Wicked problems: Wicked solutions

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***Abstract*-Wicked Problems are considered impossible to solve using the current problem-solving paradigm. The contribution of this paper is to dissolve the problem of solving Wicked Problems by introducing an alternative paradigm, namely considering Wicked Situations instead of Wicked Problems. This perspective change enables the extremely ill-structured problems in Wicked Situations to be converted to well-structured problems and remedied via iterations of the Multiple-Iteration Problem-Solving Process [1]. The paper ends with a brief discussion on the implications of the paradigm shift to speeding up new product development for complex systems.**

Keywords-Wicked Problems; Wicked Solutions; complex problems; systems engineering; new product development; Design Thinking; QRD; Quality Requirements Definition; Quality Function Deployment, QFD.

I. *INTRODUCTION*

Wicked Problems are considered impossible to solve using the current problem-solving paradigm. When faced with insolvable problems, the best way to approach them is to absolve the problems or bypass them by finding an alternative paradigm. For example in the military domain, when a frontal attack fails or is inappropriate an alternative approach such as a flanking attack may be attempted. The search for an alternative paradigm to solve the problems associated with complex systems that began in 2004 [2] with a change of perspective. Perceptions from the *Generic* perspective indicate that in mathematics, complex numbers consist of a real and an imaginary component. An inference from the *Scientific* perspective in the problem-solving domain is that the complexity may contain an imaginary or mythical component. This leads to the research question of "*are there myths in the problem-solving process that hinder the solving of complex problems and increase the complexity of the problem solving process?*" This question led to the research findings documented in a set of three papers. The first paper [3] analysed the problem-solving process and identified six myths and their corresponding realities which clarified and simplified the problem-solving process. The second paper [1] introduced a way to manage complex problems via an incremental change within the current problem-solving paradigm. This paper, the third paper, builds on the previous papers and proposes a paradigm shift that dissolves the problem of solving Wicked Problems by:

1. Building on the findings from the first two papers [1, 3].
2. Changing the paradigm.

This paper starts with a discussion of the ways of remedying problems [4] in Part II. Part III provides a working definition of a complex problem since the the scientific community cannot agree on a single definition of a complex problem [5] cited by [6]. Part IV categorizes problems by their structure; well-structured problems, ill-structured problems and Wicked Problems. These categories of structure are further discussed in Parts V, VI and VII. Part IX briefly outlines some characteristics of Wicked Solutions. Part X discusses the implication of paradigm shift to New Product Development and Design Thinking. The conclusions of this paper in Part XII are:

1. Changing the paradigm and dealing with Wicked Situations can dissolve the problem of solving Wicked Problems.
2. New products are Wicked Solutions

II. *WAYS OF REMEDYING PROBLEMS*

One of the myths associated with the problem-solving process is that all problems can be solved [3]. This is an incorrect assumption. The reality is that problems are either solved, resolved, dissolved or absolved [4], where only the first three actually remedy the problem. The word 'solve' is used to mean solved, resolved or dissolved, when a better word would be 'remedy'. The four ways of remedying a problem are:

1. ***Solving the problem*** is when the decision maker selects those values of the control variables which maximize the value of the outcome (optimal solution).
2. ***Resolving the problem*** is when the decision maker selects values of the control variables which do not maximize the value of the outcome but produce an outcome that is good enough or acceptable (satisfices the need) (acceptable solution).
3. ***Dissolving the problem*** is when the decision maker reformulates the problem to produce an outcome in which the original problem no longer has any actual

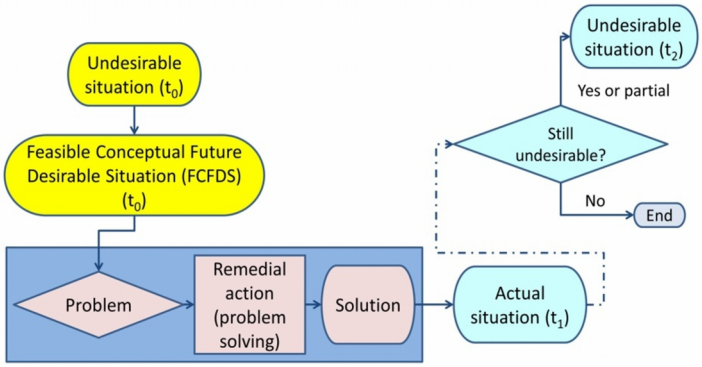

Figure 1 The extended holistic problem-solving process

meaning. Dissolving the problem generally leads to innovative solutions.

4. ***Absolving the problem*** is when the decision maker ignores the problem or imagines that it will eventually disappear on its own. Problems may be intentionally ignored because they are too expensive to remedy, or because the technical or social capability needed to provide a remedy is not known, unaffordable or not available.

III. *COMPLEX PROBLEMS*

Wicked Problems are thought of as being complex (objective complexity) and complicated (subjective complexity). Let a complex problem be "*one of set of problems posed to remedy the causes of undesirability in a situation in which the solution to one problem affects another aspect of the undesirable situation*" [1]. Consequently remedying a complex problem will require:

1. More than a single iteration through the Multiple-Iteration Problem-Solving Process [7] since each pass does not remedy the set of problems.
2. The causes of the undesirability to be remedied at different levels and locations in the situation hierarchy, simultaneously or sequentially.

IV. *THE STRUCTURE OF THE PROBLEM*

Perceived from the *Continuum* perspective [8], problems lie on a continuum of categories which ranges from 'Well-structured' through 'Ill-structured' to 'Wicked' [9]. The following sections discuss attributes of each of the named categories [3].

V. *WELL-STRUCTURED PROBLEMS*

Well-structured problems are problems where the existing undesirable situation and the Feasible Conceptual Future Desirable Situation (FCFDS) shown in Figure 1 are clearly identified. These problems may have a single solution or sometimes more than one acceptable solution. Examples of well-structured problems with single correct solutions are:

- Mathematics and other problems posed by teachers to students in the classroom. For example, in mathematics, 1+1=2 every time.
- Making a choice between two options. For example, choosing between drinking a cup of coffee and drinking a cup of tea. However, the answer may be different each time.

Examples of well-structured problems with several acceptable but different solutions are:

- What brand of coffee to purchase? Although the solution may depend on price, taste and other selection criteria, there may be more than one brand (solution) that meets all the criteria.
- Which brand of automated coffee maker to purchase?
- What type of transportation capability to acquire?
- Finding the cheapest airfare between Singapore and Jacksonville, Florida if two airlines charge the same fare.

Well-structured problems with single solutions tend to be posed as closed questions, while well-structured problems with multiple acceptable solutions tend to be posed as open questions.

A. *Formulating Well-structured problems*

Well-structured problems may be formulated by applying the following four-part Problem Formulation Template [10]:

1. ***The undesirable situation*** as perceived from the each of the descriptive Holistic Thinking Perspectives (HTP) [10].
2. ***The FCFDS*** as inferred from the descriptive HTPs (the *Scientific* perspective).
3. ***The problem,*** which is how to convert the FCFDS into reality (the *Scientific* perspective).
4. ***The solution*** which is something that solutions the undesirable situation and has to be interoperable with evolving adjacent systems over the operational life of the solution and adjacent systems (the *Scientific* perspective). In non-complex systems the solution is often the FCFDS. The solution is made of two interdependent parts:
   a. The System Development Process (SDP) or transition process that converts the undesirable situation to a desirable situation.
   b. The solution system operating in the context of the FCFDS.

Placing the solution before the problem is based on the dictum of working back from the answer [11] and allows risk management to be incorporated into task planning instead being an add-on in the current systems engineering and project management paradigms. The risk management is achieved by ensuring that risks identified in a task are mitigated or prevented in earlier tasks in the project schedule.

B. *Remedying well-structured complex problems*

Well-structured complex problems consist of a set of interconnected problems according to the definition in Part III. The undesirable situation posing the well-structured problem or set of problems may be transformed to the FCFDS using the Multiple-Iteration Problem-Solving Process in the manner represented in Figure 2 [1]. The Multiple-Iteration Problem-Solving Process shown in Figure 2 is a modified version of the holistic extended problem-solving process [10]. It consists of two sequential problem-solving processes embedded in an iterative loop. The first problem-solving process converts the ill-structured problem [3] posed by the complex situation into one or more well-structured problems. Since one problem solving approach does not fit all problems [3], the second problem-solving process is tailored to remedy specific type of problems..

Choice of which of the problems identified by the first problem-solving process to tackle in the second problem-solving process will depend on a number of factors including urgency, impact on undesirable situation, the need to show early results and available resources.

This sequential evolutionary process is sometimes known as '*build a little, test a little*' and evolves the solution from a baseline or known state to the subsequent milestone which then becomes the new baseline.

In general, undesirable complex situations must be remedied by evolving a solution using multiple passes of the Multiple-Iteration Problem-Solving Process where each iteration produces a better (less undesirable) situation. Moreover, to make it more difficult, one party's remedy may be another party's undesirable situation and foster further change. For example the tank was developed to remedy the undesirable well-structured situation that machine guns were slaughtering attacking infantry attempting to cross the no man's land between the trenches in World War I. So, while tanks remedied an undesirable situation for the attacking forces, tanks created a new undesirable situation for the defending forces who then developed anti-tank weapons, which led in turn to further changes in military doctrine and technology, and so on.

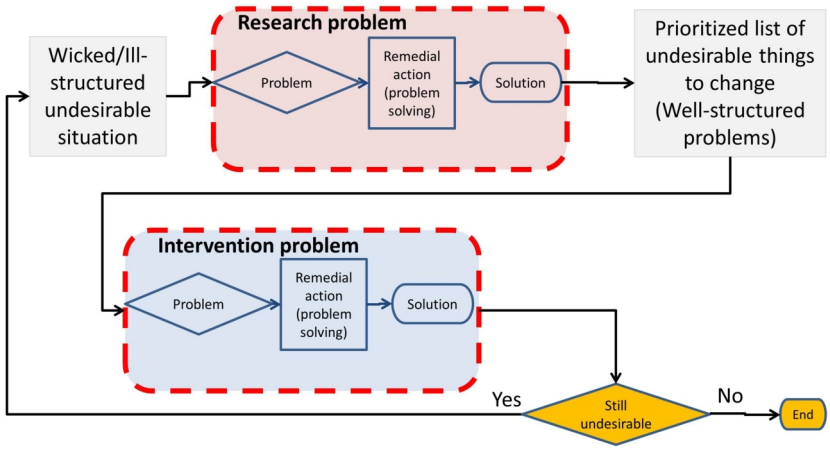

Figure 2 The Two-Part Multiple-Iteration Problem-Solving Process [1]

VI. *ILL-STRUCTURED PROBLEMS*

Ill-structured problems, sometimes called 'ill-defined' problems are problems where either or both the existing undesirable situation and the FCFDS are unclear [12]. Examples of ill-structured complex problems are:

- The initial feeling that something is wrong and needs to be changed which triggers the problem-solving process.
- Where to dispose of nuclear waste safely? This is where the FCFDS is unclear.
- How to combat international terrorism? This is where different stakeholders perceive different causes of the situation and different ways of dealing with the causes.

A. *Formulating ill-structured problems*

Ill-structured problems may be formulated by applying the following four-part Problem Formulation Template [10]:

1. ***The undesirable situation*** is the need to convert the ill-structured problem into one or more well-structures problems.
2. ***The FCFDS*** is the ill-structured problem replaced by one or more well-structures problems.
3. ***The problem,*** which is how to convert the ill-structured problem into one or more well-structures problems.
4. ***The solution*** is the FCFDS.

B. *Remedying ill-structured complex problems*

The undesirable situation causing the ill-structured complex problem cannot be remedied until the ill-structured problem has been transformed into one or more well-structured problems. Consequently, finding a solution requires converting the ill-structured complex problem into a well-structured complex problem or series of problems. Determining the real cause(s) of the undesirable situation and finding solutions sometimes means doing both functions in an iterative and interactive manner. In this situation, initially:

- ***The undesirable situation*** is an ill-structured problem.
- ***The FCFDS*** is one or more well-structured problems.
- ***The problem*** is how to convert the ill-structured problem into one or more well-structured problems.
- ***The solution*** is the FCFDS.
- ***The problem-solving process*** converts the ill-structured problem into one or more well-structured problems.

As an example consider the ill-structured problem of how to win a war. This problem is broken out into two lower level ill-structured problems (1) how to defend the nation, and (2) how to destroy the other side and end the war. These problems are then further broken out into a number of well-structured problems, which if remedied successfully will end the war.

Ill-structured problems are remedied using the Multiple-Iteration Problem-Solving Process in the manner represented in Figure 2 [1]. This is a time-ordered-multi-phased evolutionary approach that solutions one or more of the well-structured problems, integrates the solutions, re-evaluates the situation and then repeats the process for the subsequent set of problems [13].

Take care when converting ill-structured problems into a series of well-structured problems because you can end up with different and sometimes contradictory well-structured problems which would generate different and sometimes contradictory solutions.

VII. *WICKED PROBLEMS*

Wicked problems also known as 'messy' problems[1] are extremely ill-structured problems[2] first stated in the context of social policy planning [14]. Wicked problems [15]:

[1] When complex

[2] Technically there is no problem since while the stakeholders may agree that the situation is undesirable, they cannot agree on the problem.

- "Cannot be easily defined so that all stakeholders cannot agree on the problem to solve.
- Require complex judgements about the level of abstraction at which to define the problem.
- Have no clear stopping rules (since there is no definitive 'problem', there is also no definitive 'solution' and the problem-solving process ends when the resources, such as time, money, or energy, are consumed, not when some solution emerges).
- Have better or worse solutions, not right and wrong ones.
- Have no objective measure of success.
- Require iteration - every trial counts
- Have no given alternative solutions - these must be discovered.
- Often have strong moral, political or professional dimensions".

A. *(Re)-Formulating Wicked Problems*

Wicked Problems may be (re)-formulated by applying the following four-part Problem Formulation Template [10]:

1. ***The undesirable situation*** is an undesirable situation containing the characteristics listed above [15].
2. ***The FCFDS*** is the undesirable situation without any of the desirability.
3. ***The problem,*** the transformation from the undesirable situation to the FCFDS, seems to be unachievable in the current paradigm.
4. ***The solution*** is the FCFDS via an alternative paradigm which dissolves the Wicked Problem.

B. *Remedying Wicked Problems*

Once re-formulated, Wicked Problems may be remedied by using the following process as discussed below:

1. Change the paradigm from Wicked Problems to Wicked Situations.
1. Assume multiple causes of undesirability in the Wicked Situation.
2. Use the Multiple-Iteration Problem-Solving Process.

1) *Change the paradigm.* Instead of trying to solve or resolve Wicked Problems, absolve the problem by changing the paradigm. Instead of dealing with ill-structured problems deal with ill-structured situations. Instead of dealing with Wicked Problems deal with Wicked Situations.

Ill-structured situations may be a result of stakeholders perceiving the situation from single different perspectives in the manner of the fable of the blind men perceiving the elephant {Yen, 2008 #652}. Tools developed for gaining an understanding of the system (situation) and the nature of its undesirability include:

- Checkland's Soft Systems Methodology (SSM) [24].
- Avison and Fitzgerald's interventionist methodology [25].
- The Nine System Model and the HTPs [26-28].

A Case Study describing the MSOCC data switch replacement project {Kasser, 2005 #169} discusses a situation in which a SSM similar to Avison and Fitzgerald's interventionist methodology [25] coupled with an object-oriented approach for viewing requirements was used in a tailored version of the system engineering problem-solving process in a complex environment by a systems engineering team in an ill-structured situation posed by the need to illicit, elucidate and achieve consensus on two sets of requirements[3]: the functional and performance requirements for the upgraded system and the transition requirements for replacing the existing system. Both an optimal systems architecture and optimal System Development Process (SDP) design were achieved in a relatively short period of time compared to using the standard systems engineering approach. Moreover, the customer deemed the Systems Requirements Review (SRR) and the System Requirements Document [29] complete and comprehensive.

As perceived from the *Generic* perspective, Wicked Situations manifest themselves in the first step of the Scientific Method problem-solving process even if nobody is consciously using the Scientific Method to address the problem. That is, the current situation is under observation, but a working hypothesis to explain the causes of the observations (desirable and undesirable) has yet to be developed. Examples of such situations are:

- The state of the art of chemistry before the development of the periodic table of the elements.
- The state of electrical engineering before the development of Ohm's law.
- Any situation for which the there is no theory to explain the observed behaviour.

2) Assume multiple causes. One of the characteristics of Wicked Problems mentioned above is "*Cannot be easily defined so that all stakeholders cannot agree on the problem to solve*". Assume that this situation may be due to the following:

1. There may be more than one cause of the undesirability.
2. The lack of consensus on the definition of the problem is due to there being multiple causes.
3. The lack of consensus is a result of different stakeholders viewing the Wicked Situation through different filters known as "*cognitive filters*" in the behavioural science literature [16], and as "*decision frames*" in the management literature [17].

Examine the situation from the perspectives perimeter and the eight descriptive HTPs [8]. Use inductive reasoning to create the hypothesis for the causes of undesirability in the situation and deductive reasoning to support the hypothesis (*Scientific* perspective). In the real world, the hypothesis is often created from some insight or "hunch" based on the observations.

The assumption of multiple causes leads to perceiving that there may be multiple solutions (perhaps even at different levels in the hierarchy of systems) one or more for each cause.

3) *Use the Multiple-Iteration Problem-Solving Process.* Removing the undesirability in Wicked Situations is now a

[3] The MSOCC switch upgrade took place in 1989. Avison and Fitzgerald didn't publish their methodology until 2003.

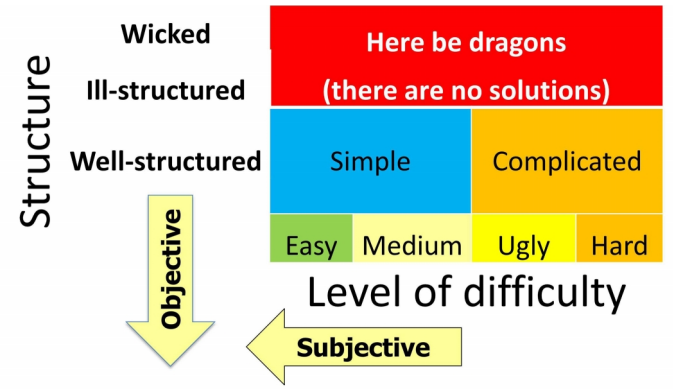

Figure 3 A problem classification framework [9]

matter of using the Multiple-Iteration Problem-Solving Process [1] to create and remedy well-structured problems as discussed above.

VIII. *A PROBLEM CLASSIFICATION FRAMEWORK*

The alternative paradigm permits the framework for classifying problems shown in Figure 3 [9]. The framework is based on distinguishing between subjective and objective complexity (*Continuum* perspective) and the four levels of difficulty of the problem [3] where the axes are:

- ***Level of difficulty:*** (subjective complexity).
- ***Structure of the problem***

Different people may position the same problem in different places in the framework. This is because as knowledge is gained from research, education and experience a person can reclassify the subjective difficulty of a problem down the subjectivity continuum from 'hard' towards 'easy'.

Note that complexity is not included in the framework since complex problems, can and are being remedied as discussed in Section III. For a discussion on the dichotomy of complex problems, see Kasser and Zhao [1].

IX. *WICKED SOLUTIONS*

Wicked Solutions have similar characteristics to Wicked Problems. When creating Wicked Solutions, the initial solution may not be the needed solution, since Wicked Solutions:

1. Evolve via the Multiple-Iteration Problem-Solving Process [1].
2. May only remedy part of the undesirability in the whole Wicked Situation.
3. May satisfice and not necessarily satisfy the problem in a single pass through the Multi-Pass Problem-Solving Process.
4. May apply simultaneously in the Wicked Situation hierarchy at more than one level and more than one location at a particular level.

X. *APPLICATION OF THE PARADIGM SHIFT TO NEW PRODUCT DEVELOPMENT*

New product development has been mapped into the learning process as a sequence of problems known as Design Thinking [18-20]. The undesirable situation is the need to develop a new desired product. The first problem is what product (or service) to provide to users, which is not necessarily the first product that comes to mind. After working on the first product, the learning process produces a finding that the first product is not what the users need and identifies an alternative product, so the process iterates and the new product development team learns about the need of the user and how the product will be used in its context [18, 19].

This process can be mapped into a modified version of the Multiple-Iteration Problem-Solving Process shown in Figure 4 where the output from the first research process is not a list of problems to solve, but is instead a product concept or prototype. The first process ends at a stage gate which determines if the product is indeed what the user needs and if the product should proceed to the second process which in this situation is the production process.

Having mapped new product development into the Multiple-Iteration Problem-Solving Process used in systems engineering, the benefits of applying systems engineering in improving Design Thinking [21] in dealing with complexity can be seen. Design Thinking has a number of definitions including:

1. A systems approach to design visualizing the product operating in its context [22].
2. An iterative learning process by multi-disciplinary experts from sociology, psychology, engineering, science, design, etc., working together and evolving the new product [20].
3. A human-centered approach enabling the engineers to think outside of the box [19, 23].

Design Thinking takes place in Column A of the Hitchins-Kasser-Massie Framework (HKMF) [24]. The systems engineering approach in the enabling paradigm of systems engineering [25] improves Design Thinking by managing the undesirable situation in a systemic and systematic manner. The systemic approach views the new product in its operational context as a system from each of the HTPs [8]. The systematic approach being via Active Brainstorming [10] in the Multiple-Iteration Problem-Solving Process.

These 'A' paradigm systems engineering [26] activities

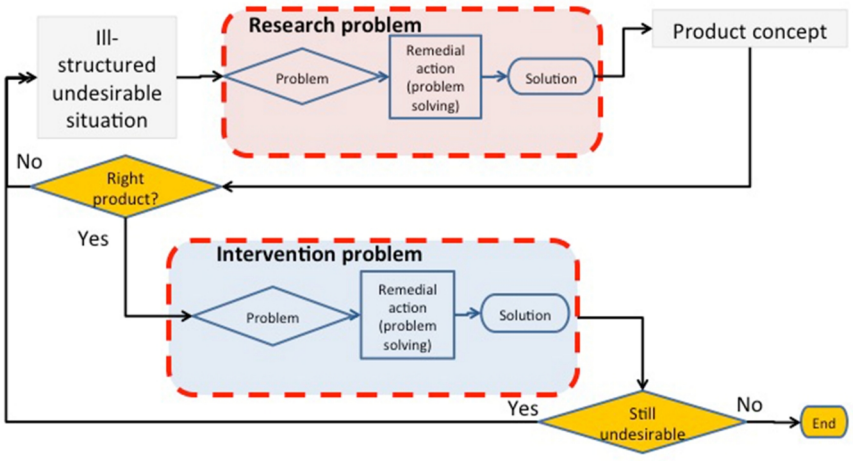

Figure 4 New Product Development variation of the Multiple-Iteration Problem-Solving Process

can contribute to the new product development process by reducing the number of iterations in the first process. When the systems comprising the undesirable situation and the FCFDS (the proposed new product operating in its context) are examined systemically from the HTPs, a better understanding of the user's as well as other stakeholders' needs is achieved as a result of observing the situation from the different perspectives. This better initial understanding reduces the number of iterations of the first process. See the conceptual proposal to replace the Technology Readiness Level (TRL) by a Technology Availability Window of Opportunity (TAWOO) for an example of the thinking process [27].

XI. *SUMMARY*

The contributions of this paper are:

1. Dissolving the problem of solving Wicked Problems by:
   a. Assuming multiple causes of undesirability.
   b. Changing the paradigm.
2. Conceptualizing an approach for speeding up new product development for complex systems by introducing a systemic and systematic methodology to Design Thinking based on the alternative paradigm.

The alternative paradigm approach discussed in this paper changes "Wicked Problems" to "Wicked Situations". Then creatively converted dealing with the extremely ill-structured problems in Wicked Situations to well-structured problems via an approach for managing complexity based on the Multiple-Iteration Problem-Solving Process [1]. Part IX briefly outlined some characteristics of Wicked Solutions. Finally, Part X discussed the implication of paradigm shift to New Product Development and Design Thinking.

XII. *CONCLUSIONS*

The conclusions of this paper are that:

1. Changing the paradigm and dealing with Wicked Situations can dissolve the problem of solving Wicked Problems.
2. New product development is performed in the context of Wicked Solutions.

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