Uncertainty and Indeterminacy in the Project World[1]

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Introduction

The ideas in this article arise from the philosophical puzzle around the meaning of uncertainty and probability when applied to a single occurrence. That is to say that, whereas statistics and probability calculations are very meaningful in conditions involving a large number of events, what this all means is much less clear for a unique event. This conundrum therefore applies in the case of projects, each of which, as defined by PMI [ref 4], has the characteristic of "uniqueness".

The scientific area in which uncertainty and unique events has been extensively studied is in quantum physics. Although, it may seem rather a long stretch from projects to particles, some insights into project risk management can be gained from this comparison, as will be explained below by describing the ideas from quantum physics that are relevant to this analysis, and noting their relevance to project risk management: the uncertainty principle, indeterminacy, probability waves and entanglement.

The terminology used in quantum physics is a potential barrier to understanding:

- The term "uncertainty" is associated with the lack of precision available in measuring (and therefore predicting) certain quantities – whereas in projects, the term "uncertainty" is associated with lack of knowledge about the occurrence or not of an event or condition.

- The term "indeterminacy" is associated with lack of knowledge about an outcome or set of outcomes. In projects, as mentioned just above, the term "uncertainty" is used for this as well.

This article analyses the practice of project risk management with respect to each three major features of quantum theory: uncertainty, indeterminacy and entanglement, and draws a few action-oriented lessons for practitioners.

In this article, I will try to reduce the risk of confusion by using the terms Q-Uncertainty when referring to the meaning used in quantum theory, to distinguish it from the everyday use of the term "uncertainty".

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[1] *Second Editions are previously published papers that have continued relevance in today's project management world, or which were originally published in conference proceedings or in a language other than English. Original publication acknowledged; authors retain copyright. This paper was originally published in the PM World Today eJournal in June 2011. It is republished here with the author's permission.*

Q-Uncertainty

The *uncertainty principle* in quantum mechanics states that the more precisely you try to measure the momentum of a particle, the more inaccurate will be the measure of position. Similarly, in the project world, the more strictly you limit variation in one component of the triple constraint of time, cost and scope, the less accurate is your control over the others, so the greater is the uncertainty over the result with respect to that component. In the project environment, this arises from the fact that the three parameters of the triple constraint are not mutually independent. This will be explained next by expanding the following three truisms which show the pairwise relationships between the components of the triple constraint as shown below (Figure 1):

a) Time is money (cost)
b) Rome (scope) wasn't built in a day (time)
c) You don't get owt (the product scope) for nowt (cost)

This section will finish with a brief conclusion about how projects should deal with this type of Q-Uncertainty.

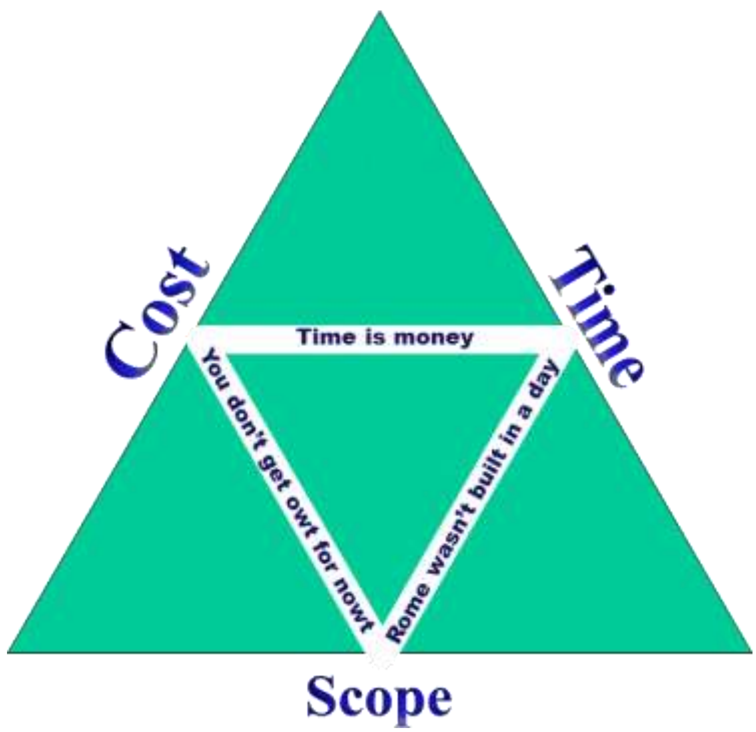

Figure 1: The Triple Constraint with the Pairwise Relationships

Time is Money

There are a number of categories of links between time and money:

1. If the project is aimed at providing a money-making capability, the faster the work can be done, the better the return on investment

2. If the value of the money to be spent is evaluated using net present value, the later the spend, the less the project will have cost in adjusted money

3. In order to complete work sooner, you can often pay for either more efficient resources, or for overtime

The interaction between these factors means that imposing an immovable completion date will reduce the options for stabilising the cost dimension. Similarly, if the overall budget is fixed – and even more so if the profile over time is imposed – the options for attenuating variable effects on time by adjusting the resources (money, manpower, etc.) will be severely limited.

Rome wasn't Built in a Day

Although there are many mechanisms by which project schedules can be accelerated (fast tracking or crashing for example) each of these techniques has a natural limit that cannot be improved upon. For example, although, given enough resources (but see the impact on time), a number of actions can be carried out simultaneously, there a dependencies between actions that make it impossible to run them simultaneously: you cannot, for example, pour concrete foundations until the corresponding hole has been dug. Similarly in crashing, there is a limit to the increased execution speed available from adding resources, due for example, to the reduction in efficiency of each individual as the number of people applied to a given job increases. There are many other restrictions, such as the fact that some natural phenomena cannot be rushed and that excessive use of overtime also reduces efficiency and leads to increased errors and therefore time-consuming rework.

This implies the following two constraints:

- If the completion date is immovable, the only way to adapt to a slip from the planned schedule is to remove activities from the plan – thereby reducing the scope

- On the other hand, if all of the planned functions have to be produced, there is no guarantee that the final date can remain as forecast

You don't get Owt for Nowt

Each function or feature of the project product needs to be either purchased or created. This implies clearly that if parts of the work turn out to be more expensive than expected, or if the available budget is reduced, then either the scope will need to be reduced to avoid a budget over-run, or the spend to achieve the full scope will have to exceed the allowed amount.

A Reason for the Q-Uncertainty

Therefore if one of the two parameters is forced to take a fixed value, its inherent variability – which exists even if the allowed value is fixed – will be added to the other parameter because this parameter has to vary both because of its inherent variability as well as to correct for the movements in the other one. Because of this type feedback effect, the variability of the "uncontrolled" parameter can become virtually unlimited if the other parameters are to be determined precisely. The project manager has to take this into account throughout the lifetime of the project, as explained next

Living with Q-Uncertainty

The first step is for the project manager to make sure that the key stakeholders are aware that this principle is a fact of projects that cannot be overturned. It can of course be dealt with, for example by providing sufficiently large contingency buffers for each of the triple constraint components (time, cost and scope). There are two associated strategic questions, however, that need to be resolved at the very start of the project:

a) The relative importance of each of the categories (e.g. is time of the essence, or is it of low importance?)

b) The relative size considered acceptable for each contingency buffer.

Associated with these decisions, there needs to be a way of tracking and forecasting the usage of these buffers and deciding on the actions to be taken depending on the analysis. The range of possible actions will depend on the relative importance of the constraint components.

As mentioned in the introduction, this is not the only lesson from quantum theory, and the *indeterminacy principle*, explained below, provides valuable insights into what in projects is (confusingly!) known as "uncertainty".

Indeterminacy

From here on in this section, the terms “uncertain” and “uncertainty” will be used in the project sense, rather than as discussed earlier in section on the quantum uncertainty principle.

The parallel with the quantum world does not stop at q-uncertainty. In quantum mechanics, the *indeterminacy principle* is characterized by the fact that the state of a system “shows itself in waves or clouds of probability” [ref 1] as depicted Figure 2 from [ref 2].

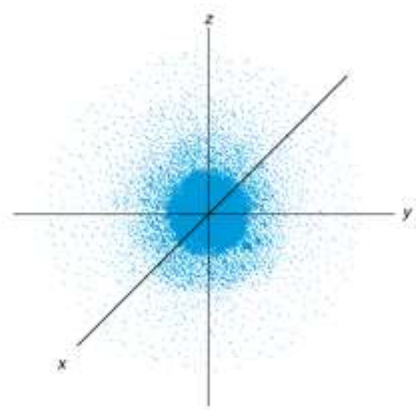

Figure 2: A Probability Cloud

The same actually holds true for projects: in addition to the natural variability of all of the estimated quantities, you have to account for risks specific to the project – i.e. the numerous uncertain situations (events or conditions) which could affect the success of the project.

Early-on in the project, all of these uncertain situations are feasible to lesser or greater extent, so, until it completes, the project is in a state where all corresponding degrees of success and failure are present, superposed at one and the same time in the form of a wave or cloud of probability. Actions of the project manager can affect the overall risk exposure but, until this wave function collapses, and the actual situations or conditions prevail (as “resolved risks”, or “issues”), there is no deterministic way of knowing definitively the actual state of the situation. In projects, at a given point in time, an uncertain situation may already have occurred, but until that occurrence is actually known, the indeterminacy remains (in a similar way to Schrödinger’s cat [ref 5]). The role of status reviews can therefore be seen as a way collapsing the part of this wave function that covers all of the risks resolved up to a given point in time, and regenerating the wave function for the remainder of the project. Project closure freezes all of the options and determines the final outcome. Each of these points will be expanded-on below.

Collapsing a Risk

The associated indeterminacy disappears once the state of the potential event is known – either because the event has occurred, or because it can no longer occur, such as when a preventive action has been successfully carried out. It is generally not sufficient simply to tag the corresponding risk as either "prevented" or "issue to be addressed" since, due to the wave-like nature, the overall system of risks will be affected by the change in the status of this risk – i.e. the disappearance of its wave-function. For this reason, all affected risks as well as the overall risk to the project need to be re-assessed. But when does the risk collapse? That is addressed next.

Past Undetected Events

In quantum theory, the detection of a particle collapses the corresponding wave function. Similarly, for risks, it is not the occurrence of the risk that removes the indeterminacy, but the knowledge – either direct or indirect – of its occurrence. For example, the loss of a cargo at sea will not affect the investor until its loss is known. However, the sooner the risk can be collapsed, the less uncertain the project becomes, and the more confident the stakeholders can be about the outcome and the actions to take to achieve that outcome. In a project environment, the situation is even more complex, since different stakeholders may well not all recognize that a risk has occurred.

The role of status reviews in providing this added confidence is explained below.

Status Reviews

Despite the saying "what you don't know can't hurt you", this level of careless optimism cannot be a good guide to project success. On the contrary, one advantage of increasing the amount of certainty in a project is to reduce the overall complexity of managing the risks, since there are fewer potential interactions within the cloud. Status reviews are designed to control as far as possible any emerging instability by identifying facts that have become definite and taking actions to reduce the uncertainty about others. In this way, a status review reduces as far as possible the indeterminacy that encompasses the project outcome.

Another major beneficial result of status reviews – and the corresponding reports – is to ensure that all stakeholders have the same level of knowledge about the indeterminacy state: which risks are no longer active, etc. An extreme version of status review is carried out at project closure, which is examined next.

Project Closure

Although, in theory, once a project completes, there are no events that can further impact its outcome, that does not mean that the result is automatically well known. On the contrary, one major risk that needs to be addressed in every project is a disagreement between stakeholders as to the value and quality of the final deliverables or outcome: this indeterminacy has to be resolved explicitly and for all of the influential stakeholders to accept the resolution. This has to be planned from the start, the stakeholders managed throughout the project, and a major effort made at the end to ensure agreement: even the best-run project can be deemed a failure if this final step is mismanaged.

Entanglement

Within quantum theory, there is also the concept of "entanglement". This occurs under specific conditions when a number of particles share common characteristics and act, to all intents and purposes, as a single quantum entity. This has as consequence that a change to one of the entangled particles automatically and immediately causes the corresponding change in all of the others – wherever they are (See Figure 3 from [ref 3]).

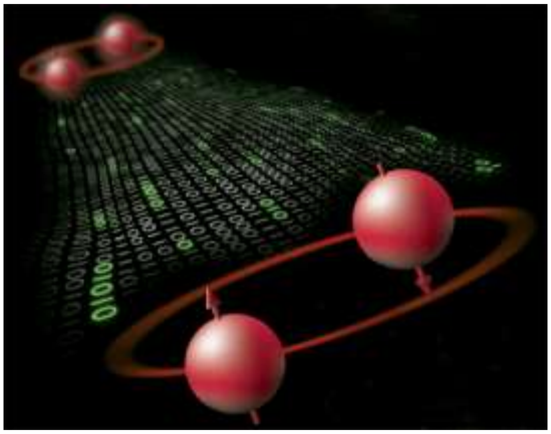

Figure 3: A representation of Entangled Particles

For risks, the parallel is for potential situations that are tightly correlated (whether one knows it or not). For entangled particles, the entanglement is normally fragile and a degree of external stimulation (e.g. heat) can break the entanglement. The same also holds, of course, for correlated risks, since changes to the external environment can disrupt the correlation and totally change the overall effect of the set of risks.

These concepts apply in the project management domain well beyond individual projects. In fact, a typical example of project-related entanglement is the management of programs and portfolios. In both of these cases, the components all contribute to a greater or larger extent to the objectives (program benefits or portfolio strategic goals) and are mutually interdependent.

This needs to be understood in the risk management world since initial decisions on the viability or safety of an undertaking are often based on an initial analysis including the available knowledge about the situation and risks at that point in time, and this can later be invalidated by the effect of the environment on the relationship of supposedly correlated situations or of correlations between risks that were thought to be independent.

Conclusion

Action-oriented conclusions

An analysis, however interesting, between the concepts of quantum physics and project management would remain a fairly empty exercise if it did not serve to provide some new insights into how better to manage projects. That is not the case for this analysis since the following insights have been described.

<u>To deal with Q-Uncertainty</u>

- Define the relative importance of each of the components of the triple constraint
- Agree a range of variation (contingency buffer) for each of these components
- Develop a mechanism for tracking and forecasting use of these buffers
- Agree on actions to be taken in case of unacceptable variance

<u>To deal with Indeterminacy</u>

- Accept that all potential outcomes are possible until the corresponding event occurs
- Accept that probability does not forecast the outcome; it merely gives an indication of confidence level
- Ensure that the probability clouds are collapsed and simplified as soon and as much as possible by holding effective risk reviews and status meetings
- Work closely and continuously with the project stakeholders to avoid invalid assumptions and other misunderstandings

<u>To leverage Entanglement</u>

- Identify interdependencies between potential events and make use of the corresponding correlations when assessing the project outcome, and when adjusting the analysis on risk closure.

- Determine the interactions and effect on the probability cloud when new risks are discovered.

Final comments

To explain this another way, based on an extract from [ref 1]:

"[The wave function] tells us the likelihood that a particular experiment {in our case: situation or project} will yield a particular result. In the experiment, that provides actual information. Measurement {implementing and reviewing the project} is the act of turning potentiality into actuality, an act of choice, choice among multiple possible outcomes. After the measurement, there are roads not taken. Before the measurement, all roads are possible – one can say that all roads are being taken at once." So, executing the project turns potentiality into reality.

This is the basic reason why project risk management is a major conceptual challenge to practitioners and other project stakeholders – "it ain't rocket science!" you might say; certainly not; it's much more complex than that: it's quantum mechanics!

References:

[ref 1] J.A. Wheeler, K. Ford "Geons, Black Holes and Quantum Foam: a Life in Physics", W.W. Norton & Co., 1999

[ref 2] http://www.chem.ufl.edu/~itl/2045_s99/lectures/lec_10.html accessed 15 May 2011

[ref 3] http://www.daviddarling.info/encyclopedia/Q/quantum_entanglement.html accessed 15 May 2011

[ref 4] [PMI 2008] *A Guide to the Project Management Body of Knowledge: PMBOK Guide* – Fourth Edition, Project Management Institute (2009)

[ref 5] Erwin Schrödinger, (November 1935). "Die gegenwärtige Situation in der Quantenmechanik (The present situation in quantum mechanics)". Naturwissenschaften. 23 (48): 807–812. Bibcode:1935NW.....23..807S. doi:10.1007/BF01491891.

About the Author

Crispin Piney

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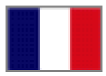

After many years managing international IT projects within large corporations, **Crispin ("Kik") Piney**, B.Sc., PgMP is now a freelance project management consultant based in the South of France. At present, his main areas of focus are risk management, integrated Portfolio, Program and Project management, scope management and organizational maturity, as well as time and cost control. He has developed advanced training courses on these topics, which he delivers in English and in French to international audiences from various industries. In the consultancy area, he has developed and delivered a practical project management maturity analysis and action-planning consultancy package.

Kik has carried out work for PMI on the first Edition of the Organizational Project Management Maturity Model (*OPM3™)* as well as participating actively in fourth edition of the *Guide to the Project Management Body of Knowledge* and was also vice-chairman of the Translation Verification Committee for the Third Edition. He was a significant contributor to the second edition of both PMI's Standard for Program Management as well as the Standard for Portfolio Management. In 2008, he was the first person in France to receive PMI's PgMP® credential; he was also the first recipient in France of the PfMP® credential. He is co-author of PMI's *Practice Standard for Risk Management*. He collaborates with David Hillson (the "Risk Doctor") by translating his monthly risk briefings into French. He has presented at a number of recent PMI conferences and published formal papers.

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