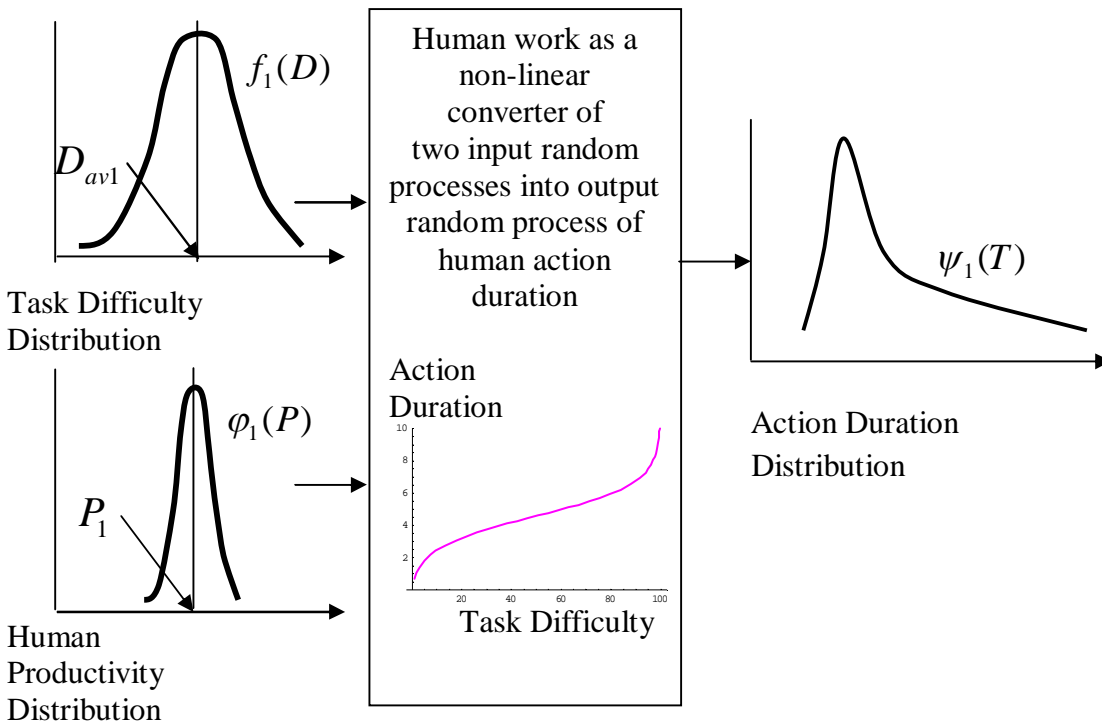


Fig.4. Presentation of human work as a random non-linear process

## 2. Probability of success of human actions

Assume there is a planned time for human action which is the  $T_p$  in Fig.5.

If the action completion time  $T$  is less than planned time  $T_p$  then the probability of success

$Pr ob_{Success}$  can be calculated as

$$Pr ob_{Success} = \int_0^{T_p} \psi(T) dT \quad (2)$$

Accordingly the probability of failure of the human action can be calculated as

$$Pr ob_{Failure} = \int_{T_p}^{\infty} \psi(T) dT \quad (3)$$

Probability density function of human action duration  $\psi(T)$ , as it indicates Fig.6, is a function of several parameters, including task assignment related parameters. Moreover the probability of success of human actions is a function of uncertainties inherent to the definitions of task difficulty and human productivity. Besides it strongly depends on the errors made by management during task breakdown and task assignment process.

Distribution Function of  
Human Action Duration

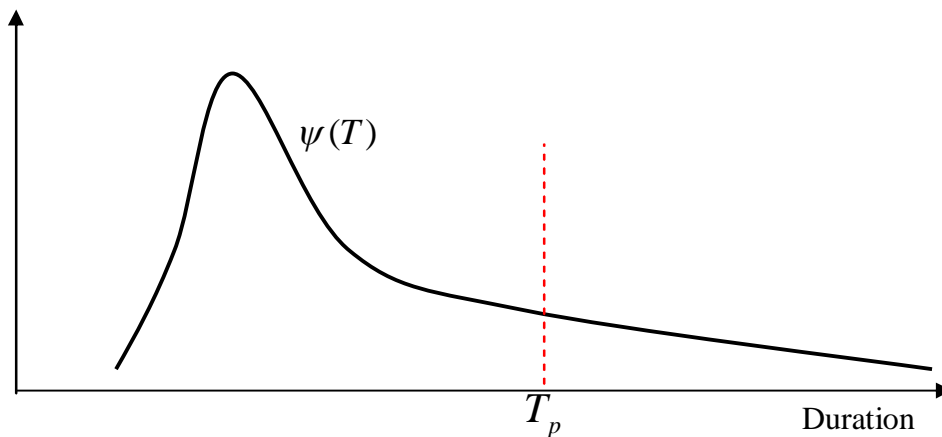


Fig.5. Distribution Function of the human action duration.  $T_p$  is the action's planned time

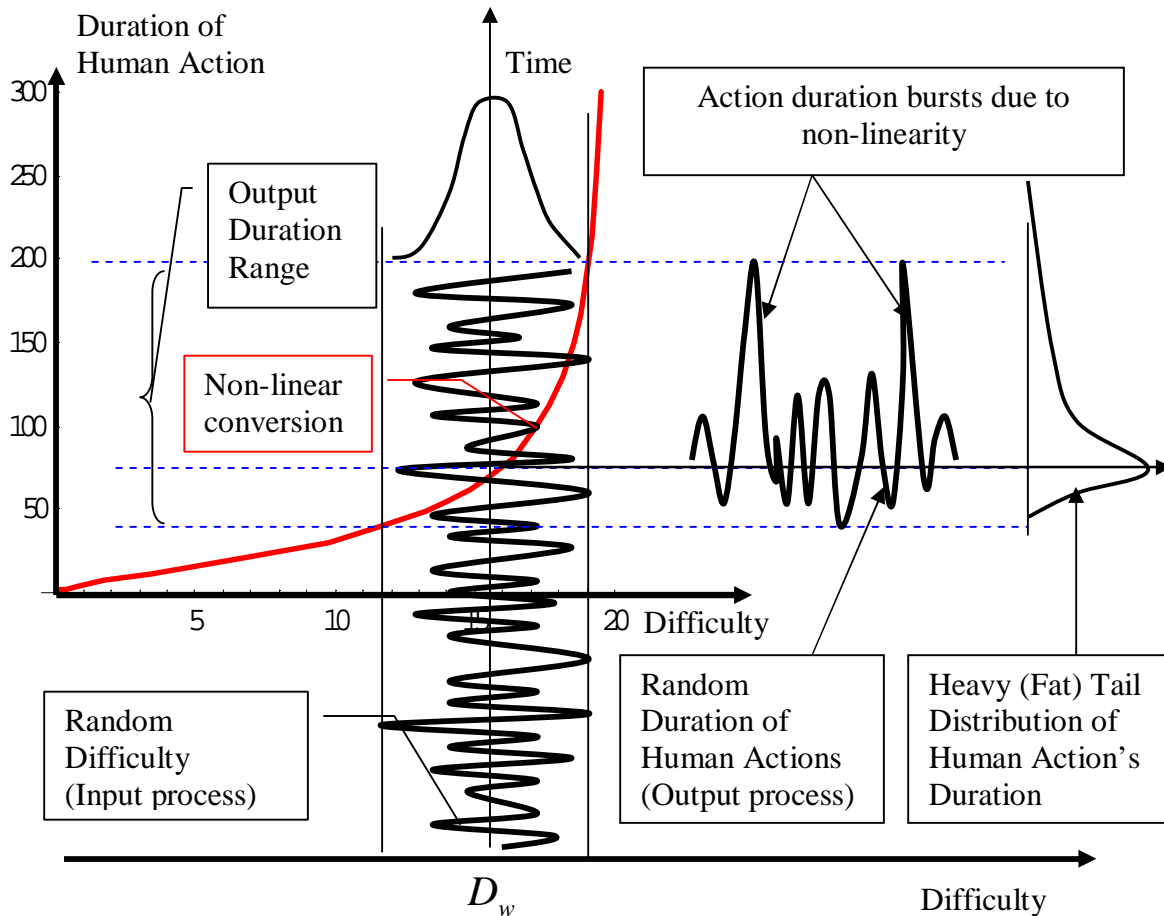


Fig.6. Non-linear transformation of the action's difficulty into the action's timing

### 3. Relations between task assignment and probability of success (or failure)

Task assignment has a direct impact on the probability of success or failure. Let's show that graphically. In Fig.7 are presented several options of work with the same planned time  $T_p$  and different difficulties. It is clear that the assigned tasks with lower difficulties have more chance to be completed within the planned time. Analysis of this picture indicates that depending on the degree of difficulty, the assigned task can be feasible or not. Therefore task assignment process is a major contributor on the project failure or success. Also this picture shows that there must be a trade-off between schedule risk and the level of difficulty of the assigned task for the given time constraint  $T_p$ .

It is necessary to pay special attention to the form of risk functions for different difficulty levels. It changes from normal distribution for the linear portions of  $T(D)$  curve to Heavy tail distributions for the non-linear parts of the same curve.

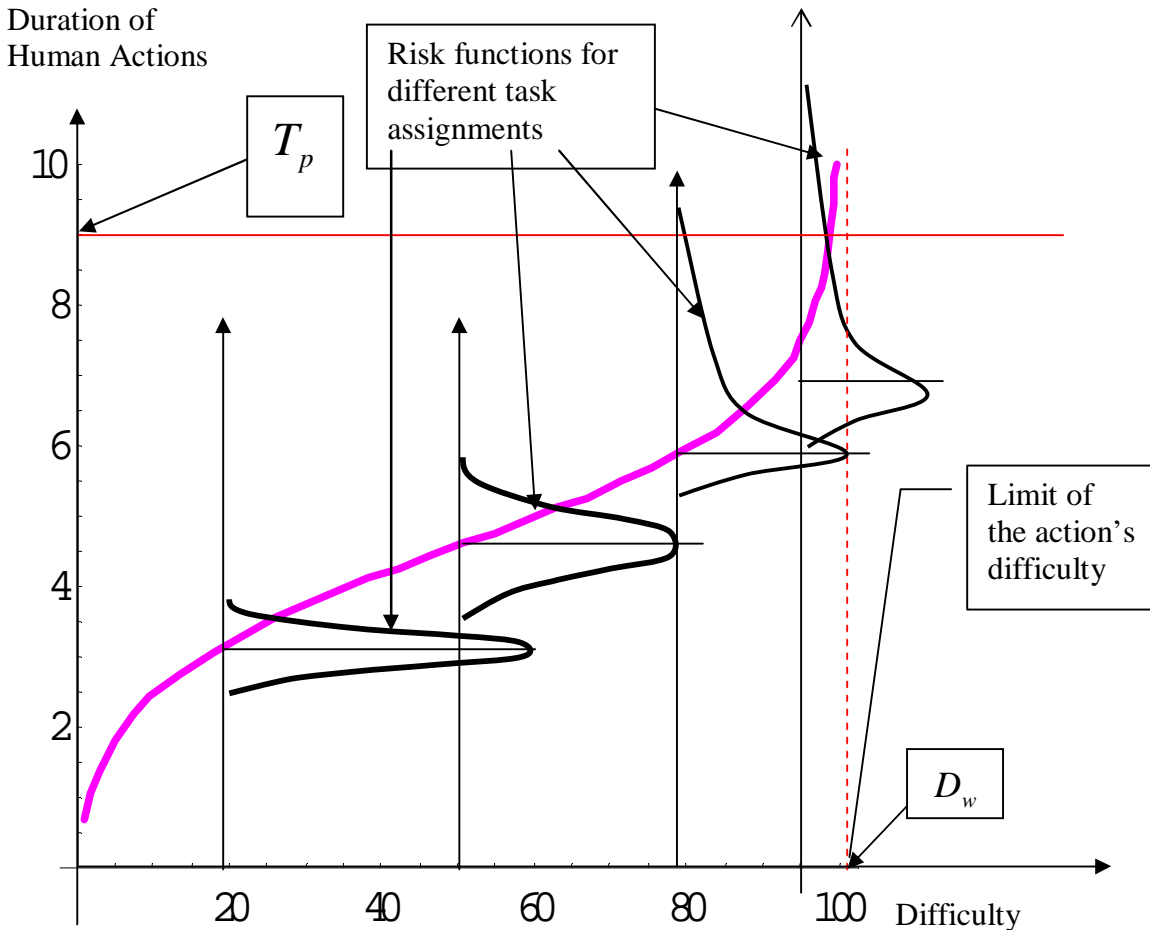


Fig.7. Task assignment can be a major contributor in the project failure

So the probability density function of success  $\psi(T)$  is a function of task difficulty  $D$  and the difference  $D_w - D$  between the difficulty wall  $D_w$  and the real task difficulty  $D$ . This difference shows how far the assigned task is from the difficulty upper limit  $D_w$ . This means that the probability of success can be heavily impacted from the task assignment and it is a direct function of task difficulty  $D$ , planned time of work  $T_p$ , task difficulty upper limit  $D_w$  and human productivity  $P_{Ind}$ .

$$\Pr ob_{Success} (T_p, D, D_w, P_{Ind}) = \int_0^{T_p} \psi (T, D, D_w, P_{Ind}) dT \quad (4)$$

Accordingly the probability of failure can be defined as

$$\Pr ob_{Failure} (T_p, D, D_w, P_{Ind}) = \int_{T_p}^{\infty} \psi (T, D, D_w, P_{Ind}) dT \quad (5)$$

To make a transition from the individual probabilities of success and failure to the corresponding group or team probabilities of success  $\Pr ob_{STeam}$  and failure  $\Pr ob_{FTeam}$  we need to use the following expressions:

$$\Pr ob_{STeam} = \prod_{i=1}^n \Pr ob_{Successi} (T_{pi}, D_i, D_{wi}, P_{Indi}) \quad (6)$$

$$\Pr ob_{FTeam} = \sum_{i=1}^n \Pr ob_{Successi} (T_{pi}, D_i, D_{wi}, P_{Indi}), \quad (7)$$

where n – is the number of team members.

Expressions (6) and (7) are applicable for the cases when there is no interaction between the team members.

#### 4. Uncertainties and Disparities in task breakdown and task assignment

There are many task assignment related uncertainties. In fact based on his own experience, knowledge and intuition manager makes numerous decisions on how to break down the whole work into appropriate portions in accordance with the people capacities and time available. The successfulness of his/her actions is based on his/her ability to correctly assess or evaluate the difficulties of tasks – portions of the whole work and the capacities of people. These two responsibilities are the core of the art of project management and depending on the experience, knowledge and management skills he/she can be somewhere between success and failure. Therefore this process needs to be analyzed comprehensively.

Let's analyze task assignment process using the method of human performance characteristics. For each portion of work or task assigned to someone of developers there are difficulty related two parameters. The first one is the real difficulty  $D_R$  of task and the second one is the proposed difficulty  $D_P$  by the manager (Fig.8.). The difference between these two values of task difficulty can play a crucial role in success or failure of work.

There is a real project execution process and a reflection of this reality in the management’s mind. If the difference between the two is small then this is an early sign of the future success. But if there are significant differences between the reality and its reflection in management’s mind this is already an early sign of the future failure.

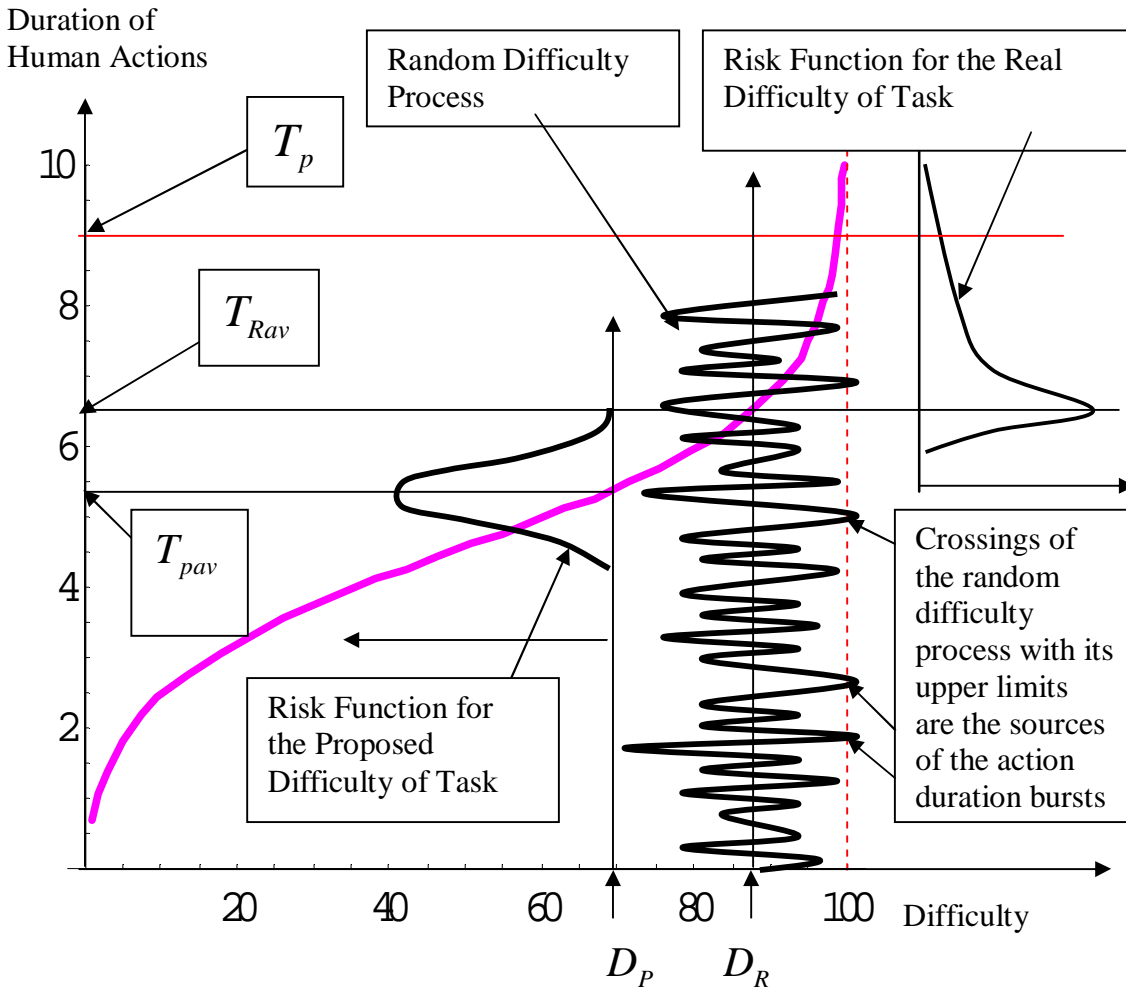


Fig.8. The real difficulty of tasks can generate Heavy tail risk functions

Likewise, the differences between the real difficulty  $D_R$  and the proposed difficulty  $D_P$  contain important information on the project execution process and therefore can become a starting point for schedule risk analysis.

Let’s analyze both cases when the proposed difficulty  $D_P$  is bigger than the real difficulty  $D_R$  and vice versa. If  $D_R > D_P$  then there is a serious risk of failure because the accomplishment of a task with an average difficulty  $D_R$  will have difficulty variations too (Fig.8). If the random difficulty process has crossings with its upper feasible limit then these

crossings are the sources of action duration bursts and consequently for the schedule failure. The action average duration for the proposed difficulty  $D_P$  will be  $T_{pav}$  and for the real difficulty  $D_R$  it will be  $T_{Rav}$ .

This analysis indicates that the schedule risk estimation problem cannot be solved within a framework of the deterministic approach. It is because the value of the average duration  $T_{Rav}$  doesn't reflect properly the problems related to the crossings of the random difficulty process with its upper limits. Also in real project risk analysis it is necessary to take into account the difference between the real and proposed task difficulties  $D_R - D_P$ .

If the real difficulty of the assigned task  $D_R$  is lower than the proposed difficulty  $D_P$  then the further timing analysis needs a new approach based on the Parkinson's Law. This law states that "work expands so as to fill the time available for its completion" [2]. For our analysis it means that even if the real action difficulty is lower than the proposed one, the action will fill the time available completely, i.e. the work will take the whole planned period of time.

In project management practice the difference  $D_R - D_P$  is an important measure of the quality of manager's work. Besides this difference has a random character with corresponding probability density function, which might become a part of schedule risk analysis.

## 5. Differential equation for Human Action Duration

The core of the proposed schedule risk analysis methodology is the relationship between human action duration and difficulty of tasks. It is possible to obtain this relationship by solving differential equations of design process [3]. In the specific case of human action duration and schedule risk analysis the corresponding differential equation has the following form:

$$\frac{dT}{dD} = \frac{A}{P_{Ind} D^\alpha (D_w - D)^\beta} \quad (4)$$

In this equation  $P_{Ind}$  - is the individual productivity index, which is a relative measure of human productivity,  $A$  - is a parameter which is a function of the work structure and management style (meetings, communication, etc.),  $\alpha$  and  $\beta$  - are the form factors that cover the individual diversity of the human's capacity to overcome the difficulties.

The boundary condition for this equation reflects the simple fact that if the difficulty of some action is 0, then the action duration is 0 too.

The solution of this equation is the relationship between human action duration and action's difficulty.  $P_{Ind}$ ,  $A$ ,  $\alpha$  and  $\beta$  are the parameters of this relationship. For some specific cases it has analytic solutions. In particular if  $\alpha = \beta = 1$ , the analytic solution of (4) has the form:

$$T = \frac{A}{P_{Ind} D_w} \text{Log} \left[ \frac{D}{D_w - D} \right] + C, \quad (5)$$

where C is the integration constant. Taking into account the behavior of the logarithmic curve in the vicinity of point 0, the boundary condition can be  $T = 0$ , when  $D = D_s$ , where  $D_s$  is a small number close to 0. For this boundary condition the solution is

$$T = \frac{A}{P_{Ind} D_w} \text{Log} \left[ \frac{D}{(D_w - D) D_s} \right] \quad (6)$$

A typical solution of this equation is presented in Fig.1.

Differential equation (4) is able to cover a wide variety of human action dynamics.

In Fig.9 is shown the specific case with two individuals who have different productivities and the same ability to overcome the difficulties (they have the same upper limit of action difficulty  $D_w$ ).

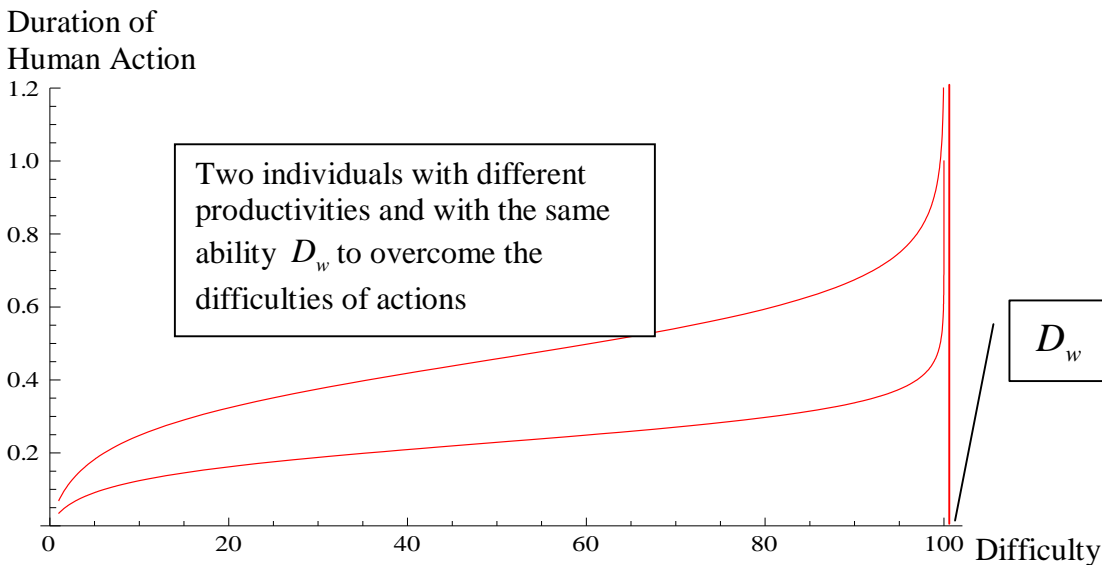


Fig.9 People can have the same upper limit of the action's difficulty but different productivities

In Fig.10 is presented the case with three individuals who have different productivities and different abilities to overcome the difficulties of tasks.

Duration of  
Human Action

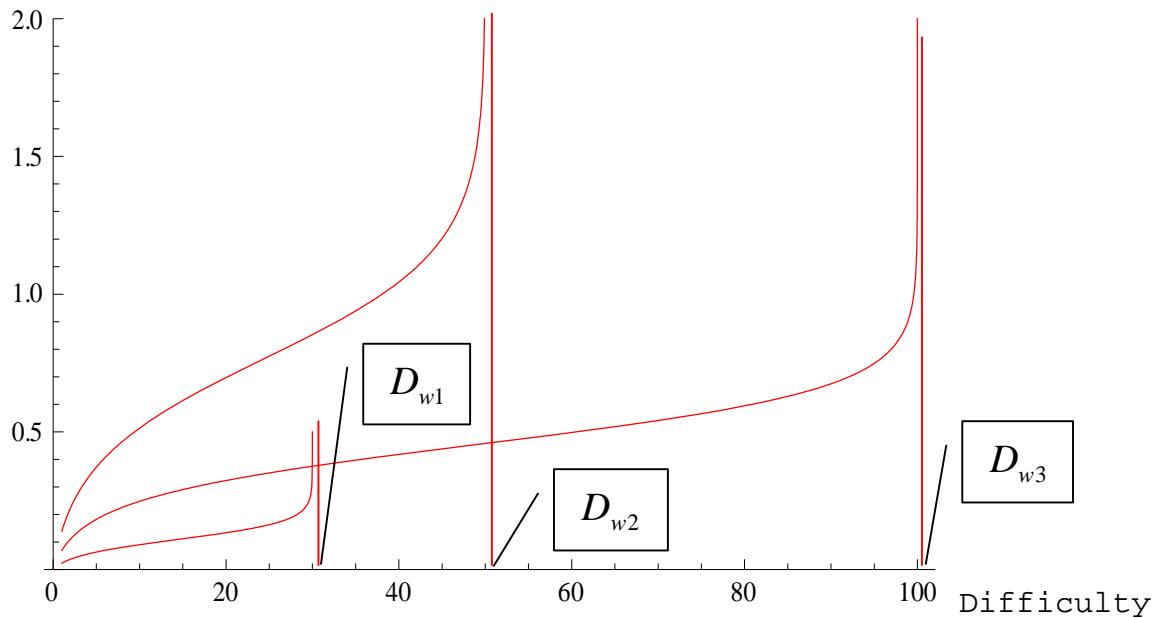


Fig.10 Three individuals with different productivities and different abilities to overcome the difficulties of actions

### 6. Differential equation for human productivity

Despite of the constant character of productivity index  $P_{Ind}$  of individuals their current productivity can be changed dynamically, depending on the difficulty of tasks and corresponding actions.

Considering human productivity as the number of actions fulfilled in the unit of time, we can obtain a new differential equation for human productivity from equation (4)

$$\frac{dP}{dD} = -\frac{AP^2}{P_{Ind} D^\alpha (D_w - D)^\beta} \quad (7)$$

The boundary condition for this equation is  $P(D = D_w) = 0$ . In Fig.11 is presented a typical solution of this equation.

Utilization of this equation can lead to the generation of different performance characteristics  
Human productivity

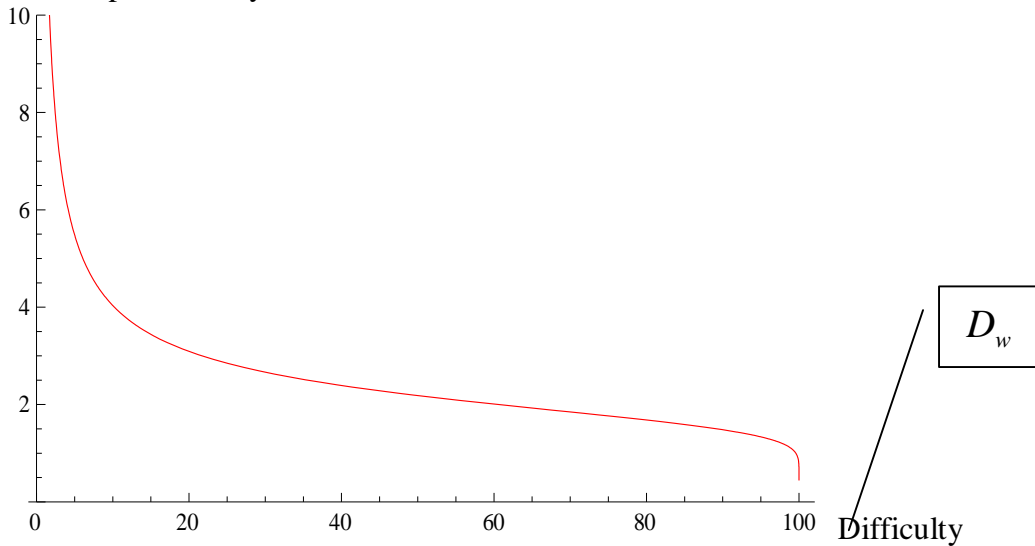


Fig.11 Typical solution of the differential equation of human productivity for one individual

of human groups. In Fig.12 are shown productivities of three individuals with different abilities to overcome the difficulties of actions.

Human productivity

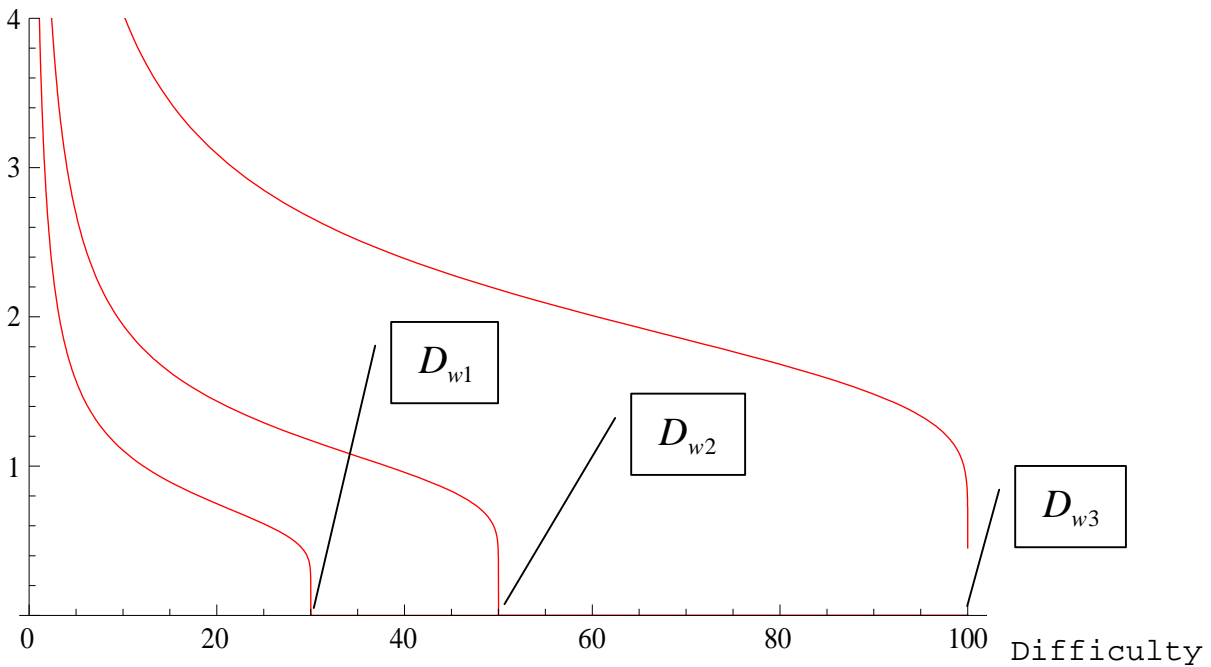


Fig.12 Productivities of three individuals with different abilities to overcome the difficulties of actions

Also equations (4) and (7) are able to model interactions between people and describe quantitatively how one individual can speed-up and slow-down another individual's work.

### Conclusions and future work

1. Task breakdown and task assignments have direct impact on the success or failure of projects.
2. Task breakdown and task assignments are connected with uncertainties and disparities because they are based on the manager's experience and intuition and therefore may contain errors.
3. The random character of the action difficulties and the random character of human productivity can aggravate the situation because the resulting human action duration fluctuations can cross the limits of the planned time.
4. In their turn the non-linear behavior of human performance characteristics may become another serious source of the schedule risk serving as an amplifier for human action duration fluctuations.
5. Therefore, depending on the real circumstances, task breakdown and task assignments may become major contributors to project success or failure.
6. New quantitative risk assessment methodology has to be based on mathematical models of human performance characteristics and on the theory of transformation of random processes.
7. Human action duration can be described by differential equation (4) which is applicable both for physical and mental action descriptions.
8. In parallel with human static productivity  $P_{Ind}$  there is a dynamic productivity  $P$  which can be described by differential equation (7).

### Future work is connected with:

1. Quantitative description of human interactions based on the new differential equations of human performance characteristics.
2. Mathematical description and modeling the dynamics of the upper limits of the human action difficulty as a result of the learning process.
3. Mathematical description of the dynamics of the quality of human actions.
4. Optimal stopping problems of human actions as a trade-off between cost, risk and quality.
5. Applications of the theory of transformation of random processes for schedule risk analysis.

## References

1. Pavel Barseghyan (2009) “Human Effort Dynamics and Schedule Risk Analysis”. *PM World Today* – March 2009 (Vol XI, Issue III).
2. Parkinson’s Law from Wikipedia. [http://en.wikipedia.org/wiki/Parkinson's\\_law](http://en.wikipedia.org/wiki/Parkinson's_law).
3. Pavel Barseghyan (1998). “Stability and convergence of the million transistor chip design”. *Information Technologies and Management*. 2, 1998. Yerevan (in Armenian language).

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