Managing risk spaces

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Traditional risk management strategies have looked no further than to minimize the consequence and frequency of upsets. Such practice not only ignores synergies but lacks accountability. In the real world, resources are finite, and how they are allocated to best advantage is fundamental to mitigation strategists of meta-system risk spaces.

By constructing a generalised risk space, that strategically orders ambitions, and consequently legitimises proportional claims over budgets, the strategist may apply elementary methods to maximise outcomes whilst according minimal risk to the ensemble.

Examples drawn from discrete projects herein typify how meta-systems may be evolved. Early steps can be taken to suspend risk in a manner construed to shelter prime objectives against a disproportionate throttling of resources and eventually fortify a strategic posture.

Managing risk spaces.

Risk mitigation is an awkward exigence which has steadfastly resisted the introduction of formal metrics. A perception that ad hoc methods are rife in the industry and congerings the norm has led to low esteem and tumultuous relations for all within its horizons. Despite these difficulties, the pressure to perform is spiralling to new heights with litigation feeding an infatuation for accountability that discounts innovation. For those successful risk strategists consistently punching above their weight, it is due time we examined their beliefs and challenged the practice of black arts.

Before progressing further it will be useful to have a common understanding of some more restrictive meanings that will be used throughout the following passages, for otherwise regular words and phrases.

Risk space:

Experience has proved that all endeavours port risks and to that extent could be thought of as porters of a *risk space.* Whether the endeavour be termed a program, project, development or any aspect thereof, its *risk space* can be quantified according to the set of its objectives and resources. Endeavours with the highest objectives and lowest resources will carry the largest *risk space*. Not only does each endeavour port a *risk space*, but each *risk space* is unique to its endeavour. Depending on the nature of the endeavour, the more appropriate term for objective may be capability, goal or requirement and for resources*;* budgets, goods or reserves.

Risk types:

As the only risks of interest are those relevant to objectives, one should expect to be able to identify each risk in terms of an objective. Multiple risks may also arise in relation to each of these objectives.

Risks are often amenable to expression in terms of mathematical probability functions that yield likelihoods of failure or system upset in proportion to a number of like experiences. There have been volumes written on probabilities and the functions that can model risks of this or that character, but for those interested a search of the literature will reveal them, and the use of specific functions will not be addressed here.

Once a risk to an objective has been identified, there will be interest shown in communicating the gravity of that risk. Traditionally this has been promulgated in terms of a *Risk Index (RI)* which is a product of the consequence and frequency of an upset. Since however our risk space is comprised of objectives, and the risks necessarily relate to losses thereof, the consequence of our *Risk Indexes* will be the amount of the objective lost as a result of the upset concerned. An example will help to clarify this concept of risk consequence which is necessary to deal effectively with objectives which are not absolute. Take an objective to keep system mass under 20kg. If there were an optional sub-system that weighed 21kg, any risk of requiring that option would render the objective unattainable and have as consequence the totality of the objective's value. On the other hand, an alternative subsystem weighing only 5kg might only reduce the margin afforded to an ensemble, and a risk carrying such a consequence would be only a fraction of the total value attributed to the 20kg objective. In either case the consequence must be combined with the upset frequency to determine the *RI* to the objective.

In mathematical terms we can express the Total Risk to an objective "***j***" as:

$$R_j = \sum_i RI_{i,j}$$,where $RI_{i,j}$ is the *Risk Index* of the upset ***i*** to the objective ***j***.

and the total project risk (**R**) as:

$$\mathbf{R} = \sum_j \sum_i RI_{i,j}$$

Risks that can and are eliminated by design no longer form part of a Risk Space. The Risk Space in such instances adjusts to compensate the resources used to achieve the design solution which eliminated the risk concerned. Whether the risk space is larger or smaller as a result of such developments depends entirely on the initial risk exposure and the expense of the solution.

Objectives on either side of a partitioned system have no upsets in common. In mathematical terms this may be expressed as:

$$R_j \wedge R_i = 0 \text{ for all } i \neq j, \text{ since } RI_{p,i} \wedge RI_{p,j} = 0 \text{ for all upsets } \boldsymbol{p}.$$

Risk Contributors:

The rate of change of a *risk space* with respect to the *risk index* will be termed the R*isk Contributor*. Either a change of *risk space* resources or the surety of its objectives may result from a change to a *risk index*. In mathematical terms the *Risk Contributor* (*RC*) may be written as:

$$RC = \frac{dRS}{dRI}$$

The *risk index* is always more acceptable as it becomes less frequent or of lower consequence, and in traditional terms should ideally be eliminated or driven to 0.
By contrast, if one worked to eliminate a *risk contributor*, it may commence well but in the limit, expenditure will become wasteful as the consequences of a problematic design solution became less responsive to mitigation. A point will be reached in dealings with residual risks beyond which further expenditure on *mitigation* will be disproportionate to the advances made.

Management:

Once a risk is identified it can only be managed by an adjustment of objectives or the expenditure of resources. Following this principle the costs of mitigation and the value of capabilities will be needed to implement the management algorithms that follow.

Having previously developed the concept of a Total Risk to an objective, we can now simply combine this with the value of the objective in order to obtain a cost for supporting a risk. This cost might also be understood as the cost insurance would be looking for in order to evaluate its premiums.

In mathematical terms the cost (C_j) of carrying a risk to an objective "***j*** " ,can be written as:

$$C_j = \sum_j o_j R_j$$,where o_j is the value of objective "***j*** ".

Once there is a cost associated with project risk, activities including those of risk reduction, can be traded off according to their implementation cost and the expected value of their return. Particularly in the case of risk mitigation activities, we need to examine the costs of reducing specific upsets, and balance this against the value of an improved hit rate for objectives. If we were seeking to establish where reliability improvements should be directed for the best return we would need to ascertain the before and after cost of supporting particular risks, and compare these with the cost of implementing a specific mitigation strategy. Similarly, if we were seeking to justify the expense of a risk mitigation activity we would need to look at its cost compared to the value of improvements to objective retention.

An example may help explain the process of identifying where mitigation activities are best directed. Consider a system comprised of 2 objectives, one valued "k" times as much as the other i.e.

Value(objective #1) = k x Value(objective #2).

All other things being equal we might expect to manage this system so that the risk to objective #1 was 1/k that of objective #2 i.e.

$R_1 = (1/k)R_2$.

That would mean those things of most value are best protected, but what would be our expenditure to achieve this and might it differ if disproportionate investments were involved? Suppose for example the same degree of risk mitigation requires spending "n" times as much on objective #1 as for #2. The optimal management algorithm for this system is not determined by the risks as indicated above, but rather according to the following rule:

If k > n then
spend on mitigating the risk to objective #1,
else spend on mitigating the risk to objective #2.

This is only stating the obvious i.e. invest first where the return is best. In practice doing so requires significant skill and particularly to judge the form of "k" and "n" which will almost never be constants.

Another major task of risk management, which is not dealt with here but only mentioned for completeness, is the initial identification of upsets relevant to the system. This is particularly important since an unidentified risk will pass by without any controls. Most of the general texts devoted to this task rely on brainstorming or preliminary expert reviews but occasionally niche industries have developed check lists which should be recognised according to their utility as determined by experience.

The polygon model:

As a visual model for managing risk, this analogy with a polygon may have potential. A polygon may be constructed of an area which is representative of a program's *risk space.* That area is therefore determined by the program *objectives* and *resources* and should initially be taken as given in the sense that a strategist will generally not exercise influence over this area directly but rather operate through adjustments to its perimeter. Each side of the polygon is further associated with a particular risk and its length is determined by the *risk contribution*.

The project will need a minimum number of independent risks to construct the polygon but this should not be too difficult given that the list of risks should be comprehensive, including technical, safety, legal and/or capital risks however described. Risks may also be decomposed into constituent parts, just as primary objectives may be considered a collection of secondary ones. In any case for a program carrying one risk, the model would degenerate to a one dimensional problem having a trivial solution wherein all resources are used to mitigate a risk.

The sum of the risk contributors will return the costs of risks, and their total or the perimeter of the risk space polygon is then the cost of the project's risk profile. The risk mitigation strategist must exercise their influence by control of risk contributors that re-dimension the lengths of the polygon sides, but these sides are forever constrained to enclose the risk space. In order to do that a common parlance must be found to perform tradeoffs and capture objective merits in comparative terms. It is from this scale of comparison that the relative merits or activities and finally a justification for their use of resources originates.

The project manager's objective will generally be to contain the maximum risk space with the resources available, however strategically proficient organisation will not neglect to explore realignments of the objectives that can deliver win-win outcomes. A poorly managed project which is unduly focused on one risk, will translate to a flattened polygon in the model. The total risk of a poorly managed project is unduly high for the risk space it encloses.

The polygon model tells us that there is an optimal level of consideration to be given to each risk contributor, in order to enclose the maximum risk space. When each side is of equal length the polygon is regular, and the minimum perimeter to area ratio is achieved. By analogy the program carries the lowest cost risk profile consistent with the program's objectives and resources. So the task of managing risk is actually one of optimisation, and more precisely equalising contributors in relation to each and by consequence all others. The model demonstrates that outcomes are going to be optimal when the contributors are all equal. Eliminating a risk contributor from a project's total risk may initially appear a sound objective but that can't be achieved without a consequential inflation of the risk space through the depletion of its resources. Note also that a risk contributor that became 0 would no longer retain any of the risk space to which it was bound. As originally indicated, the risk space is determined by goals and resources and a project that eliminates risks will need massive resources or no goals to remain bound.

Conclusion:

Experienced risk practitioners will remark that there will generally be many specifications driving the design and that assigning a dollar value to each has been traditionally unnecessary and would impose additional expenditures. Noting that we cannot compare apples with oranges such criticism is just, but it is equally true for the data preparation activities behind all decisions. One should not only be able to articulate desirable features but also clarify the importance with which they are held in order to delegate the responsibility of fielding the optimal solution.

Cost benefits of product improvements can be studied through market surveys and those studies then used to decide on the utility of implementing one change or another. In so doing we may determine where the highest leverage is to be found for our investments and allocate resources accordingly.

There remains much work both on the model and the application of the methods proposed. Certainly there needs to be a way of quantifying and comparing merits of divergent development strategies and only through a suitable description of program objectives and interdependencies can that end be achieved.