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THE KNOWLEDGE GRADIENT AS REASONABLE DECISION-MAKING TOOL IN PLANNING

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Abstract. This paper aims to focus on identification and selection of the decision-making tools by planner using the ratio between known and unknown in sophisticated planning process. Decision situations in planning are multiplex (company objectives extrapolated through modelling in the future and mixed with uncertainty and risks), dynamic (dependent and independent events amalgamated in space and time and reflected in advanced analytics applications) and requires subjective thinking abilities from planner in the conditions of vague information, unvalidated data and tough deadlines. The objective of the research is to find the most appropriate tool in decision making for different planning situations through evaluating knowledge gradient for identified situation. Specific hypothesis of the study is usage of the knowledge gradient during decision-making under uncertainty that helps planner to easier the plan creation. The closest fields of application are planning in manufacturing transportation, logistics, delivery, supply chain management, organizational management.

Keywords: *decision-making in planning, decision-making under uncertainty, the knowledge gradient in decision-making.*

Rezumat. În această lucrare autorii își propun să se concentreze pe identificarea și selecția instrumentelor de adoptare a deciziilor de către planificator folosind raportul dintre cunoscut și necunoscut în procesul de planificare sofisticat. Situațiile de decizie în planificare sunt complexe (obiectivele companiei extrapolate prin modelare în viitor și amestecate cu incertitudine și riscuri), dinamice (evenimente dependente și independente amalgamate în spațiu și timp și reflectate în aplicații avansate de analiză) și care necesită abilități de gândire subiectivă din partea planificatorului în condițiile informațiilor vagi, a datelor nevalidate și a termenelor limită dure. Obiectivul cercetării este găsirea celui mai potrivit instrument în luarea deciziilor pentru diferite situații de planificare prin evaluarea gradientului de cunoștințe pentru situația identificată. Ipoteza specifică a studiului este utilizarea gradientului de cunoștințe în timpul luării deciziilor în condiții de incertitudine, care ajută planificatorul la crearea planului. Cele mai apropiate domenii de aplicare sunt planificarea în

producție, transport, logistica, livrare, managementul lanțului de aprovizionare, managementul organizational.

Cuvinte cheie: *luarea deciziilor în planificare, luarea deciziilor în condiții de incertitudine, gradientul de cunoștințe în luarea deciziilor.*

"Courage is rightly esteemed the first of human qualities because it has been said, it is the quality which guarantees all others".
Winston Churchill [1].

1. Introduction

The modern development of the decision making started in 1654 with works of Fermat and Pascal on probability theory ("the expected value theory"). The idea is to identify all the consequences, having value and calculated probability multiply them and add them up. Later Daniel Bernoulli proposed "expected utility theory" applied to many areas of behavior. In the decision-making processes there also tools like game theory, optimal allocation of resources, planning, prediction, artificial intelligence, empirical rules. The decision-making tools are applied for many areas and some of them are: production, transportation, investment, banking system, project and risk management, work scheduling, forecasting, expert systems, insurance, data communication, diagnosing disease, translating languages, aircraft control domain, providing customer service, autonomous vehicles. The objective of the article is to find out the selective tools and rules applied in planning process.

According to Henry Mintzberg, the most important attributes of planning are:

- planning means thinking about the future;
- planning means controlling the future;
- planning is decision making;
- planning is integrated decision-making;
- planning is a formalized process of producing an articulated result, in the form an integrated system of decisions [2].

The central element in planning is decision-making [3]. The basis for decision making is knowledge, the ratio 'knowledge / unknown' and ratio 'confidence / doubt'. "Knowledge in decision making process" is rate of conformity to the real state of affairs, confirmed by facts (checked through repeatable experimentation, observation, and measurement) and reason arguments and facilitate achieving planner's goal (plan creation). For convenience we will call it in article "knowledge". Let's define other notion. "Unknown in decision making process" is the future unpredictable risk related to achieving the planner objective (plan creation) that may or may not occur, but is extremely difficult to identify in advance. For convenience we will call it in article "unknown". Planning and decision making exists as far as there are thoughts about planning and decision making. As Roy Thompson, a great business entrepreneur, made the following recommendation: "If one wants to be successful, one must think: think until it hurts" [4]. Moreover, fear blocks thinking and planner should invent personal ways to overcome those constrains. Some unknown situations in planning arise due to the fact that nobody thinks about them. "Confidence during decision making process" is self-imposed level of certainty of planner related to achieving planner's goal (plan creation) and it could be a limitation in decision making process. "Doubt during decision making process" is not only lack of confidence, but "when in doubt" planner is intently questioning (by means of judging, reasoning, assumption formulation, hypothesis testing, experimenting, also managing and organizing situations) the circumstances and conditions of planning

situations in order to find a satisfactory decision that facilitate achieving of the main objective: plan formation. Along with 'doubt during decision making process' comes fear. Fear is projected in the future together with ignorance, but reflects in the present and spoils the actual decision-making situation. So, unknown and doubts are strengthened by fear and counteraction is the courage of the planner, who dares to know in uncertainty situation.

Basic term "decision making" may be seen (as a metaphor) as a laboratory to predict, test and create new knowledge during planning process and take decision on course of thinking and acting with the aim to prepare the plan. The expression "decision making as laboratory" is not randomly applied here and consist of: objective settings, organizing, experiments carried out through hypothesis testing, simulations, modeling, observation, measurement, building judgements, calculating inference and learning from specific situations. In decision making there are two opposing forces (related to knowledge and unknown): contemplation (planner's ability to think) and organizing (planner's active will). Elements of contemplation in "decision making": observation, deep reflective thought, the act of anticipating, self-questioning, deliberative concentration, resourcefulness, ingeniousness, judgement, reasoning, courageously deciding with final goal: invent the plan. Elements of organizing in "decision making": achieving objectives, "decision making laboratory", criteria for decision, impact of decisions, priorities in activities, risk savvy, trades off between options, deliberative and courageous forming the situation in the direction to emerge more knowledge and more certainty with final goal: shape the plan.

The goal of actual article is to define the conditions, when planner is successful in decision-making process in preparation of the plan in full, on time and at agreed level of accuracy and is evaluated the hypothesis of the knowledge gradient during decision-making under uncertainty.

2. Materials and Methods

In the article we will use also the following terms. "Stable and known situation" is predictable future situation, when planner knows all the future events that can happen, the whole list of risks, the impact of all consequences and there are methods for good probability estimations and calculations and all this is situation with epistemic certainty and knowledge. For "stable and known situation" planner can easily calculate what can happen, with what probability and with what consequences for specific event. "Unstable and with large uncertainty situation" is unpredictable future situation, when planner do not know the future events that may happen and there is no way to estimate or calculate probability of the events. Planner can't apply probability theory to "unstable and with large uncertainty situation" because this is situation with great epistemic unpredictability that cannot be calculated and optimized [3]. Term 'planner" will be used in the following sense: "planner as the cause of decisions in planning with the objective to shape the plan". Term "decision making work" is to find out the robust solution for plan. "Irreversible decision" is the decision that cannot be changed once implemented or it is too late to influence planning situation, because it is impossible to replay the initial situation: circumstances have gone, cost of changing is too high. "Reversible decision" is the decision that might be changed once executed and could be improved by iteration.

The basic element for building a plan is knowledge. Knowledge consists of facts, judgments and conclusions [5]. The main problem in planning is the lack of knowledge. In other words, planner terribly needs knowledge, specific knowledge for a given situation. The main task (related to decision making) of the planner is the identification, searching, building

and development of new knowledge using available tools. At the same time, to be productive in decision making, planner should admit that he or she do not know (at least for initial stage of thinking, before decision making). The key moment for planner is not to become stack for long time with one state of mind: "I do not know" or "I know". If the planner does not know, then he or she find the necessary knowledge. If planner knows then should check the basis for such statement.

What are the requirements for planner to be a good decision maker? The planner must have a phenomenal intuition combined with releasing of energy equal to that which occurs at the moment of teaching-learning process, an energy that manifests itself through thinking and compassion (acceptance, absolute positivity). From objective point of view "a company's value is just the sum of the decisions it makes and executes" [6].

The planner must be able to switch instantly from subjective active contemplation to objective active action (organization of materials, people, resources and time) and back. These are two opposite abilities that oppose each other. If the planner admits wrong assumption in contemplation and then applying it, then there is a fallibility situation or as Daniel Kahneman and Amos Tversky explain it: "What is perhaps surprising is the failure of people to infer from lifelong experience such fundamental statistical rules as regression toward the mean, or the effect of sample size on sampling variability. Although everyone is exposed, in the normal course of life, to numerous examples from which these rules could have been induced, very few people discover the principles of sampling and regression on their own" [7]. How to reduce happening of fallibility situations in planning process? Usually, authors recommend to make better estimates, learn from mistakes and use software to make a calculated prediction [8]. The main problem arises from "unstable and with large uncertainty situation" where planner has not clear data and even estimates are made on slippery basis. How to solve this situation? Applying risk competency planner is recollecting the task is in focus now, what is known and what is unknown in this specific situation (and planner needs this specific knowledge now) and find the direction where to make observation and where to apply the will to exit the mist of uncertainty. The principal condition for finding direction of investigation is where the planner detect the fastest way to reach robust knowledge and the practical rule is to use planning software application data, organizational knowledge, relevant people planner knows for specific situation, personal planning experience, ability to observe and organize planning situation. The second condition is that all systems and planner's mind have fallibility and the planner have to check the ratio "variance of the specific planning position (acceptable error in the estimates) – accepted level of accuracy required in plan (accuracy is closely related to the plan reliability)".

Planner communicate easily and patiently with others, keeping good mood, which is basis for maintaining the creativity in planning process. Why so? Negative mood is incompatible with plan creation. If someone is in negative disposition then that person is dangerous for himself or herself, not to mention to approach planning process. The main reason is that negative emotions "can stimulate high levels of false memory, relative to remembering neutral events" [9], which in its turn increase the probability of errors during planning process. Simultaneously, the tension for solving problems (external circumstances as a source of objective problems) induces in planner negative emotions. How to deal with such situation? Planner is the trained fighter with subjective negative mood and external objective circumstances to deliver plan according to requirements. The planner thinks and acts not like everyone else and not even like himself or herself a minute ago, but like himself

or herself in a single unique, unrepeatable version, that is means to be noble and virtuous (in strength equal to the most ardent passion and in stamina equal to the courage of the bravest in battle [10]). The planner is placed in a paradoxical situation, when emotions, passions, fears are excluded from the planner's field of work, which is in opposition to the requirement to the planner to create objective plan, that is, planner should to be an extraordinary person, combining exceptional passion in creating an objective and robust plan and equally phenomenal subtlety in dealing with uncertainty which is behind the plan.

Everyone could be a planner, if you are ready to learn how to deal with risks and unknown and if you dare to build knowledge. Risk is the likelihood that an event will occur in the future (specific risk related to the determined objective or risk derived from the objective planner has to achieve, not all world risks to be assessed). So, one of the basic competencies of the planner is risk competency, which means the ability to weight up the risks and uncertainties and to have the courage to fight with personal fear and to take responsibility for the decision made. The more planner knows about the situations in planning and in the material domain which is represented in plan, the better understanding, more control over assembling the plan and less fear in working with risks and uncertainty situations planner has. In other words, the risk competency of the planner is to hit the points of truth even dealing with uncertainty.

Activity of planner is measured by performance mostly and less by procedures. If the planner prepared a successful plan, nobody is asking about procedures how the results are achieved: by logical tools, by probability calculations, by intuition (open and free will decision making approach). In case the planner failed to create a plan according to specific requirements then the way how the plan was built will be under scrutiny and the main focus will be how close the planner followed the procedures (defensive decision-making approach). Planner is accountable for the results of decision-making activity. That's the reason most of planners accept defensive decision-making approach. In case the high management stay on the course of transparency related to decision making in the company then the defensive decision-making approach will be less. One of the planner tasks is: to prepare the plan with required performance level in full, on time and with required level of accuracy. In other words, how planner make decisions, when optimization is out of reach in “unstable and with large uncertainty situation”? How to make rational decisions in such situations?

First of all, planner should recollect what task is in focus now. Regarding to the planner organizational task is to prepare the plan in full, on time and at agreed level of accuracy. Derived task is to make fast, objective and accurate decisions in order to deliver the plan.

For understanding “stable and known situation” let’s take an example of calculations of probability of delivery bread from the school program. The example is the following. A company has three suppliers of bread: the first supplier delivers 30%, the second delivers 30% and the third delivers 40% of the total bread for a shift. The non-standard production consists of: the first supplier - 5%, the second - 4% and the third - 2%. The task is to calculate the probabilities: a) Bread taken at random is non-standard; b) The non-standard bread was taken from the second. The solution to the problem. We consider the events: A – the bread taken is non-standard; B (i) – non-standard bread is taken from supplier $(i), i = 1, 2, 3$.

We have the following situation: $p(B1) = 0.3$, where $p(B1)$ is the probability that bread is delivered by the first supplier; $p(B2) = 0.3$, where $p(B2)$ is the probability that bread is delivered by the second supplier; $p(B3) = 0.4$, where $p(B3)$ is the probability that bread is delivered by the third supplier; $pb1(A) = 0.05$, where $pb1(A)$ is the probability that non-

standard bread is taken from the first supplier; $pb2(A) = 0.04$, where $pb2(A)$ is the probability that non-standard bread is taken from the second supplier; $pb3(A) = 0.02$, where $pb3(A)$ is the probability that non-standard bread is taken from the third supplier.

Using the total probability formula, we conclude what is the probability that the bread taken at random is non-standard $P(A)$:

$$P(A) = 0.3 * 0.05 + 0.3 * 0.04 + 0.4 * 0.02 = 0.015 + 0.012 + 0.008 = 0.035 \quad (1)$$

Using Bayes' formula, we determine the probability that the non-standard bread is taken from the second supplier $pA(B2)$

$$pA\ (B2) = \frac{p(B2)*p(b2)(A)}{p(A)} \quad (2)$$

$$pA(B2) = \frac{(0.3*0.04)}{0.278} = \frac{0.012}{0.035} = 0.34 \quad (3)$$

We calculated probability that the non-standard bread is taken from the second supplier is $pA(B2) = 0.34$. So, the planner knows the probability of the unwanted event, but some additional actions are needed.

Now let's make analysis of the "unstable and with large uncertainty situation", similar to described above – planner pick up the phone and order the quantity of bread not only for one shift, but also for 1.5 shift (in order to cover the non-standard quantity of bread delivered by suppliers, which will be not be used in manufacturing process) and with communication efforts and using intuition (rethought past experience) planner is solving the problem. The problem is that some delivered bread is non – standard. Instead of finding out and calculating long list of free parameters and unnecessary probabilities, which also may add additional information, variances and errors, planner prefers to make shortcuts and with courage, with less computational efforts and allocated time solved the problem.

What are the consequences from two examples? They are:

Probability theory is a theory of certainty and is useless when the planner is dealing with the situation with large uncertainty. In the "stable and known situation" planner is mostly passive. Empirical rules are indispensable for good decision making under uncertainty. They are not the product of a flawed mental system. In the "unstable and with large uncertainty situation" planner is active through applying cognitive abilities is organizing the situation to achieve the company goals.

Applying the calculation from "stable and known situation" to "unstable and with large uncertainty situation" is not productive. "Stable and known situation" are the situations when all alternatives, all risks, consequences and probabilities are known, situations that can be find, for example, in chess play. Real planning circumstances are "unstable and with large uncertainty situation", when planner deals with events with certain degree of uncertainty and for such situations planner have to decide in what direction to think, communicate, act and how much to be calculate and what should be ignored.

In "stable and known situations" there are methods to calculate optimal solution with maximization of the performance. For "unstable and with large uncertainty situations" there are no way to calculate optimal solution in order to maximize the productivity or even there is no method to calculate the risk and cost of consequences. So, for "unstable and with large uncertainty situations", for real planning conditions, optimization is an illusion, which may mislead the planner.

Planner has the task to create added business value. Large scale planning applications used by planner are complex and extremely interdependent from other working systems. The

paradox consists in the fact the multiplex planning software are working under the condition "stable and known situations" and the planner task is to find or invent simple methods to use the results of planning software systems to real planning conditions in order to achieve the key business indicators (KPIs). How it is possible to do so? The closest planner's tools are constructing judgements and reasonings which is good mind tool to use the results from planning software ("stable and known situations") to the real world of planning ("unstable and with large uncertainty situations").

Next, let's check what cognitive assumptions are behind the "stable and known situations" and "unstable and with large uncertainty situations".

An example of "stable and known situation" is planning software application used by planner. The cognitive assumption of planning software application is that tomorrow is like yesterday and application ensure good extrapolation from previous data (posterior knowledge as facts) to future data (a priory knowledge as expectations). So, planning software application which is big and complex data sets with multiplex algorithms is "stable and known situation". Previous data used by planning application are 'posterior knowledge as facts' and future data are 'a priory knowledge as expectations'. Knowledge is in the past and in future (a priori knowledge as expectations) there are only formal knowledge without confirmation from experience [5]. There are several consequences:

Planning software application is highly successful when dealing with data with small variations from yesterday to today ('extrapolation').

Planning software application allows planner to make fine tuning optimizations.

An example of "unstable and with large uncertainty situation" is planning situation when a new product is the launching (all cycles).

The cognitive assumption of "unstable and with large uncertainty situation" is when future states cannot be well foreseen. Introducing new product creates in planning additional variability for specific product: unpredictable consumer behavior, difficult demand and supply forecast, unknown safe inventory volumes for new materials as ingredients for launched product, shortages, unknown practical line efficiency, resources allocations. Here there are several consequences:

Planning software application is not effective for such situation, because there are no previous data ((posterior knowledge as facts) for launched new product. Planning software application should be populated with initial masted data, but there are missing at initial stage of launching. Mark Twain humorously noted that "It is hard to make predictions, particularly about the future."

At launching stage of new product there is no option for optimization yet (optimization of volumes of materials, resource allocation), because planner has no initial experienced confirmed data for planning a new product. Planner should make swift and smart decision under uncertainty with the deadline to present plan for new product. At this stage planner cannot calculate the necessary data, planner may estimate the data for new product. How to overcome the challenges that arise from launching of new product which is "unstable and with large uncertainty situation" from decision making perspective? The planner's task is to keep the business running without interruption. In the situation with huge uncertainty planner use empirical rules to deliver the plan for new product:

Use historical review for the product with similar features and from the same sales category and this makes it possible to find approximate initial estimations.

Collecting available information from other teams and this also add a little bit of certainty for new product. Initial data. For initial stage, planner should have bigger variance deviation (than for products with long history behind) for material inventory. Should be stated from the very beginning the probability of undersupply or oversupply of inventory, because of lack of experience confirmed data. Initial KPI for inventory should be bigger that for products with planning history.

Creation of simple model. Planner should start with the simple model that can be kept in one mind, because plan consists of quantitative data, where materials, resources, calendars are arranged in relation to each other according to a particular sequence, pattern, order, which is easier to control in simple model than on large one with complexity and confusion. Planner is not only passive operator that follows the planning rules, but also is an active creator of new planning models, new rules, new understandings through making valuable discovering. At this stage three are three sources of errors.

One source of error is the measurement error, which could be minimize by finding that the value is too far from the norm and planner call to the material responsible or to supplier and check again the number provided. Second source of errors are mind bias that could be countered by randomness and the range of sample planner got. Third source of errors in plan is ratio "accuracy – flexibility" or "successful plan – flexibility to learn". For this type of error planner do not expect unbiased system or unbiased mind that know everything, but to keep rational proportion between "plan meets requirements versus planner learned about biases and variances and controls them".

Planner don't know everything, but in the course of a search, seeking carefully and thoroughly through facts, estimations, reasonings make bold guess where "direction and the rate of fastest increase of knowledge" and follow it. "No law requires managers to be consistent" [11], but planners do have to be consistent even suffering from lack of specific knowledge to solve problematic planning situation.

Planning assumptions. Establishing of planning premises for new product is good for expressing in the written form what are initial statements about new product (product estimations and expectations) and how planning assumptions changes during the lifecycle of the product (based on posteriori knowledge). Planner should judge the stability of the planning premises and how well they fit the organizational requirements and to take corrective actions to meet company's objectives.

Contemplation. Planner has the right to keep silence for 60 seconds in order to contemplate and ponder over the planning situation. Plan is not happening by chance, but with attention, observation, contemplation, checking data as they appear as facts or estimations as facts, constructing judgements and reasonings in the conditions of silence and considering the ratio "known-unknown" – all necessary elements for the streamlining work of assembling plan.

Planning at the level of "confirmed facts". Planning starts with the data seen as facts like quantity of materials available for production lot, production lines available. Planner takes into account the resources that are ready for use in planning process as facts proved by counting them physically by responsible person and finding them in the planning software application as numbers ("planned values as facts" confirmed at the stage of preparing plan, present time confirmation).

Planning at the level of "estimates, not yet confirmed as facts". Planning continues with the data that are not yet confirmed as facts, but planner estimates them as facts

(available to promise) like the material will arrive later than plan is finished, but earlier than the production line will start manufacturing. Planner use estimates of future situations (tonight at 22:00, tomorrow at 04:00, the day after tomorrow at 11:00) as basis for decision making and registered in the planning software application as numbers ("planned values as estimations", waiting for physical confirmation latter, but confirmed verbally or by emails at the stage of creating the plan).

Planning at the level of "judgments and reasonings". Having scarce data about new product planner analyze the planning numbers that are available with extended judgments and reasonings, which will allow to extract and build new estimations about new product that are necessary for creating plan. We may call this approach "planning at the level of judgements and reasonings" as there is no experience proved knowledge until factual data will be available. "The knowledge gradient" is influenced by planning input parameters, turbulence factors, requirements for planning output parameters and decisions constrains and in Table 1 and Table 2 we present a few lists of them and their dependencies.

Partly the approach to KPIs and parameters used in Table 1 and Table 2 are taken from sources [12, 13].

Table 1

Planning input parameters and turbulence factors

Nr.	Parameters	Stable and known (planning application) situation	Unstable and with large uncertainty situation (usually outside of planning application)	Planning level		
				Confirmed facts	Estimates, not yet confirmed as facts	Turbulence factors (defined during judgments and reasonings)
1.	Supply chain demand / supply		Commercial demand / forecast		Restricted commercial models for demand that generate predictions	Wrong material delivery, unacceptable poor quality of material)
2.	Raw materials delivery reliability	In stock (partly)	Unacceptable / urgent changes to production schedule	In stock (partly)	Available to promise (on the way: to be delivered)	New planning volumes, different time window, requested raw materials are not yet in stock
3.	Raw materials lead times	Safety time set up in the system	To be delivered till manufacturing starts.		To be delivered till manufacturing starts	Discussed and agreed by phone call and confirmed by email from supplier

Continuation Table 1

4.	Raw materials inventory fluctuations	In stock (partly)	Replenishment process	Raw materials safety stock	Is safety stock ensured?	Overstock or shortage of raw materials
5.	Manufacturing resource productivity	Machine capacity by design	High demand variability	Machine capacity by design	Engineering design changes (not communicated)	Machine capacity shortages, labor shortages
6.	Raw materials transportation times	Delivery time set up in the system (safety lead-time)	Poor delivery performance	Inventory wrong counting, posted in the system	Available to promise (on the way: to be delivered)	Urgent changes to production schedule, late delivery, forecast inaccuracy
7.	Specific machinery setup time / changeover time	Machine times by design and lot-sizing rules	Rescheduling			Manufacturing inflexibility, downtime, acceptable production sequence, set-up costs
8.	Yield	Planned yield in system	Unbalancing the machine productivity and the human capability			Product mix, multi-site production planning problem, yield factor
9.	Scrap	Planned scrap rate	Quality control issues and a low level of operational efficiency			Rejected: raw materials, during production process, as finished good
10.	Overall manufacturing equipment effectiveness	Planned data: availability rate, performance rate, quality rate				Six big losses: unplanned stops, planned stops, small stops, slow cycles, production rejects, startup rejects

Table 2

Planning output parameters and decision constrains

Nr.	Parameters	Stable and known	Unstable and large with uncertainty situation	Planning level: Confirmed facts	Planning level: Estimates, not yet confirmed as facts	Planning level: Decision constrains (defined during judgments and reasonings process)
1.	In full prepared plan		Management pressure			Situation, when planner report in good time a duration for an additional activity, but direct manager enforces unrealistic time to fulfill specific activity
2.	On-time prepared plan		Planning application system issue			Planner's tools are faulty: no access to actual info and time to recover is too long or unknown and affects negatively plan preparation
3.	Accepted accuracy of prepared plan		No enough support from the customer on resolving issue			Planner asked early detailed information (email and phone), but nobody from customer is not answering or respond too late, when the problem not be solved
4.	Information waiting time		Inconsistency in information			Two different sources, with equivalent power, provide contradictory information. For example, Team Leaders were in different meetings and cascaded opposite information
5.	Information waiting time		No access to customer portal			Planner asked access to customer portal to manager, but access was not given on-time

Other technique of fast decision-making process authors presented in the article "Fast decision making in planning" [14].

In the article "Decision making planning: the meta-decision approach" is made an attempt "to achieve higher-quality decisions with less time and less resources invested" [15]. Main result of the research is meta-decision approach is beneficial which imply planner's

reflection. Respectively, reflection and self-reflection are practically useful for planner because it helps to boost productivity during decision-making process.

3. Results and Discussion

Summing up the discussion above, we propose the following:

Simplifying. As long as planner is dealing with complex software planning systems the question is to identify the main problem, building judgments and inference reasoning and the question of simplifying is how much to reduce observable situation in order to find good decision.

Question about simplifying could be divided in three specific questions:

a) **Descriptive question**. What is list of available decision-making tools planner may use?

b) **Normative question**. In which situations planner could apply successfully the specific decision-making tools and in which situations applied decision making tools could lead to failure? For example, on what the planner is focused: on finding when the specific material is arriving or to make complex computations to define the probability when the specific material is arriving? In "unstable and with large uncertainty situation" one reason (well worked out) could give better planning accuracy than complex computations. In order to find one good reason planner is framing up judgments and reasonings for specific situation.

c) **Question about organizational structure**. How to organize the work of planners in order to have resonance effects amplifying better rational decisions on the level of planning department? How to create a working environment in planning that facilitates good rational decisions in building common plan?

Building the knowledge gradient under uncertainty. There is no proof or argument that future events will happen only in this or that way and correspondingly that the planner will have new knowledge about those events in the future before events will happen. The direction of the events that have occurred and the knowledge gained depend both on the circumstances on the material side of planning and on the decisions made by the planner. The planner's ability for emerging and developing new knowledge implies creativity (freedom to create) in conditions of lacking knowledge and freedom of will (freedom of choice) also in conditions of ignorance. That is why is impossible to foresee precisely in what direction and in what volume new knowledge will appear or be developed in advance (forecast in the future). At the same time, there is an expression "leap of faith" and, by analogy, we introduce the expression "leap of knowledge" when the direction and result of the search for knowledge is successful. The simple tool that we have proposed to solve the question "In what direction and how planner define the way to continue the quest for new knowledge?" is "the knowledge gradient".

Explanation of the knowledge gradient under uncertainty. Planners are focused on creating a successful plan. In this respect they are practically oriented, substantiate their decisions on procedural planning books and empirical planning rules. Having the task to deliver required plan and, at the same time, to survive in "unstable and with large uncertainty situation" planner needs a range of tools. From the range of available tools planner have to pick up one that allow to find the "direction and the rate of fastest increase of knowledge", which in its turn, after applying selected decision, keep agreed level of accuracy. For planner one crucial criteria in planning and decision making is ratio "effort – accuracy" in plan at the acceptable level. The planner periodically should recollect the tasks are solving now in order to create the plan and to keep in mind with what type of situation planner is dealing: "stable

and known situation" or "unstable and with large uncertainty situation". "Situation" requires specific decision tool and not vice versa. The decision-making planner's task is to find appropriate tool to solve decision making problem with less effort and achieving satisfying accurate plan. So, planner should not find every time optimal solution form all possible alternatives, because rate "effort – accuracy" requires too big effort or the optimal solution could not be computed. Someone may ask: "What is the problem with decision making tool? I may use every tool". The core factor that influences the creation of the robust plan is: "What is known and what is unknown for every position in plan?". Planner's level of knowledge defines the plan, but not psychological states and not emotional states of planner which derived from knowledge the planner has. So, finding the "direction and the rate of fastest increase of knowledge" for specific situation is one powerful mind tools that helps planner to create robust plan. That tool frequently is under evaluated – the planner's trained mind, - like recognition of pattern in the planning data, recall tracking, the ability to recollect own task quickly. In order to find the "direction and the rate of fastest increase of knowledge" for specific situation planner have to learn (and keep alive this ability permanently) to recognize, check and test the correlation between "known and unknown" for specific situation. We would like to emphasize that planner using planning software system as well as judgmental and reasoning tools, going forward and backward, until finding satisfactory decision. Analysis offered by multiplex planning software system is not posed in opposition to human judgement and reasoning: they are used complementary by planner.

How to apply the knowledge gradient. How planner knows where to find necessary new knowledge for solving specific planning situation? Apparently, planner knows nothing. It is not so: planner knows the requirements for plan creation with specific objectives and tasks. So, starting with "unstable and with large uncertainty situation" and keeping in mind plan requirements, planner have a mind map with "to be plan", known areas and unknown regions with ambiguity mountains, uncertainty valleys and the Mariana Trench of risks. Planner do not have a device like GPS to find needed knowledge or data. The process of founding new imperative knowledge by planner consists of:

a) Mind contemplation on missing knowledge

- *Search direction:* to look thoroughly for what knowledge or data is missing and this is search direction – to build the shortest route from current "known with certainty" departure point to destination point "to be plan" and the route runs through the unknown regions.
- *Size step / leap / iteration:* how many steps are used from an initial value to generate approximate solutions which is following as a result from the previous solution.

b) Actions to acquire missing knowledge

- *Search direction:* in navigation there is a similar process by which an unknown location is found using three known distances from known locations – planner search for the agent (supplier, carrier, manufacturer, truck, etc.) which is third point between two points: current "known with certainty" and "to be plan".
- *Size step / leap / iteration:* in case one agent is not enough to define the missing knowledge, planner introduce second agent to measure of departure from ignorance straightness (current "known with certainty" and "to be plan") or more agents are added. Planner asks respective agent additional information and add "estimation data" (not knowledge yet) in plan.

- *Criteria to stop the search:* first satisfactory solution ("estimation data" plus "judgement") between current "known with certainty" and "to be plan".

c) If search direction for new knowledge is erroneous

- *If direction is wrong or iteration step is unproductive*, then planner re-start the process again: direction, step size, shortest path for acceptable solution.

Finding a direction where more knowledge will be found faster starts with recollection of the tasks of the planner and swinging between "confidence" and "doubt" in relation to a specific case, a specific "knowledge - unknown" in the planning process. Thinking between "confidence - doubt" and "knowledge - unknown" is drawn along the line "making a decision that contributes to the formation of the plan". Planner every time choose the option closer to slope coordinates "knowledge - plan" that adds old and new knowledge to develop and settle the plan. From the range of options planner check and choose the one which corresponds to the criteria "direction and the rate of fastest increase of knowledge" correlated to plan preparation.

Other way to evolve the knowledge gradient is usage of check list of 5 – 7 parameters, created by planner from personal professional experience, usually invented ad hoc for specific uncertain situation. Planner is not going through all variables and arguments, but going through improvised check list, select one specific parameter or one variable that might swiftly generate new knowledge and stabilized the specific situation (initially as unstable with large uncertainty). We are using modal verb "may", because there is no guaranty that the first attempt will be successful. Sometime planner makes several attempts and they appear to be unsuccessful, but even negative results are used to rapidly diminish the volume and puzzling effect of unstable with large uncertainty situation. Planner pick up only specific variables or data mostly relevant to operational objectives and simultaneously offer "direction and the rate of fastest increase of knowledge" in order to shape the plan.

Paradox of building the knowledge gradient under uncertainty. In this case we return to an old paradox of thinking, attributed to Socrates: in order to know something, I must already know what I want to know. So, I should know in advance the result of thinking and the direction where to think. But the result of thinking I do not know at the beginning of thinking. How planner solve the problem which is unsolved for philosophers? Planner define what is known and is not, identify the facts, check the doubtful data and construct on them judgments and reasonings finding future estimations for tomorrow in the plan.

Unit of measure of the knowledge gradient under uncertainty. Applying the knowledge gradient to ambiguous decision-making situation there is a necessity to measure the volume of knowledge. How planner measures the increasing volume of knowledge (direction of searching that offer new knowledge) and in the fastest way (velocity in increasing the volume of arising new knowledge)? We may humorously propose a unit of measure of knowledge such as "one Einstein" or "one Kant", but the question how to measure and quantify it remains unsolved. The planner could measure the volume of knowledge and the rate of its increasing / decreasing using the ratio "I know – I do not know" or the ratio "What I know now related to specific situation? What I may know in case I would go in the direction of this investigation?". After going in the respective direction of searching and organizing, planner again enquires, checks the ration "known – unknown" and evaluate if the new epistemic and material situations is moving ratio in the direction of increasing or decreasing in the course along to reach the destination. If the ratio does not offer more knowledge, more certainty and control over specific element in plan then planner abandon this direction and quickly

restart the process of searching and organizing (always in pairs, because planner is not only the searcher, but planner is an active organizer of "material situations" as well as "cognitive situations" related to planning), until finding satisfactory level of knowledge and confidence in the decision made to achieve the objectives of the plan. The problem of measurement of knowledge is well discussed and analyzed, for example, through self-reports, free elicitations and objective tests [16]. The cited authors expressed their caution in interpretation of the result of their studies, because too many conditions influence the measurement of knowledge, for example, instead of measurement of knowledge, tests measure the difference between educational background of interviewed like learning from experience or formal training. Knowledge can be seen as organizational public (internal) goods and nobody can hide them only for personal usage. "True knowledge is built through the contributions of many people, and to try to deny parts of the past is to emerge with only a partial understanding of the subject, and to create the danger that the wheel will be reinvented, although disguised in different colors, time and time again" [17].

Reversible or irreversible decision. Most decision making cannot undo after implementation. In other words, planner should check if this a reversible or irreversible decision? Practical rule for decision making: irreversible decision requires deep pondering to avoid the trap of "cannot change anything" or "is too late to return to previous situation". Consequence is the following: once implemented, irreversible decision is too costly to be taken once again.

Reversible decision allows iterations, so such decision might be improved after being executed. Planner check out the ratio "invested cost before decision - severity of the consequences after implementation of the decision" based on the estimations.

As a result, one of the indispensable planner's competency is risk competency in order to deal with risks and prepare the company for an uncertain future. As some examples of uncertain future could be: the volatility of the market for specific product, inflation, new project, periodical restructuring of the company, goal settings, assumption analysis, delay in delivery of the material, questionable data, lack of data from other colleagues and suppliers. Planner transforms uncertain future in realistic plan with numbers, resources, calendars, shortly – the plan with definitive and positive certainty.

Transparency in decision making. Planner is dealing with ratio between individual defensive decision making versus risky decision making for the benefit of the whole company. How to achieve the goal: transparency in decision making? Level of transparency in decision making is set by high management of the company: more transparency is the better, including high management decisions to be under scrutiny of analysis and to be ready to receive all range of feedbacks. Transparency in decision making allows planner to apply knowledge, skills, inventive mind and risk savvier approach together with accountability, responsibility and open style in the running of the company for the benefit of all stakeholders.

Individual thinking experience. The planner builds judgments and reasonings based on facts and future estimations and individual thinking experience is the minimum requirement for planner.

Experience exchange. The planner may benefit from planning exchange experience with other planners (from the same site or from other sites) and also from other managers in the company. The planning experience exchange is beneficial as for new planners as well for experienced planners.

Shadowing managers. For planners is useful to shadow periodically other managers in the company and planners will know and understand how actual process in the company are organized and how managers take decisions in real conditions.

Experimentation in decision making within the limits of the reason. Experimentation is situation in which one or more variables are deliberately changed (planner's question to situation) and the effect of that changes on other variables is observed and measured (planner's answer to situation). Through an experiment, planner tests a hypothesis, which is supported or refuted through observation and measurement. Experimentation has the goal to leave "unstable and with large uncertainty situation" with unknown variables and, through experiment, define and know specific parameters reaching acceptable "stable and known situation". After building judgments and reasoning chains, planner use parameters resulting from experiment in creating plan (specific position in plan).

Ability to ask reasonable questions. The planner's task is to ask questions that start with actual "unstable and with large uncertainty situation" and find the "direction and the rate of fastest increase of knowledge" for specific situation in order to come to "stable and known situation".

4. Conclusions

There is a natural attempt to reduce all decision-making tools to the one general tool, which can be applied to all planning situations. But this is only a planner's dream. Practically, planner identify the specific situation individually, stop for a while, think and apply specific decision-making tool for each specific situation.

Planner produce plan, which is filled with numbers. Before numbers become clear values, planner was working with approved objectives, forecasts and predictions, facts and estimations with uncertainties and risks of available and arriving materials, resources, according to the planning calendar. So, behind numbers in plan, strict values apparently neutral and objective, there are many doubts and judgements, frustrations and reasonings experienced by planner during plan preparation. The uncertainties and risks are around the plan until the plan is executed (physical fulfilment). In other words, the plan is a domain of islands of facts bridged with knowledge designed to shape rational and objective view with the task to achieve plan goals.

What we do not know at the time of planning may later turn into the necessity to take emergency measures to overcome the crisis, into inevitable cost losses, into forced negative experiences. As a rule, the requirement in the company "must be done with great haste, with a sense of urgency, because it is very important" is a result of not properly planned or thought through event, process, activity.

Planner task is to balance or to re-balance between known (objectives, resources, calendars) and unknown in order to prepare the plan in full, on time and at required accuracy. The ratio between "known-unknown" is a huge resource for cognition in decision making in planning.

High management obligation is to organize transparency of decision making in organization that keeps every decision maker accountable and responsible, sharing information, building robust plan and hold on open culture at workplace.

Building the knowledge gradient in planning in order to make reasonable decision making is a fascinating journey under uncertainty with hopes and disappointments, with joys

and regrets, with curiosity how to became a human being, who dares to know and to be a human being with compassion as a consequence of knowledge.

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