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MODERN TIGER TEAMS:

TEAM PROBLEM-SOLVING FOR THE 21ST CENTURY

by: Alex Pavlak

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INTRODUCTION

The sobriquet "Tiger Team" was invented by the press during the 1970 Apollo 13 crisis. The first Tiger Team was NASA's mission-control team that figured out how to return the astronauts safely to earth. NASA's sensational success made Tiger Teams part of our lexicon and a popular management practice. The phrase Tiger Team became synonymous with a temporary expert problem-solving team.

Traditional Tiger Teams are an ad-hoc small group of experts that managers cobble together to resolve a crisis. Case study shows performance has been inconsistent, ranging from spectacular to dismal. Crisis occasions are rare, lessons learned are lost as the problem is resolved and the team dispersed. The result is that the traditional Tiger Team concept remains primitive while powerful supporting disciplines evolve as independent disciplines. There is no published knowledge base for temporary expert problem-solving teams. One purpose of this paper is to provide a reference.

There have been substantial advances in various forms of problem solving and teamwork. Looking at the traditional Tiger Teams through the lens of recent advances reveals why the traditional Tiger Teams work and still work well today. This view through the lens also reveals un-applied knowledge, exceptional opportunities for improving and generalizing the traditional Tiger Team concept.

The first body of knowledge is total problem-solving processes. Total problem-solving combines recent theoretical and empirical developments in rational problem-solving (defining the problem) with creative problem-solving (finding solutions). In addition to heuristics, total problem-solving influences teamwork: content and process skill requirements, participant selection, and team leadership structure.

Modern advanced teamwork, the second body of knowledge, offers a variety of tools not normally exploited by traditional Tiger Teams. Such tools include group building, and content-process split leadership. The short duration of the team allows management to tap otherwise unavailable talent, to employ leadership structures that cannot be sustained for long-term teams, and allow the team to physically function at an exceptionally high level of intensity and performance.

A third knowledge area comes from experience - Tiger Teams in action. Case studies, some of which predate the sobriquet Tiger Team, provide practical guidance for the integration of advanced teamwork with total problem-solving processes.

While Modern Tiger Teams are an exceptionally powerful tool for managing high profile crises, the principles can also be used effectively to manage low profile everyday disruptions. The tools should be come reflexive: given a problem with certain characteristics, the Modern Tiger Team is the best practice to follow. Modern Tiger Teams can resolve difficult problems and unexpected disruptions by synthesizing new ideas, spanning organizational boundaries, and optimizing critical decisions.

Dr. Alex Pavlak, Thales Research, Inc., 315 Dunham Ct., Severna Park, MD 21146; 410.647.7334; *thales@comcast.net*

WHAT ARE TIGER TEAMS?

Traditional Tiger Teams are temporary ad hoc problem-solving teams, an elite small group of experts that have been convened to resolve a crisis. The Traditional Tiger Team is a rather primitive concept. While its performance can be spectacular, it is not reliable. It is driven by the passion of a crisis, much depends on happenstance. This section places Tiger Teams in perspective with traditional teams to identify the basis for their performance.

ORDINARY TEAMS

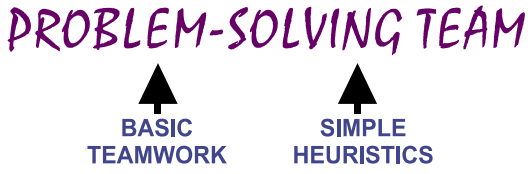
Teams are all about cooperation and coordination. The classic example is a sports team. When a hockey team is "in the zone" the players are so in touch with each other that they flow like a single organism and the result is a sight to behold.

Teams have long been recognized as an effective management practice, particularly in the military. During World War II General Dwight D. Eisenhower became quite effective at using his staff to help make decisions.[1] Aircraft flight crews, emergency medical teams, military teams, have been around for a long time. The use of management teams, project teams, interdisciplinary product teams, reached the tipping point with the quality management revolution around 1990. The first edition of *The Team Handbook*[2] was published in 1988 and the latest edition remains the bible.[3] Katzenbach[4] published a strong empirical analysis of management teamwork in 1993 and Swezey[5] published on the first research based review of team training in 1992.

Traditional teams derive their productivity from simple multi-functional coordination. Traditional teams can find solutions that are part of a training set. For example firefighters are trained to determine the source of fuel (petroleum, wood, electrical etc.). Then depending on the source, they implement specific suppression techniques. It is all training, stimulus-response. Critical incident commanders do not "think" about the process. Their trained response is fast, accurate and repeatable.

Trained response is very effective as long as the situation falls within the training set. If a problem falls outside of the team's speciality, members inexpertly hack away at the problem employing whatever problem-solving skills happen to be innate to its members. The results can be very disappointing. Traditional teams are not problem-solving teams because they have not been trained in general problem solving. At best they have been trained to react to a specific stimulus.

PROBLEM-SOLVING TEAMS



Problem-solving teams execute heuristics to solve problems. (Heuristics are semi-empirical problem-solving tools such as brainstorming and root cause analysis.) Problem-solving teams are based on basic teamwork plus simple heuristics.

A good example of traditional problem-solving team is a brainstorming group. Brainstorming is a simple process mainly used for shallow problems where everyone in the group has a clear idea of the whole problem. Members will synthesize a new concept by cooperative building on the ideas of other participants. This cooperative building is an important qualitative improvement. The product becomes is greater than the simple sum of the parts.

Effective brainstorming requires a facilitator with an explicit understanding of the process in order to coordinate the process. There are many different kinds of problems and each kind demands a different solution strategy. Problem-solving teams generally focus on a specific class of problems characterized by the team charter. The team becomes skilled with those strategies and heuristics that are used repeatedly; those process that are not used regularly by a team tend to atrophy. A team with the task of inventing new consumer products will become quite skilled at brainstorming and its variants but are unlikely to have a clear understanding of root cause analysis. Traditional problem solving teams tend to specialize.

TRADITIONAL TIGER TEAMS

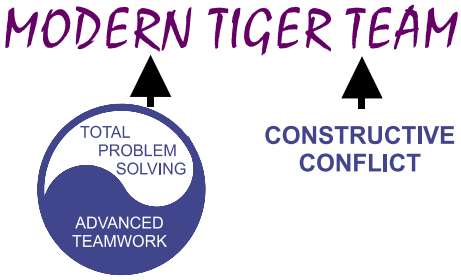
Traditional Tiger Teams are associated with ad hoc crisis problem-solving. When confronted with a crisis, management can assemble a Tiger Team, a temporary group of the best content experts that they can find. The duration is short (days, not weeks). The team convenes to solve the problem and then disperses.

The remarkable aspect of Tiger Teams is that while their construction and processes are quite primitive and unsophisticated, they can be spectacularly effective. The Cuban missile crisis, the Apollo 13 mission crisis were both resolved by Tiger Teams. However, their performance is not reliable; the Shuttle Columbia foam strike Tiger Team was ineffective. Lessons learned from these three classic cases are presented at the end of this paper.

Traditional Tiger Teams are characterized by constructive conflict, the struggle to reconcile different perspectives. Constructive conflict is discussed in more detail in the next section.

The basis of traditional Tiger Team effectiveness is the crisis motivated commitment of content experts. Exceptional commitment overcomes many sins. Exceptional commitment enables the other four elements of advanced teamwork (trust, constrictive conflict, accountability, goals) to be achieved almost naturally, with little explicit effort required.

MODERN TIGER TEAMS



In simple summary terms, Modern Tiger Teams eliminate the need for crisis motivation by integrating advanced teamwork tools with total problem-solving heuristics. Like traditional Tiger Teams, performance is characterized by constructive conflict. The Modern Tiger Team goal is to reproduce or exceed the performance of traditional Tiger Teams, do this reliably and repeatedly, and provide this performance for low profile everyday problems.

THE PURPOSE OF CONSTRUCTIVE CONFLICT

Constructive conflict is the intense open honest struggle to reconcile different perspectives. It is the heart of the Modern Tiger Team productivity. With multi-disciplinary problems, everybody understands a piece, but only a piece of the problem. No one person understands the whole problem in depth with all its nuances. The solution comes from the synthesis, the integration, the real time give and take among the experts who have a deep understanding of a piece of the problem. An elegant solution comes from fitting these different perspectives together in a natural optimal way.

This struggle requires a deep dialog among experts. The dialog is not one-on-one but one to many. In real time, each person must grasp the position of each of the other participants and fit his own perspective into this group vision, the whole solution. Normally this intimate dialog occurs in the mind of a gifted individual. With Modern Tiger Teams the struggle is explicit, everyone participates.

During constructive conflict individuals must make compromises. The goal is to optimize the final solution. The pieces or components that makeup the solution cannot all be optimized. The struggle is to fit these pieces together in a way that optimally satisfies the goal.

The advantage of constructive conflict is holistic thinking - the ability to synthesize whole concepts by integrating diverse disciplines and perspectives. Most so called "teams" are really workgroups, an extension of the group leaders skills. The integration occurs in the mind of the leader. As a result, these work groups are limited by the capacity and skill of the group leader. With Modern Tiger Teams the integration occurs by the group as a whole.

This section shows how constructive conflict can improve problem-solving by beginning with its impact on classical problem-solving theory and basic thinking tasks. We then discuss examples of successful constructive conflict and conclude with its challenges.

CLASSICAL THEORIES OF PROBLEM-SOLVING [6]

The two main theories of problem-solving are the Associationist philosophy and the Gestalt philosophy. These two theories present alternative views of the psychology of thinking. Neither one is right or wrong, rather both perspectives offer useful guidance about how to solve problems under different circumstances.

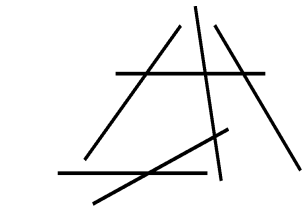
Associationism: Thinking as learning by reinforcement.

Associationism is usually traced back to rules originally expressed by Aristotle. The belief is that mental life can be expressed in terms of two basic components: ideas (or elements) and associations (or links) between them. There are three rules or "laws" of association: contiguity, similarity, and contrast. Contiguity refers to nearness, as when a baby's shoe reminds you of the infant. Similarity means that a picture of a lion will remind you of a cat. Contrast means that a midget might remind you of a giant. These Associationist ideas provided the basis for Osborn's brainstorming.[7]

Gestalt: Thinking as restructuring problems.

Gestalt psychology originated in 1912 with an effort to understand perceptual phenomena.[8] According to Gestalt psychologists, the process of problem-solving is a search to relate each aspect of a problem situation to each other. This results in structural understanding - the ability to comprehend how all the parts of the problem fit together to satisfy the requirements of the goal. "Insightful problem-solving involves productive thinking – that is, the person must go beyond past experience and overcome misleading situational influences to formulate a novel approach to the problem."[9]

A classic example of Gestalt thinking is the so-called six-stick problem: Given six sticks, how can they be arranged to form four equilateral triangles with each side one stick long? One could push those sticks around on the table forever without getting anywhere (a persistent anomaly). The solution is "A-Ha," a tetrahedron. The insight required to solve the problem is to think in three dimensions rather than two.



Insight involves reorganizing the primitive elements of the problem in a new way. A reductionist attack will fail since the whole problem must be solved at once. The intellect must have the capacity to thoroughly understand all aspects and nuances of the primitive elements to envision how they could fit together in a new arrangement. This principle is one reason why Modern Tiger Teams can out perform even gifted individuals. The Gestalt concept of insight provides powerful tools that guide the Modern Tiger Team process.[10]

BASIC THINKING TASKS

Deduction and Induction are not theoretical approaches like Associationism or Gestalt but rather tasks that are performed in both theories. Problem-solving involves both deductive and inductive reasoning in varying combinations. For example, in mathematics we have the inductive synthesis of theorems and conjectures followed by their deductive proof.[11]

Deductive reasoning: Thinking as logically drawing conclusions.

Deduction is defined as inferring specific conclusions from general premises. Deduction implies that thinking involves the combination of existing information by following specific rules. Deduction interprets thinking as the processing of premises by using specifiable operators – similar but not identical to logical operators.[12] e.g. the categorical syllogisms such as: "All A are B; All B are C; Therefore all A are C." Deduction is consistent with the information processing approach used as the basis for early work in artificial intelligence.[13] Deductive reasoning is used to define the problem and evaluate hypothesis.

Inductive Reasoning: Thinking as hypothesis testing.

Induction is defined as inferring a general conclusion from specific instances. Through inductive reasoning, a set of rules enable the formation of general concepts from raw data. For example, what is the rule used to generate the following sequence on numbers: 1, 1, 2, 3, 5, 8, 13, 21, 34...? The rule is that each number is the sum of the two preceding numbers - the Fibonacci series.

Holland et al present a credible set of rules for induction that they believe has the potential to explain synthesis of *Great Ideas*.[14] Other more traditional cognitive scientists believe that *Great Ideas* have a holistic character that cannot be explained by current induction theory.[15] The truth probably lies somewhere in between. While induction often has an insightful holistic character, rules can go a long way to describing the process. Inductive reasoning is used for solution finding.

Analogical Reasoning: Induction with the aid of analogs.

Analogical reasoning is a mechanism by which the mind can reach beyond its direct experiences.[16] When confronted with unfamiliar or surprising situations, we attempt to understand by comparing the novel event (the target) with something that we do understand (the source). Correspondences provide the basis for inferring new information. Children are quite good at analogical reasoning as their world consists of an endless series of surprising situations.

Analogical reasoning is often used as the basis for measuring intelligence. One test takes the form of defining a proportional source relationship (A:B) and asking what does that imply about the target relationship (C:?): A is to B as C is to what?

$$A : B :: C : ?$$

For example:

loaf of bread : slice of bread :: lemon:?

The answer is of course a "slice of lemon." Four year old humans and chimpanzees can answer this question. Other primates cannot. In one sense analogical reasoning is a modern extension of Gestalt psychology.[17] There are a number of tools for stimulating analogical reasoning in total problem-solving (forced fits, Synectics, multi-constraint analysis[18]...).

MANAGING CONSTRUCTIVE CONFLICT

We see examples of constructive conflict most clearly in dyad (two-person) collaborations. Two people with complementary skills and background accidently meet at the right place and the right time and the resulting problem-solving performance makes history. Examples are Crick & Watson and the discovery of DNA structure, Hewlett & Packard and the Hewlett-Packard Company, Gates and Allen and the Microsoft Company. Based on this experience, the model for new business ventures is a young technical firebrand teamed with an older experienced financial person.

Reconciling divergent perspectives stresses social relationships. The reason dyad collaborations are fairly common is that the dyad is a natural stable human social structure. We would see more high performance dyad collaborations if their establishment did not depend so much on happenstance and if the dyad did not need to reinvent the process with each new collaboration.

If a dyad works better than an individual, why don't we see more constructive conflict in groups of three or more? In fact we do see flashes of constructive conflict productivity in larger groups. Oppenheimer and the Manhattan project; the author's experience orchestrating the invention of TAVA, a novel sonar system concept; a variety of engineering, architectural and software development teams; and traditional Tiger Teams (case studies are discussed a the end of this paper).

Larger groups suffer from more challenges than dyads.

- First, groups of three or more require a leader. The group usually is an extension of the leader's skills with integration occurring in the mind of the leader. This limits group performance to the leaders capabilities and skills.
- The leader must have respected content skills as well as good teamwork skills, a rare combination.
- If the leader is to orchestrate the group through the problem-solving process, s/he needs an explicit understanding of the process. It is practical for a leader to maintain depth of understanding for only a narrow range of problem types.
- True problem-solving teams, where members are communicating primarily with each other rather than through the leader, are virtually non existent.

To overcome these challenges, we need an explicit understanding of the general problem-solving process as well as advanced teamwork skills tailored for problem-solving. The next two section of this paper will look at explicit problem-solving and teamwork for modern Tiger Teams.

EXPLICIT PROBLEM-SOLVING

People learn how to solve problems as an apprentice, through the direct experience. As a result, the content expert's understanding of the problem solving process is intuitive. People find it difficult to articulate the process. Individual skills are generally restricted to a narrow range of problem types. Problem-solving expertise is characterized by personality temperament (Myers-Briggs). Some people are very talented at discovering creative approaches, others are skilled at causal factor analysis.

A team needs to be able to explicitly identify the steps that it needs to take to perform its task. The leader needs to guide the group through a definite sequence of steps. In this sense team problem-solving is different than individual problem-solving. The orchestration of a problem-solving team demands an explicit understanding of the sequence of steps. Some experts have thought this through this process for a narrow range of problem types.

Unfortunately we are confronted with many different types of problems. Each type demands a different solution method. For example we have well defined problems and problems that are simply a fuzzy mess; problems that require inductive reasoning or deductive reasoning; insight problems where the whole problem must be solved at once through hypothesis testing, and reductionist problems which can be solved by analyzing its parts; people problems with many or no acceptable solutions or physics and mathematical problems with one exact solution.

The problem-solving literature is highly fragmented. Everyone presents a different perspective and there is no definitive text on the total process. This section attempts to present such an overview. Fortunately, the conceptual core of the problem-solving process is very simple. It consists of two sequential stages: first define the problem, then find solutions. It is important for the problem-solver to understand this fundamental sequence and the status of the problem in the process.

This section address the heuristics that have been developed to address each step, and concludes with the total problem-solving process.

WHAT IS A PROBLEM?

Problems are defined as obstructed goals. Without a goal or without an obstruction, there is no problem. Furthermore, every problem has three defining characteristics:

present state
goal state
obstruction

The effort to define the problem is an effort to clearly and thoroughly identify each of these characteristics. With some problems the goal state is clear and the present state is fuzzy, with other problems the inverse is true. With other problems both present state and goal state are clear and obstructions are not.

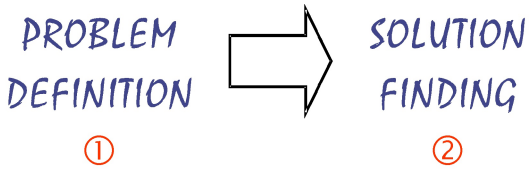
PROBLEMS vs PUZZLES

Like problems, puzzles are also obstructed goals. The distinction is that with puzzles, the solver has had experience with a similar problem in the past and understands the procedures for finding solutions. For someone trained in physics, calculating the time it will take for a ball to fall from a table is a puzzle. S/he knows how to analyze the situation and perform the calculation. For someone untrained in physics, this is a problem because s/he needs to invent the equations from first principles.

Precedented puzzles are often best solved by individuals. Teams can be more effective than individuals when the puzzle is complex and requires multi-functional coordination. Most of what the literature calls problem-solving teams are really puzzle solving teams.

PROBLEM-SOLVING'S CONCEPTUAL CORE

The conceptual core of the problem-solving process consists of two sequential stages: Problem Definition and Solution Finding. First you define the problem then you conduct a disciplined search for solutions. All problem-solving models embed these two stages.



For some problems all the effort goes into defining the problem. Once the problem has been defined, the solution is obvious, a trivial step. An example here is an automobile that won't start. The mechanic conducts his diagnosis, root cause analysis, and discovers a broken fuel pump. All the time and effort goes into the diagnosis and little effort needs to be directed at finding a solution. The mechanic still needs to find a solution but it is a trivial step - replace the pump. Many manufacturing quality problems fall in this category. This class is called rational problem-solving.

For other problems, the reverse is true. The problem definition is obvious and all the effort goes into finding a solution. An example here is a corked bottle of wine and no corkscrew. How to remove the cork to pour the wine? Present state, goal state, obstruction are all obvious and require little effort. The challenge is to find a creative way to remove the cork. This class is called creative problem-solving. In later sections we will show that creative problem-solving generally benefits from teamwork.

Most real world problems tend to require a mix of creative and rational problem-solving. The murder-mystery detective spends most of her time in a rational deductive analysis of clues but every so often needs to take a creative inductive step: develop a theory of the crime.

People tend to have a talent for either rational problem-solving or creative problem-solving, but

rarely both. This is a Myers Briggs personality temperament diversity along the Judgment - Perception dimension. Skills that make one a good manager (discipline, organization, control, attention to detail, closure) are the same skills useful for rational problem-solving but not creative problem-solving. Likewise people who are very good a thinking outside of the box (exploring, inquiring, meandering) may be creative but often get bored with schedules and tedium and tend to not have the discipline to be good managers.

By constructing a problem-solving team we can combine the best of both skill sets. We can combine people with good rational skills with people with good creative skills. Managers do not need to be good creative problem-solvers. They do need to understand the process and manage people to generate creative solutions.

BASIC STRATEGIES

At the strategic level, there are several basic approaches that should be addressed early:[19]

- **Have we seen this before?** Truly unique problems are very rare. Indeed, past experiences generally contribute to acceptable solutions. If the methods are identical we have a puzzle not a problem.
- **Perspectives** - Sometimes a different perspective makes the problem easy to solve. What are candidate perspectives?
- **Variations** - If we become stuck, change something, anything.

RATIONAL PROBLEM-SOLVING

The purpose of Rational problem-solving is to define the problem: present state, goal state and obstructions. For many practical problems, once the cause is understood, the solution is obvious.

There are many heuristics, semi-empirical tools that are useful aids for defining the problem. These tools break the problem apart, exposing relationships and clarifying goals. A partial list includes:

- **Root cause analysis:**[20] Every effect has a cause. Causal factor diagrams, which illustrate cause and effect chains, can be used to find that cause which, if eliminated, would prevent recurrence.
- **Kepner Tregoe Problem Specification:**[21] This analysis approach focuses on what the problem is, what it is not, and the distinction between the two.
- **Fishbone Diagrams:** Given an effect, a fishbone diagram is a useful device for identifying and categorizing causal factors.
- **Problem Restatement:**[22] This approach is useful in clarifying goals. Don't assume the water on the floor is from the waterbed. It might be a leaky pipe or roof.
- **Camelot:** Create an idealized situation, a Camelot and compare with the existing situations. What are the differences, why do they exist, what problems or opportunities are suggested?
- **Pattern Searching:** During the Fog, the confusing early stages of a crisis, try to make sense of

the data by looking for patterns, causal or otherwise.

- **Benchmarking:** Search for potential problems by comparing your situation with your best competitor, the best of the breed. The comparison could be with a fictitious super-competitor.
- ...

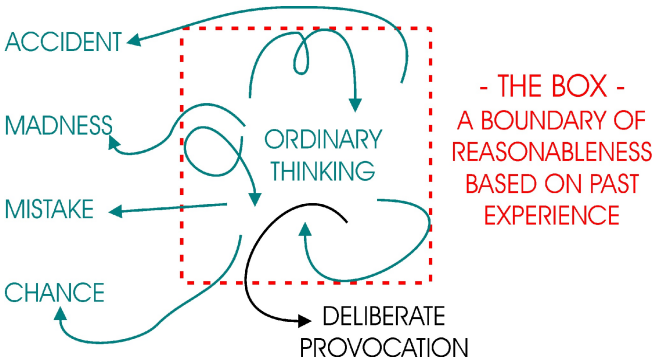
Individuals can often do a good job of reductionist problem analysis. In general, analysis is best conducted by multiple independent sources. Teams are useful in terms of covering the disciplinary bases, judging and evaluating, and in developing closure.

CREATIVITY

Creativity has been defined as the ability to produce work that is both novel and appropriate to the pursuit of a goal.[23] Guilford has argued that creativity and problem-solving refer to essentially the same mental phenomena,[24] a similar sequence of stages. While creativity can be deliberately stimulated,[25] there is little consensus in the literature about techniques.[26] The following observations and approaches resonate with personal experiences.

Heuristics

There are dozens of heuristics that can assist in creative problem-solving.[27,28] Most of them have the purpose of deliberately provoking novel connections and relationships. These heuristics include: brainstorming and its many variants, a variety of analogy techniques, six thinking hats, wishful thinking, nominal groups, excursions... Again, the art is in selecting and adapting the technique appropriate to the task at hand.



Genius

There are two views of the role of genius in creativity.[29] A popular "genius" view is that "creative thinking is the result of extraordinary thinking processes, processes that are somehow qualitatively different from the 'ordinary' thinking that we all use for our daily activities." An alternative view, emerging in scientific circles, is that "... creative thinking and creative persons are extraordinary because of their products, but not because of the processes that brought these products about." Modern Tiger Teams is based on the latter perspective.

Knowledge

The role of knowledge in the creative process is also in dispute.[30] A view that is widely accepted in the scientific community is that "since creative thinking by definition goes beyond knowledge, there is ... a tension between knowledge and creativity." Based on this perspective, facilitators will encourage the group to first synthesize creative connections, then, ground the ideas in the realities

of the problem. The concern is that if the group first grounds itself in the realities of the problem it will become fixated and be unable to synthesize new connections.

An alternative emerging view, called the "foundation view," is that rather than breaking out of the old to produce the new, creative thinking builds on knowledge. After the group thoroughly understands the definition of the problem, the goals and the barriers, then it is in a position to speculate on novel links. With this approach it will be necessary to break out of old ruts. Modern Tiger Team experience supports this latter approach.

Incubation

Many eminent scientists have reported that their inspiration came during various forms of relaxation, sleep or illness within several days following a period of intense work.[31] While the phenomenon is not well understood, the speculation is that problem-solving makes unconscious progress during lulls in the work[32]. The incubation sequence involves three phases: 1) a period of intense work on the problem, 2) suspension of conscious work, and 3) resumption. Olton & Johnson[33] theorize that the time lapse allows confusing ideas to be forgotten. Prince's experience is that with small groups, incubation occurs in real time, all of the participants are bringing their varied experience to bear.[34] There is rigorous scientific evidence that sleep inspires insight.[35]

Deferred judgment

The central pillar underlying most creativity stimulation techniques has been the separation of ideation from judgment.[36, 37, 38] The approach is to defer judgment of an idea until after all possible ideas have been fully developed. The view here is that creativity and judgment are incompatible and no idea is perfect in its early stages. Ideas need to be nurtured, grown and matured before they are judged to be good or bad. Too many ideas are discarded before their full potential is explored.

This separation of ideation and judgement, common to many problem-solving models, is also rooted in the divergent/convergent production in Guilford's Structure of the Intellect model.[39] A few psychologically strong creative people have the personal flexibility to switch roles and separate ideation from judgement in their own mind. Other people benefit from assistance in the form of an artificial facilitated group.

Divergent & convergent thinking[40]

The classic distinction between divergent and convergent thinking was established by Guilford[41] and Mednick.[42] Facilitators can stimulate creative progress by deliberately shifting the group into one of these modes at the appropriate time.

The divergent-convergent schema suggests exploring a large number of possible solutions before applying judgement to evaluate and develop. Divergent thinking refers to thinking that flows outward form a concept, making contact with other ideas and possibilities. In studies on problem-solving, artists often create interesting structures without specific goals in mind by simply playing

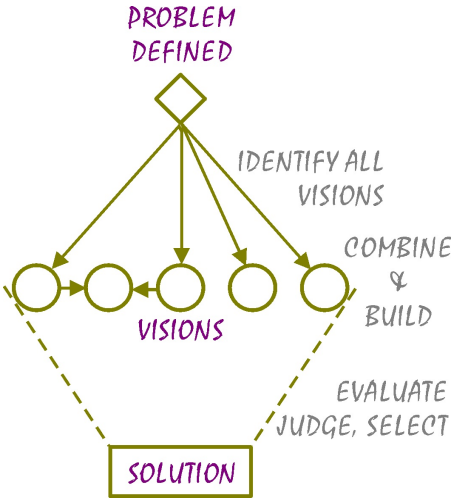
with the possibilities.[43] Convergent thinking focuses on a goal, the creative insight is a solution that makes sense out of apparently disconnected facts. Divergent and Convergent thinking is often used in sequence resulting in the Synectics creative problem-solving model.

CREATIVE PROBLEM-SOLVING

The purpose of creative problem-solving is to conduct a disciplined search for solutions. The process begins with a defined problem. The present state, goal state and obstructions are clear, either because the problem is self evident or a rational problem-solving process has produced a definition worthy of being pursued.

A disciplined search means to deliberately identify all possible options before selecting one. We all have a bureaucratic tendency to settle on the first good idea that comes along. This works fine as long as an optimal solution is not critical. Pick an idea and move on because the best solution is often not that important. However, for important problems we should be thorough. This means deferring selection until all viable candidate solutions have been identified.

A common model for Creative Problem-Solving is Divergent-Convergent thinking as illustrated in the adjacent figure. A preparatory phase had defined the problem and established some criteria for evaluating solutions. The divergent phase is a brainstorming-like phase which has the purpose to identify all possible visions (solutions). The divergent phase includes combining and building visions to create new solutions.



Once we have an exhaustive list of solution candidates, we can then evaluate and judge them by our pre-selected evaluation criteria. This convergent phase begins by organizing and categorizing solutions then winnowing them down to a selected set. This set can then be evaluated through a rank and score procedure.

One of the first effective empirical tools was Alex Osborne's brainstorming.[44] Brainstorming is based on four rules which have impressively withstood the test of time. Osborne's four rules are:

- **Criticism and judgement are ruled out** during the divergent phase. The principle here is that stimulating novel connections is inhibited by premature judgment.
- **"Free-wheeling" is welcomed**. Free association, wild and wacky ideas, breakout of conventional thinking and open the way to new practical ideas. It is easier to tame down, to make the ideas practical and reasonable later.
- **Quantity is wanted**. The greater the number of ideas, the more likely that some of them will prove useful.
- **Combine and build**. Build ideas into better ideas. One idea sparks another idea which sparks another. This is the process by which group products become greater than the sum of the parts.

As with the rational problem-solving phase there are many heuristics that can aid the creative problem-solving process. A particularly good source of heuristics is Higgins.[45] Most of these heuristics are aimed at stimulating novel connections. A partial list includes:

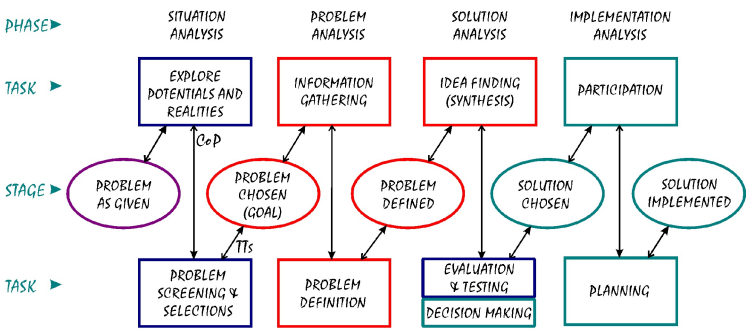
- **Brainwriting**: A non-oral form of brainstorming to which basic brainstorming rules apply.
- **Nominal Groups:**[46] A brainstorming variant whereby individuals develop ideas anonymously, in isolation, then the group combines, builds, evaluates and judges. This is a simple process that eliminates many dysfunctions without expert facilitation.
- **Analogies, Metaphor, Similes**: The common thread is to compare the problem with something else, then derive insights from similarities and distinctions.
- **Excursions:** This is an extreme analogic technique originally developed by Synectics. Participants visualize an excusrion through some physical location that has nothing to do with the problem. They then draw analogies with the problem and share experiences.
- **Past Solution Analysis**:[47] Looking for clues from similar problems that have already been solved is often effective.
- **Free Association:** Start with the problem definition, then just write whatever comes to mind. Looking for a train of thoughts that might lead to a solution. Works for individuals and groups.
- **Delphi Technique:** Circulate the problem statement to the group, collect responses, summarize and redistribute, iterate. This is deliberate technique, the way the Supreme Court finds solutions.
- ...

Teams have two distinct roles in creative problem-solving. During the divergent phase teams are particularly good at stimulating each other, building and combining ideas. Teamwork during the divergent phase is synergistic, the whole is substantially greater than the sum of the parts. During the convergent phase we are looking for multiple independent perspectives. This is a judgmental phase where the team average opinion is superior to the expert participant.[48]

TOTAL PROBLEM-SOLVING PROCESS

As discussed earlier, the conceptual core of the problem-solving process consists of two sequential phases; problem definition and solution finding. These two stages are embedded in a larger overall process that includes beginning tasks that precede the core and concluding tasks that follow. The appropriate tasks will vary depending on the nature of the problem at hand.

The adjacent figure provides a general view of the whole process. Problem-solving proceeds through a sequence of stages: problem as given, problem chosen, problem defined (present state, goal state, obstruction), solution chosen and solution implemented.



THE PROBLEM-SOLVING PROCESS

The first task in situation analysis is to explore the universe of possibilities, all potentials and realities. This could be accomplished by a traditional seminar or workshop followed by breakout groups to summarize potential problem definition. The second task in situation analysis is screening of potential problems and selection of the one to be pursued. This screening and selection can be done based on self interest. The result is a chosen problem.

Most texts deal with some subset of this process. Total problem-solving refers to the whole process. The core tasks, problem definition and idea finding are best implemented by the tightly integrated Tiger Team.

TEAMWORK FOR MODERN TIGER TEAMS

Teamwork is all about coordination. In the real world, simple multi-functional coordination can have a huge practical impact. But, ordinary teams are not problem-solving teams. Ordinary team problem-solving skills are the simple sum of available innate talent. At best, ordinary team problem solving skills are equivalent to those of its most talented member. At worse, group interaction can degrade the performance of its most talented member.

Modern Tiger Teams are expert problem-solving teams. The teamwork goal is the synergistic combination of talent. Individuals build on the ideas of others. Constructive conflict allows diverse skill sets to be applied in a mutually supportive fashion. As a result, the whole is greater than the sum of the parts. Teamwork for Modern Tiger Teams differs from traditional teamwork in several important ways:

- **Constructive conflict** - The primary performance engine is the intense, open and honest struggle to resolve diverse and often conflicting perspectives.
- **Team construction** - In addition to covering the content bases, a problem-solving team needs a diversity of problem-solving tools and perspectives. There is an optimum group size.
- **Leadership** - A content neutral (but culturally savvy) process manager minimizes the risk of the traditional technical group leader introducing biases.
- **Intensive management** - The overall effort that goes into planning, member selection, heuristic approaches, formats, agendas, strategies, group building, norms, is considerably greater than with traditional workshops.

This section develops the teamwork aspects of Modern Tiger Teams. We begin by exploring the need for teamwork in problem-solving. We then explore the cultivation of constructive conflict followed by key factors (norms, group size, participant selection, communication patterns, leadership, environment) enabling Modern Tiger Team performance.

WHY PROBLEM-SOLVING NEEDS TEAMWORK

Ordinary teams have been effective at tasks that benefit from multi-functional coordination. Examples are flight crew coordination, multi-disciplinary report writing, process improvement, quality and project management. Teams are also effective at problem-solving when the task is anticipated by a training set or where one of the team members has the necessary understanding and skill. Teams have struggled with deep or difficult problems, when no one person has the capacity to grasp the whole problem.

To build the necessary intellectual capacity

A "discipline" is a subset of man's knowledge that is sufficiently narrow that one person can become an expert. By devoting a career to a discipline, the expert understands the historical basis, the classic problems and solutions and all aspects of the scope of the discipline. As the knowledge base matures

the discipline becomes increasingly complex. Eventually, new people entering the field cannot grasp the whole discipline in sufficient depth and sub-disciplines are spawned. The scope of a discipline is defined by the capacity of an individual.

By definition then, a deep multi-disciplinary problem must involve people from more than one discipline. An obvious reason to construct a multi-disciplinary team is to apply a broader skill base. When a problem spans multiple disciplines, there is no one expert who understands the whole problem in depth. Rather, the necessary knowledge base can only be constructed by assembling experts from each of the component disciplines. A simple example here is a surgical team involving a surgeon, anesthesiologist, and scrub nurse.

To exploit diversity

Diversity among group members improves problem-solving performance potential for two reasons:

- Perspective diversity allows the team to look at the problem in different ways. An appropriate representation, a particular perspective, often makes the solution search much easier.[49]
- Tool or skill diversity increases the total set of tools that can be applied to the problem thereby increasing the likelihood of a successful solution.

To exploit this diversity, the group needs to function as an integral unit, a team. Proxies for diversity are discussed in a following section titled Participant Selection

To provide superior judgment

Surowiecki correctly points out that the independent judgement of many knowledgeable people provide better more reliable results than individual experts.[50]

To stimulate ideas

Left in isolation, our mental processes get bogged down in a rut. We settle into a traditional solution pattern and when that does not work we get stuck.[51] Interaction with another person jars the thought processes, breaks out of the rut. For example, person #1 suggests idea A. That idea sparks idea B in the mind of person #2. Idea B would never have occurred to #2 without #2 seeing idea A. Likewise #1 was unable to progress beyond idea A by his/herself. Idea B is truly a group idea.

To motivate executioners

Many good ideas fail because they just fall by the wayside. Not Invented Here - nobody makes the effort to implement them. Team construction allows the inclusion of the relevant stakeholders. The motivation comes from a sense of ownership. By participating in the problem-solving process, stakeholders contribute to the solution and understand its strengths and weaknesses. The whole team "owns" the results and each member has a vested interest in a successful implementation.

CULTIVATING CONSTRUCTIVE CONFLICT

Constructive conflict is the engine driving Modern Tiger Team performance. Its purpose is to produce the best possible solutions in the shortest period of time. Its intimate dialog is enabled or cultivated by four factors: trust, goals, commitment, and accountability. Weakness in any of these four factors can be destructive.

Trust

Mutual trust os the foundation for constructive conflict. "In the context of building a team trust is the confidence among team members that their peer's intentions are good, and there is no reason to be protective or careful around the group. In essence, teammates must get comfortable being vulnerable with one another."[52]

Trust can be built a number of different ways. As we will see in the Cuban Missile Crisis case study, trust can be derived from loyalty; it can be a consequence of compelling mutual commitment as it was during the Manhattan Project; it can also be derived from a shared code of conduct as it is in the military. Trust can also be developed quickly through traditional group building exercises as long at there is no overwhelming external competitive conflict.

Goal

Teams need a purpose, clear and unambiguous goals. The more compelling these goals, the easier it will be for team members to commit themselves to their achievement. Goal setting is a responsibility of team leadership. This is a precondition to establishing a Modern Tiger Team.

Commitment

Team members must share a mutual commitment to achieve a common goal. This commitment must me more important to them than status: either the status of belonging to an elite team, or personal status through making a unique contribution. Actually achieving the common goal must be more important to members than the process of pursuing the goal.

Robust commitment can overcome a variety of sins. During the Manhattan project, scientists were so afraid of Hitler that they were willing to put aside their differences and cooperate. It is the reason why the economy can be so productive during a time of war. After WW II, efforts to maintain the Manhattan Project Level of comradery failed because the commitment was no longer there. Personal goals became more important than team goals.

Accountability

In the context of Teamwork, accountability refers to the willingness of team members to call their peers on performance or behaviors that might hurt the team.[53] For Modern Tiger Teams it is assumed that peers have egos that are healthy enough to take negative constructive feedback. Group leaders do not need to function as third grade disciplinarians, team members police their own behavior.

NORMS

Norms are standards of proper action to be followed by Modern Tiger Teams. In this section we highlight a number of norms that are particularly useful for Modern Tiger Teams.

Team charters

As part of planning it is most useful to have a document that defines the mission or purpose of the team, what it is, what it is not. What is the expected outcome? How would the result be used? The charter defines the scope of work and the parameters within which the team will work. The charter documents the basis for leadership, roles, reporting, meeting formats, agenda, members, logistics, problem-solving strategies and heuristic planning.

Group building

There are a number of facilitator exercises designed to break down interpersonal barriers and encourage the group to function as an intellectual unit.[54] Group building makes a real difference efficiently building trust even with scientific and engineering groups.

Discussion guidelines

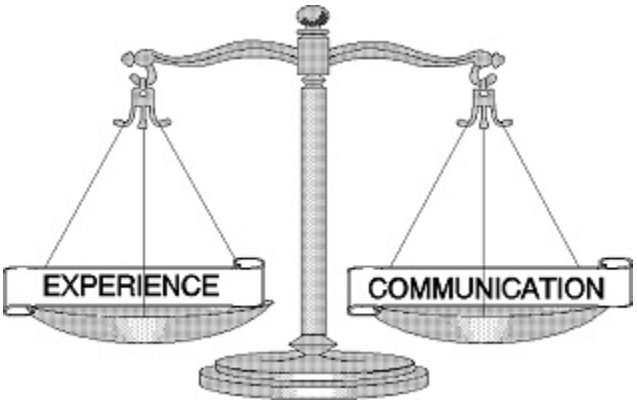
To function effectively as an integrated unit, participants need to respect certain ground rules. These rules-of-engagement are taught during the kick-off session. Here are some examples:

In & Out listening
Speak in headlines
Question for understanding only
Structure offers as:
    How to ...
    I wish ...
Build on ideas and wishes
Respect roles
Assume value
Listen for newness
No (fatal) flying missiles
Stay loose until rigor counts

Roles

Members of Modern Tiger Teams have roles to fill and these roles must be respected for the team to be effective. These roles and responsibilities can vary depending on the formats selected. Typical roles are: participating expert, content leader, process leader and scribe.

OPTIMUM TEAM SIZE



There is an optimum size for Modern Tiger Teams. One driving force is experience and skill - a team brings more experience and skill to bear against the problem than individuals. From this perspective, the larger the team the better.

The opposing force is communication - as the team grows in size it becomes more and more difficult for people to communicate. As the team grows, people become frustrated with the inability to express themselves so they interact with a subset of the group and the team fragments. This frustration is based on two factors. One is the need to wait for a turn to talk, the other is the inability to track the nuances of different conversational threads as these threads proliferate and recede in time. We see this dynamic in action at cocktail parties. A conversation starts, interested people join the group, eventually the group becomes too large and it divides into two conversations.

The optimum size of a problem-solving group depends on the task, the nature of the content, the temperament and intellectual caliber of the people, and how the group is managed. In a well managed group, everyone is an essential contributor, and leadership encourages a balanced discussion where everyone is contributing appropriately. Individuals have been trained to communicate efficiently, no wasted words. The optimum size of a well trained group is characterized by a very intense high energy dialog. An example of one of the training techniques is to encourage participants to speak in headlines, to efficiently get their point across rather than rambling.

The optimum size of a problem-solving group is related to man's ability to process information, our biological short term memory. Miller (1956) shows that people can simultaneously keep track of approximately 7 things at one time.[55] In a group setting this means that each person can keep track of seven other perspectives. Bormann's view is that the optimum size for a decision making group is 5-7 people.[56] This is an appropriate number for inexpertly managed groups. Experienced leadership can push the size of the group. Alex Osborne, the inventor of brainstorming, recommends 12 as the ideal size for a brainstorming group.[57] Fox recommends an upper limit of 9.[58] The author's experience with Tiger Team problem-solving groups is an optimum size in the range of 10-12.

The optimum size is not a precise number. A group that is too small lacks energy, viewpoints are too narrow, and (depending on content) their information resources are limited. With a group that is too large, people get frustrated and the discussion fragments.

PARTICIPANT SELECTION

Participant selection is important. The task is to pack as much potential power as possible into a limited group size. Passive observers sap energy and do not contribute to the outcome. In the section titled WHY PROBLEM-SOLVING NEEDS TEAMWORK we highlighted intellectual capacity and diversity as important principles but what are the proxies? What attributes need to be identified? There is little in the way of formal research to guide selection so we rely on logic, reason and experience to present the following:

Skills

All critical skill sets and problem facets need to be represented. Tiger Teams also provide a superb opportunity to integrate the wisdom and experience of outside experts from outside the organization.

Tools

Closely related to basic skills would be diversity in problem-solving skills, people with different approaches to problem-solving. Scott Page (unpublished manuscript, July 16, 2004) speculates the people have tool boxes, basic skills that they can bring to bear against a problem and that these tools can be combined to generate new tools. If Page's combinational speculations are correct, adding new people with different tools exponentially increases the number of tool sets that can be brought to bear against the problem.

Age

Age is an important axis of diversity. Lehman conducted a landmark study[59] of the effect of age on productivity in science, finding that scientists are most productive at around 30 years old. But Lehman's findings are controversial and the situation is more complex.[60] The author's experience is that mixing a few younger scientists in with a group of more senior scientists is most productive in that some of the best ideas come from the young scientists.

Generalist/specialist

For certain problems the group may contain a "generalist," someone with a broad but shallow grasp of the problem. This generalist does not have the depth of understanding to synthesize the solution by herself. However, the generalist may be in a position to provide a high level vision and help orchestrate a solution by the rest of the group.

Content Perspectives

"Almost always the men who achieve these fundamental inventions of a new paradigm have been either very young or very new to the field whose paradigm they change."[61] Consideration should be given to including a wildcard, someone from a different field.

Stakeholders

Team selection provides the opportunity to select important stakeholders, particularly individuals responsible to executing or implementing the solutions. As a participant they develop a sense of awareness, ownership and motivation. They understand the nuances and become motivated to embrace and promote the solution. For unexpected problems, stakeholders can be located anywhere in the traditional hierarchy.

Rational/creative problem solvers

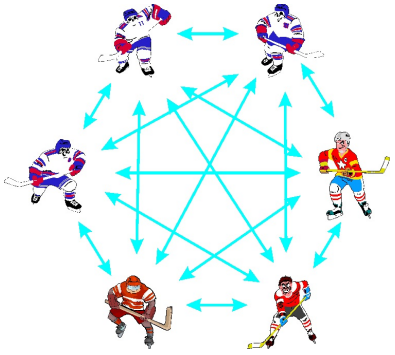
As noted earlier some people are naturally good at problem analysis, others are particularly adept at generating ideas. These two skills are closely correlated with personality and temperament. Myers-Briggs diversity can also be a useful proxy with regard to improving group dynamics. Introducing an extrovert into in introverted group can liven it up and improve the dialog.

Gender

Gender diversity would have a substantial impact on solving a gender related problem. For problems not related to gender, the author's experience is that gender diversity can help but it is low on the list of important diversity metrics.

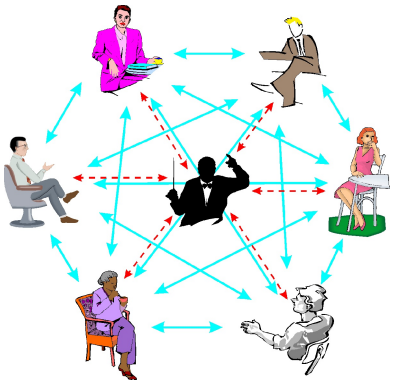
COMMUNICATION PATTERNS

With effective teams, every member is fully communicating with every other team member. The word "team" is defined as full mesh network communications (at least for this paper). This full-mesh communication is particularly noticeable in a sports team that is "in the zone." Each team member has an understanding of overall strategy and tactics. Each member is fully aware of each other and the whole team seems to flow like a single unified organism. While someone may call the play and players may take their key off different players at different times, there is no traditional leader and the dominant communication pattern is peer-peer.



The traditional problem solving group is not a team in that it displays a dominantly hierarchical or star network communication pattern. Robert Oppenheimer and the Manhattan Project is an archetypical example. The group is led by a technical group leader who derives his/her authority from a fundamentally sound grasp of the whole problem. While there may be sub-networks, the primary communication pattern is between group members and the leader. The leader makes decisions and controls content and process. Integration occurs in the mind of the leader. The group serves as an extension of the leader's capability. The counterpoint is that the group is limited by the leader's capabilities and biases.

By the full mesh definition many small groups that are called teams are really workgroups because the dominant communication mode is star network, hierarchical, rather than full mesh. Interdisciplinary process teams and many traditional Tiger Teams are examples. With other teams communications patterns switch back and forth between full mesh and star. SWAT teams and surgical teams are examples.



Brainstorming groups exhibit a dual communication pattern. Each member is in complete and intense communication with each other. Content communication is full mesh network. However, in this case there is an orchestrator, a content neutral facilitator. The facilitator's task is to manage process (not content) with a star network hierarchical pattern suggested by the dashed lines. The facilitator plays an important role in enabling the intense and complete communication. The facilitator manages process not content and is not a content participant.

The dual network consists of a full mesh content network overlaid by a simultaneous star process network. A dual network can be achieved by splitting the leadership role into content and process. This allows us to overcome the biases and capability limitations of traditional content group leaders as well as incorporating expert process skills. The dual network is a model for Modern Tiger Team communications.

LEADERSHIP

Leadership is critical to the performance of any team. Typical responsibilities are to establish a clear set of goals, select formats, agendas and methods for achieving those goals, select and motivate participants, manage administrative details, orchestrate the process, assist the team in overcoming process dysfunctions, assist the team in overcoming content obstructions, guide the team to a conclusion, and see to it that the conclusion is executed. Modern Tiger Teams stress this leadership role because the team purpose is problem-solving, the content is multi-disciplinary and esoteric, and the process parameters are more sophisticated.

Traditional group leader

The traditional group leader manages both process and content. Since content judgments are so critical to a successful outcome, the group leader's authority is derived from her grasp of content. The primary leadership requirement is that participants respect the leader's content judgement, trusting that the leader will make the right decisions. Somewhere along the line the leader acquires sufficient people skills to motivate egos and manage process.

Managing both process and content introduces an inherent conflict in the traditional group leader role. By managing process, content leaders inevitably introduce their own personal biases into the team products. Leaders can and should be active participants, but, their status within the group results in undue influence. Bias is not a serious issue when the primary purpose of the team is

coordination. Bias becomes a serious issue when the purpose of the team is problem-solving.

Traditional group leaders cannot be expert in everything. The first priority is that they be respected expert generalists. They do not have the time to be particularly skilled at mapping appropriate problem-solving heuristics, small group dynamics, teamwork and the nuances of meeting formats. As a result, high level teams are susceptible to the classic dysfunctions of small groups (dominated by authority figures, minority view not heard, premature solutions, groupthink, focus drift...). These classic dysfunctions are failures in leadership.

It is also stressful for one person to manage a high intensity team for an extended period of time. To keep the intensity and performance high, more than one person should be involved.

Traditional group leaders must be exceptionally talented individuals. Modern Tiger Teams place an increasing demand on the team leadership role, beyond what we can reasonably expect from one individual. To optimize performance with short term high intensity teams, we need to experiment with new leadership forms.

Coach

One successful model that could be used for Modern Tiger Team leadership is that of a team coach. The Modern Tiger Team coach would be a process expert familiar with the content culture. The coach is a content neutral advisor who works off line with the leader and participants providing advice on tools, skills, planning and processes. The traditional group leader remains in control and continues to be responsible for both content and process, the coach serves as an advisor only.

The coaching model has limits. The traditional group leader can still introduce bias because s/he still performs the conflicting roles of managing the meeting and participating. Even with coaching s/he still may have difficulty dealing with process and interpersonal issues.

Split client/referee leadership

Another successful leadership model is to split the leadership role into content and process. We call this the client/referee form. The client "owns the problem" in that she has primary responsibility for the outcome. The client participates in content discussion, holds content opinions and manages content direction indirectly, through the referee. The referee is a facilitator, trained in small group process, content neutral, and has a content culture background. (A referee is a culturally aware facilitator, see next paragraph.) The referee stands at the front of the room with the chalk managing the group. This form has the distinct advantage of enabling the client to manage outside of his/her personal skill base. The referee can be selected to balance the client's skills.

This client/referee model has shown excellent success with client/facilitator brainstorming groups and with creative problem-solving groups.[62] The client/facilitator model breaks down when the content becomes esoteric and the facilitator no longer understands syntax and semantics. A facilitator must understand the language. (For example, a facilitator who does not understand Chinese cannot

facilitate a group speaking in Chinese.) We can overcome these limits by introducing a referee that is a content and culturally aware facilitator.

The client/referee leadership model works very well for high intensity short term problem-solving groups, like Modern Tiger Teams. More than one person can keep the intensity high. It would be difficult to sustain for extended periods of time.

Split client/peer leadership

A practical approximation to the client/referee model is for the group leader to designate a peer to manage the process and make it clear that the peer is to deliberately adopt a content neutral position. J. D. Rockefeller used this approach managing the Standard Oil Company.[63] It allows the leader to sit back and focus on content rather than the process of managing the meeting.

Multiple content leaders

We defined leader as the individual who "owns the content," in the sense of being responsible for producing results and execution. With some projects, like basic science teams, there may be no one person. Every participant may have an equally vested interest and there is no dominant leader. The client/referee leadership model can still be used, though the referee needs to balance the demands of multiple content leaders.

ENVIRONMENT

The main requirement is to eliminate distractions enabling the group to focus. This could be accomplished by sequestering the group off site which also reinforces the importance of the task. If the emphasis is on solution finding, an informal "living room" environment (coffee tables, couches, chairs with arms) is more conducive to playing with ideas than a traditional formal conference room. Passive observers sap energy and should be avoided. Suitable A/V equipment, internet links and note keeping services should be provided.

TIGER TEAM CASE STUDIES

In this section we derive lessons learned from classical Tiger Teams. The Cuban Missile Crisis and Apollo 13 provide examples of successful teams. The space shuttle Columbia provides a failed example.

CUBAN MISSILE CRISIS

On October 16, 1962 John F. Kennedy was notified that the Soviet Union was installing nuclear ballistic missiles in Cuba. Immediately after the CIA briefing he setup EXCOM, the executive committee of the National Security Council, to find solutions. The Cuban Missile Crisis is well documented by the Kennedy tapes,[64] conferences[65] and many personal memoirs.

The EXCOM core group was carefully selected to include key players who also qualified as trusted advisors. It consisted of 14 members: some senior cabinet members, military, low level staff and outside advisors. There were several floaters. Group selection was superb. For the next 13 days the EXCOM group wrestled continuously with how to resolve the crisis.

Robert Kennedy said the EXCOM had no leader, no coordinator.[66] In fact RFK was a nominal coordinator reporting back to his brother and tasked to drive the group to reach a consensus. However, his team coordination role was weak and EXCOM exhibited a number of dysfunctions.

- While the conflict among members was always uninhibited, it was not always impersonal or constructive.
- EXCOM never did conduct a disciplined search for solutions.
- The process was undisciplined, participants were distracted, people coming and going bypassing the group to directly lobby the president.

On the positive side:

- The conflict was intense uninhibited open and honest. Commitment was extreme. People said what they thought, even if it was unkind.
- Questionable interpersonal trust was balanced by unquestionable loyalty, there were no leaks.
- The ability to debate without media pressure was invaluable.

From the problem-solving perspective there was a deep ideological split between the hawks and the doves. (This was the origin of the hawks and doves sobriquet.) They eventually reconciled this split using a Delphi approach. Each side wrote a position paper. These papers were exchanged back and forth, attacked and defended. It seemed that this technique was ad hoc, invented by the team. Eventually, the hawks realized that they did not need to bomb immediately. The group also synthesized a rather creative final solution.

EXCOM began its deliberations without JFK. His involvement in the debate increased with time.

Towards the end he was a full fledged participant and witnessed the nuances of the give and take between the hawks and doves. While JFK demanded a consensus, when the consensus was weak, he was the clear decision maker. He learned his lessons from the Bay of Pigs and did not repeat those groupthink errors. In the final analysis JFK made no serious errors in judgment about Soviet intentions.

EXCOM is an excellent Tiger Team case Study because there were no good solutions to the crisis. Every potential solution had serious risks and flaws. Throughout the crisis, no one maintained a consistent opinion. Group selection and the uninhibited constructive conflict was superb.

APOLLO 13

On April 13, 1970, the Apollo 13 spacecraft experienced a ruptured oxygen tank that ended its mission to put men on the moon and jeopardized the safe return of the astronauts.[67] [68] During the subsequent five days, the press invented the sobriquet Tiger Team to refer to the mission controllers tasked to figure out how to safely return the astronauts. The spectacular success of the Apollo 13 Tiger Team resulted in the sobriquet Tiger Team becoming part of our lexicon.

For Apollo 13, NASA had about 100 mission controllers divided into four teams: White, Black, Maroon and Gold. Gene Kranz was the overall lead flight director for Apollo 13 and also the White Team director. White team was on deck when the incident occurred and was taken off line after the event to solve the problem. The White Team was subsequently augmented by other senior controllers and outsiders and grew to about 40 people. The White team took charge during critical mission phases: mid course correction maneuvers and reentry.

Fourteen minutes after the incident, the problem was diagnosed. From that point forward, the controllers were well trained to find solutions. The task was to develop a new flight plan that was verified by the simulators. They all developed many flight plans in the past. The main difference was that while the task normally took three months, it now had to be done in three days with many serious and unique constraints and obstructions.

The NASA management culture was loosely based on a military teamwork model. Senior man decides, no voting or consensus. This hierarchical culture extended into the Tiger Team where Kranz dominated the team and made all key decisions. While he strove for a consensus, if it failed to emerge quickly, he would make the decision. Kranz designated three lead controllers and most of the work was channeled through them. During the latter stages of the effort, 40 people were working in subgroups and Kranz would move from group to group making sure everyone was pulling in the same direction.

In spite of the command and control architecture, the team did exhibit some simultaneous centralized/decentralized operations. People at lower levels would anticipate something that needed to be done and they took the initiative to do it. Decision making was centralized, one major decision, direct abort or free return trajectory, was clearly made by Kranz. The four flight directors failed to

reach a consensus by 3:1.

All of the controllers understood teamwork in the sense of coordination. In the military style, they had a clear sense of goals and were very sensitive to how their contribution fit withing the overall structure. By Lencioni's team evaluation,[69] the Apollo 13 Tiger Team scored exceptionably high on conflict, commitment and accountability, but low on trust.

The weakness in the Apollo 13 Tiger Team was trust. They were not comfortable with interpersonal relationships and they did not always feel they were being told the full story. With military teams, trust is not derived from interpersonal relations but from a strong code of conduct supported by a common subculture. Military style teams in a NASA culture with weaker code of conduct raises problems. Kranz worried that if he left the scene, senior management may overrule a prior decision with a dumb move. Exceptional commitment overcame limited mutual trust

The Apollo 13 controllers were a Tiger Team because they had no fear of constructive conflict. They succeeded because they were well trained to solve the problem. The need for quick decisions justified the command and control management style. The potential weakness in this style was overcome by Mr. Kranz's exceptional skill and judgement.

SPACE SHUTTLE COLUMBIA

On February 1, 2003 the Space Shuttle Columbia was lost during reentry. A subsequent investigation by the Columbia Accident Investigation Board (CAIB) concluded that the loss was a direct result of a breach in the thermal protection system caused by a foam strike that occurred 81.7 seconds after liftoff.[70] CAIB concluded that this was not an anomalous event but was rooted in NASA's management history and culture.

Key decisions were made by the Mission Management Team (MMT). This team had weak leadership with the whole basket of the classical dysfunctions of small groups. It was dominated by authority figures (a Thermal Protection System expert); minority views were not heard (the Debris Assessment Team); they reached premature conclusions ("why bother looking for damage if there is nothing we can do about it"), they suffered from groupthink (no debate or critical thinking), dissent and conflicting views were discouraged... However, the MMT was not a Tiger Team and this paper is about Tiger Teams. The following case study presents the view that the Debris Assessment Team (which was a Tiger Team) should have prompted a rescue effort in spite of the MMT's dysfunctions.

The foam strike was first noticed on Flight Day 2 by NASA's Intercenter Photo Working Group. They were unable to assess potential damage. Recognizing that they had never seen such a large strike so late in the launch, the Intercenter Photo Working Group immediately documented the event sending video clips to NASA and the contractor community and requested supplemental imagery.

There are a variety of assets outside of NASA that could photograph the shuttle in orbit with high resolution. During the Columbia's 17 day mission three separate requests for imagery were rejected

by the MMT. The key question is why, what failed? In retrospect, good timely imagery should have revealed the damage and prompted some sort of rescue effort.

On Day 2, immediately after the foam strike was noted by the Intercenter Photo Working Group, engineers from NASA and United Space Alliance (the contractors) assembled a Debris Assessment Team (DAT). This team spanned horizontal organization boundaries and consisted of the right engineers working on the right problem at the right time. But, they never presented a simple compelling case for imagery. Like most troubled projects, a simple compelling case existed but was unseen by the group.[71] It was: *Potential damage is proportional to the kinetic energy of the strike. The observed event had a kinetic energy 31 times greater than its largest predecessor. Analysis is useless because our models have never been validated in this range. We need imagery to assess damage.* The data analysis necessary to make this calculation was available on day 5.

The DAT was not successful pushing back against mission manager's reluctance to hear bad news. **The fundamental flaw was that the DAT did not transcend hierarchy.** No mission manager "owned" the products of the DAT. Without senior management participation, DAT members had no confidence, no strength behind their convictions. There was no nexus, key expert consultants did not participate and provided conflicting advice that was flat out wrong. The team felt they were being whipsawed by events beyond their control. No one had a helicopter view of NASA politics. They made poor choices trying to express themselves and influence NASA. They did not appreciate the need for a simple compelling argument. Eventually, they began to believe their own models.

CAIB correctly points out that effective high-reliability organizations have the ability to simultaneously operate in a both a centralized and decentralized manner.[72] NASA failed because the decentralized mode did not transcend hierarchy. DAT was horizontally but not vertically decentralized.

MODERN TIGER TEAMS

The past 50 years have seen gradual but substantial progress in many disciplines that support the Tiger Team concept: our understanding of cognitive processes,[73] rational problem-solving,[74,75] creativity[76] and creative problem-solving,[77] small group processes[78] and small group communications.[79] The past decade we have seen particularly dramatic progress as modern small group processes have been adopted by business as advanced teamwork.[80,81]

Unfortunately these powerful supporting disciplines remain fragmented independent specialities and have not been integrated to provide effective problem-solving tools. For example, teamwork advocates incorrectly assume that an effective team knows how to solve problems. This may be true for simple problems but falls quite short with anything deep or complex. Team problem-solving requires an explicit understanding of the problem-solving process. The construction of the team and the optimal leadership structure strongly depends on the nature of the problem and the duration of the task.

CHARACTERISTICS

Modern Tiger Teams integrate advanced teamwork with total problem-solving under the concept of a temporary, focused, small group of experts. The focus is on managing people to solve a broad range of problem types rather than relying on individual expert problem solvers.

Integration

The reason the integration of total problem-solving and advanced teamwork has not occurred lies in the ad hoc "crisis" nature of traditional Tiger Teams. In a crisis, managers desperately cobble together bits and pieces into a specific Tiger Team as circumstances demand and happenstance permits. Lessons learned from this experience are then lost as the problem is resolved and the team dispersed. The net result is that the traditional Tiger Team concept remains primitive and unchanged while powerful supporting disciplines continue to evolve as independent specialities.

Total problem-solving

People learn problem-solving intuitively, as apprentices, and tend to be skilled at a narrow range of problem types. Team problem-solving requires an explicit understanding of the whole process so that the team can be orchestrated through a definite sequence of steps and heuristics.

Total problem-solving proceeds through a two step sequence: problem definition followed by solution finding. Each step has its own heuristics and people tend to be skilled at one or the other of these two steps. Constructing a team provides the freedom to combine appropriate skills.

Advanced teamwork

Advanced teamwork for Modern Tiger Teams consists of extrapolating traditional teamwork tools to temporary (days), intensely managed, problem-solving teams. There are a number of factors that are particularly important.

- **Constructive conflict** - the reconciliation of strongly held opposing points of view is the core performance element for Modern Tiger Teams.
- **Optimum team size** - There is an optimum size to a Modern Tiger Team.
- **Carefully selected participants** - It is the people who solve the problem. The art is to pack as much talent as possible into a limited size team.
- **Split Leadership** - Splitting the leadership into content and neutral process eliminates bias and can improve the overall quality of leadership. There are several ways to accomplish this.

PRACTICAL POTENTIAL[82]

Modern Tiger Teams offer a number of advantages over traditional problem-solving approaches. Perhaps the main advantage is **exceptional inductive reasoning** - the big picture - the ability to discover general or overarching principles given an assortment of specific multi-disciplinary instances. Inductive reasoning demands an in-depth grasp of all aspects and nuances of the problem (provided by the balanced expert group), plus, the ability to integrate this information into an elegant conceptual whole (provided by advanced teamwork and total problem-solving heuristics).

Drawing on modern problem-solving heuristics allows the team to attack deep structural or conceptual problems that may be beyond the capacity of traditional Tiger Teams and even gifted individuals. Employing advanced teamwork tools improves coordination and the intellectual horsepower without the external stimulation of a crisis. Modern Tiger Teams can improve performance and reliability of traditional Tiger Teams as well as provide exceptional problem-solving performance for low profile everyday problems.

There are several reasons why managers may want to establish a Modern Tiger Team:

Difficult problems

Difficult problems are often characterized by persistent anomalies, inconsistencies in our knowledge base. We know that a solution exists but we have not been able to find it or build a consensus to focus on it. For example:

- In the business world this could be basic strategy i.e. a traditional long distance communications carrier is confronted with the Internet and needs a new strategy to evolve and grow.
- In basic science an example is the inconsistency between quantum mechanics and general relativity. For 75 years scientists have been unable to reconcile the two.
- In the political arena we are confronted with the inevitability of a global economy. What are the

mega-forces and what strategies can nation states use to best position themselves for a healthy future.

Unexpected disruptions

Case studies show that during unexpected disruptions and crisis, solutions usually exist that are not seen by the players. Traditional Tiger Teams have been successful resolving crisis - solving difficult problems under time constraints. Modern Tiger Team tools should increase problem-solving performance as well as provide more reliable and predictable crisis management.

Modern Tiger Teams can also provide exceptional problem-solving performance for low profile everyday problems. Scope changes, schedule slips, cost overrun, or technical surprises inevitably disrupt projects. Money is burning and commitments have been made - the situation demands that the disruption be controlled quickly. From this perspective Modern Tiger Teams can be viewed as a form of reactive risk management.[83]

Synthesizing new system concepts

Brainstorming groups and creative problem-solving groups have a clear track record for successfully developing new ideas. Modern Tiger Teams extends this application to architecting unprecedented complex system concepts[84] – feasible problem-solution pairs. It provides a method to look outside the box and conduct a disciplined search for multi-disciplinary solutions. Proposal work is one application, another is project synthesis, conceptualizing the project, a small team allocating requirements, developing work breakdown structures, schedules etc. Another application is synthesizing enterprise architecture, integrating business process with information technology.

Spanning organizational boundaries

The Space Shuttle Columbia case study showed that when a hierarchical organization is confronted with an unexpected disruption, the competence necessary to solve the problem may reside at different places in the organization. Modern Tiger Teams provides a mechanism to effectively span the vertical hierarchical boundaries (e.g. incorporate your boss in the meeting) as well as horizontal boundaries (e.g. educating client representatives about project realities, turbo-charging and motivating subcontractors) Modern Tiger Teams could aid in integrating outside expert opinion – content/process skills not normally resident in the project team.

Critical point decisions

A close corollary to crisis disruptions are organizations and projects that have reached a critical point, a strategic inflection point.[85] Modern Tiger Teams offer superior reliable judgments that can be useful for making key decisions. The ability to synthesize a helicopter view among an expert group can be most important.

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