UNIFIED

STRUCTURED

INVENTIVE

THINKING

AN OVERVIEW

eBook by

Ed Sickafus, PhD

Ntelleck, LLC

Unified Structured Inventive Thinking – an Overview

by

Ed. Sickafus

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By Ed. N. Sickafus

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WITH GRATITUDE

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OCTOBER 2001

Author biographical sketch

Dr. Ed Sickafus, President, Ntelleck, LLC, is an inventor, industrial scientist, teacher, author, and puzzle enthusiast. His industrial manufacturing experience covers steel casements, aluminum aircraft components, automotive, and ordnance. His industrial research covers air bearings, molecular pumps, and design and modeling of miniature sensors and actuators. His basic research studies in condensed matter physics include internal friction, growth morphologies of layered-structure crystals, microcalorimetry, mechanical and electrical properties of crystalline whiskers, electron scattering from surfaces of atomically clean metals, and secondary-electron spectroscopes. His industrial positions include senior staff scientist, manager of research departments, and corporate technical specialist.

He received his PhD degree in physics from the University of Virginia and honorary PD degree from the University of Missouri – Rolla.

He taught physics and engineering courses at the University of Denver before joining the research staff of Ford Motor Company. He has published over 70 scientific papers and articles on a wide range of topics. He has taught courses, given lectures and invited seminars on his research world wide; including special programs and lecture tours in Spain, Brazil, Mexico, Australia, Canada, England, Germany, Liechtenstein, Israel, Japan, China and South Korea. He holds ten patents and has numerous invention disclosures.

Ed. held positions of Associate Professor in the Physics Department of the University of Denver, Acting Head of the Physics Division of the Denver Research Institute, Manager of the Miniature Sensors and Actuators Department and the Physics Department of the Ford Motor Company's Research Laboratory, Senior Staff Scientist in the Automotive Components Division, and leader of a team of SIT experts charged with the application of SIT methodology worldwide in the Ford Motor Company.

His professional society experiences include former president of the American Vacuum Society, member of the governing board of the American Institute of Physics, and member of various society committees. He was a member of the Industrial Advisory Board of the Berkeley Sensors and Actuators Center at the University of California – Berkeley.

In 1995 he initiated the Structured Inventive Thinking training program in the Ford Motor Company and led its further development. Since retiring from Ford Motor Company, Ed. has started Ntelleck, LLC to bring USIT to non-Ford interests (with Ford's permission).

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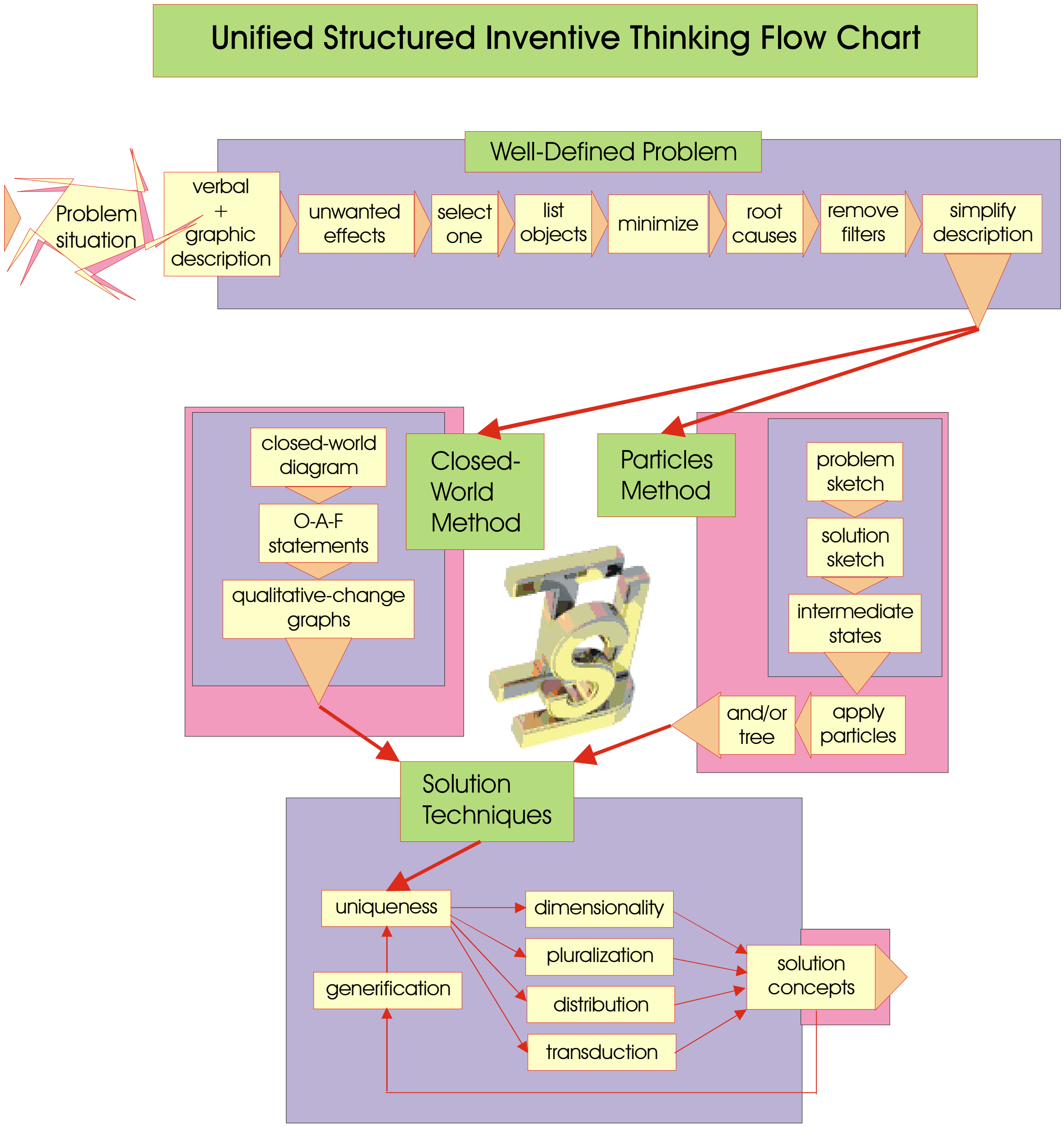

Unified Structured Inventive Thinking Flow Chart
Well-Defined Problem
Problem situation
verbal + graphic description
unwanted effects
select one
list objects
minimize
root causes
remove filters
simplify description
closed-world diagram
O-A-F statements
qualitative-change graphs
Closed-World Method
Particles Method
problem sketch
solution sketch
intermediate states
apply particles
and/or tree
Solution Techniques
uniqueness
dimensionality
pluralization
distribution
transduction
generification
solution concepts

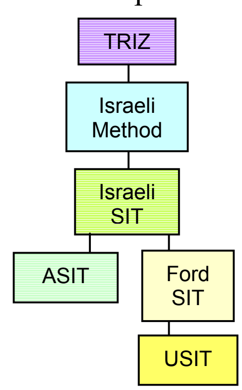
Chapter I. Introduction

Few intellectual experiences are as rewarding as innovative problem solving. Where puzzles typically challenge the problem solver to find a particular known solution, innovative problem solving challenges the problem solver to discover territory in solution space not previously visited. The goal of this challenge is to find multiple solution concepts, as many as possible, as quickly as possible and involving as much innovation as possible. Hit-or-miss, open-ended-type brainstorming may find some interesting concepts but is wholly inadequate for expansive and thorough searches. To this end, one needs the aid of a logically structured methodology. Unified structured inventive thinking (USIT) has been developed, and proven in industry, to assist the problem solver in problem definition and analysis, and then in the application of specific solution techniques for broad, in-depth searches of solution concepts. It is based on a small set of unifying components (objects, attributes and functions) joined logically and applied consistently from problem definition, through its analysis and the application of solution techniques.

This book compliments the textbook, "Unified Structured Inventive Thinking – How to Invent".[1] An overview of USIT is presented here with explanations of tools described in depth in the textbook and tools developed since publication of the textbook. While the full scope of USIT is presented here, examples, exercises, demonstrations, and discussions of details are rather limited. Supplemental materials of these types are available in the textbook and on the web.[1, 3]

1. Historical notes

The history of USIT, with its dependence on the Israeli systematic inventive thinking method (now called ASIT) and TRIZ, is explained in the textbook and not repeated here. The Israeli goals of simplifying TRIZ and freeing the problem solver of data bases and cue cards bearing essential tabulated data has been continued in USIT. It is worth noting that some differences in the original Israeli SIT method and USIT exist. These arose mostly from a different motivation. USIT has additional tools, some reorganization, a unifying theory and new strategies needed to optimize its adaptation in modern automotive manufacturing. These needs were not obvious at first but became evident as the method was introduced and taught to monthly classes of corporate engineers, scientists and management personnel. This adaptation has proven to be quite general and not limited to automotive-type problems.



Modifications introduced in USIT that address corporate needs include

- simplicity for ease of learning and applying the method,
- a unifying theory based on objects, attributes and functions,
- thinking-aid models,
- a plausible root-causes tool,

- uniqueness as a problem-solving tool,
- emphasis on generification and conceptual solutions to aid understanding fundamental phenomenology of a problem, and
- considerable elaboration of the problem definition process.

Of major concern was that the methodology should prove itself capable through cogent deliverables. Hence, the methodology is organized and taught with demands

- to achieve viable focus .... for relevance
- to produce multiple solution concepts .... for options
- to produce results quickly .... for efficiency
- to accommodate individual and group usage .... for a corporate tool
- to produce innovative concepts .... for intellectual property

My experience with teaching and applying structured inventive thinking in Ford Motor Company had a strong influence on establishing and proving these capabilities. This environment included teaching of monthly three-day courses, leading weekly user-group meetings, and participating in daily team exercises applying the methodology to corporate problems worldwide.

2. Contents of this overview

How to think about USIT when learning it and applying it is explained. It is a discipline to guide the analyst through a thorough analysis while generating new perspectives of a problem and sparking solution concepts from its beginning to its end.

Brief definitions of the key elements of USIT are discussed – objects, attributes and the functions they support. All of the tools and procedures in USIT are based on these three elements.

Two thinking-aid-type models have been developed to aid the understanding of problem situations and the role and mental application of USIT. These are discussed to introduce the reader to the philosophy of USIT. One is an object-attribute-function contact-model and the other is a mental-feedback model.

The USIT flow chart is examined before delving into its various components. Students are encouraged to practice sketching the appropriate sections of the flow chart as a problem is analyzed. This quickly engrains the structure on one's mind and eliminates any need for cue cards or other tabulated data and strategies.

Industrial experience has underscored the dire need of ability to define a problem. Most technologists pay lip service to this universal step in problem solving without investing time or effort to it. Consequently, much time is wasted in attempting to start a problem-solving session or the effort may even be abandoned out of frustration. Experience shows that a third or more, sometimes much more, of an analyst's time on a given problem can be spent on the problem's search and definition. In USIT a considerable effort is spent teaching how to construct efficiently a well-defined problem.

Once defined, a problem is ready for analysis. The first of two problem analysis paths is the closed-world method. Here the analyst initially views, not the problem situation, but the original design from the perspective of a properly working system, made up of objects in contact, and then delves into its misbehavior. By contrast, the second problem analysis path, the particles method, views the problem from an ideally functioning solution and then works back to the existing malfunctioning situation. Both of these approaches are carried over from the Israeli's work.

Both methods of analysis produce innovative thinking under constrained conditions of a minimum set of objects – a non-intuitive concept. The analyst is encouraged to develop solution concepts all through the analysis procedures.

Following problem analysis, six solution techniques are examined. These include

- uniqueness – spatial/temporal characteristics of functions,
- dimensionality – activation/deactivation of attributes,
- pluralization – multiplication/division of objects,
- distribution – rearrangement of functions,
- transduction – attribute-function-attribute links and
- generification – solution templates from known solutions.

Each technique focuses on objects, attributes, and functions, or their combinations, in various well-defined ways. The somewhat cumbersome titles (at first sight) were selected as cues to the techniques they denote.

The book closes with references to sources of other relevant materials.

3. Acknowledgements

I am grateful to Dr. C. H. Stephan, my friend and former colleague in teaching structured inventive thinking in Ford Motor Company. Our many discussions and experiences shared in the monthly classes at Ford were always thought provoking and constructive. Dr. Stephan continues to teach the classes since my retirement.

I am also grateful to the more than one thousand students both within and external to Ford Motor Company who shared their ideas and experiences with the methodology and helped lead to its deeper understanding.

Span of USIT

Problem **situation**
… usually begins (unfortunately) with a convolution of several unclear unwanted effects requiring time and effort to sort out.

Problem **definition**
… identifies a single unwanted effect, reduces it to a minimal set of objects, and removes all filters.

Problem **analysis**
… uses structured processes for creating new and unusual vantage points from which to view a problem.

Problem **solution**
… applies formal techniques focused on **objects**, *attributes*, and <u>functions</u>.

Chapter II. How to think about USIT

Since USIT was motivated by industrial needs, it is useful to understand its intent in this environment in order best to appreciate its capability.

Most important is that industrial technologists who come to USIT classes are already accomplished engineers and scientists. Many are inventors attested by their patent holdings. They are problem solvers adept and ingrained in conventional engineering tools. Consequently, USIT is designed to be an auxiliary tool and not to replace existing (proven) methodologies. And so, this is important, it takes an unconventional approach to problem solving in order to bring new concepts to the process. This puts noticeable stress on those new to USIT as they begrudgingly release their grip on old ways of thinking about problem analysis.

Students of USIT are encouraged to apply their conventional problem solving expertise before resorting to USIT; after all, they should be more efficient with the more familiar. Subsequent discovery of new solution concepts assures a greater confidence in the USIT methodology.

USIT promises unusual perspectives of a problem situation in order to discover insights others have overlooked. Unusual perspectives derive from unconventional thinking. Therefore, a student claiming to be learning or applying USIT, but using conventional analysis methods, fools him or herself and is wasting company time and money. The way to think about USIT is to set aside all other tools while applying USIT and let its structure lead you in a disciplined way to new vistas and inspirations.

Especially important is to recognize that problem-solving methodologies do not *give* solutions. The problem solver must *discover* solution concepts and then *engineer* working solutions -- KEEP THESE SEPARATED. What a problem-solving methodology does is to show the way through solution space while generating new perspectives and sparking innovative thinking. Solution concepts come to mind from the beginning of USIT application, throughout its structure, to its termination. Therefore, make every step of your procedure pay off. Solution concepts should be expected at each turn of one’s thinking process.

It is a tacit assumption of USIT that thinking is sparked by the metaphorical impact of written and spoken words as well as sketches, photographs and hardware. Throughout a USIT exercise the analyst is encouraged to write words and make sketches. As new depth is achieved in a problem these metaphors should be modified appropriately. The action of speaking, writing and sketching causes the mind to halt a moment and commit to an instantaneous state of imagery. This imagery anchors one’s focus until modification to a new anchor point is justified.

To the novice, USIT may seem to have intimidating writing, sketching, graphing and tree structures to be constructed, as evidenced by the elaborate figures in the text. In practice, the accomplished practitioner makes quick and simple notes and sketches that satisfy each of the tools. That is, all of the USIT tools are exercised, because it is this mental process of committing images to paper that creates focus and clarifies thinking, but they are not done in any elaborate fashion. Both speed and thoroughness are desirable.

Unified structured inventive thinking is a thorough search for solution concepts. A solution concept, derived from an analysis stripped of metrics, is intended to address fundamentals of physics, chemistry, biology and mathematics. Solution concepts resolve unwanted effects at their basic phenomenological level. This is the pre-engineering phase of problem solving. After the USIT procedure, an appropriate concept must be selected and engineered to produce a final working solution that accommodates all required specifications.

Students sometimes worry whether a particular USIT analysis they have created is “correct”, and how do they find out. The best answer is, “Did it cause you to think and find new solution concepts?” There is no right or wrong here, but only degrees of effectiveness. It’s something like mathematics. When given a mathematics problem to work, you don’t need the answer. Using mathematical reasoning you can test your solution’s validity for yourself – which process often presents other interesting challenges.

A most important view of USIT is as an effective and efficient (easily applied) problem-solving methodology. This is beginning to sound like so much repetition. But there is a message here that is not caught by the novice who raises the question in every USIT class, “but doesn’t that concept cause another problem?” This usually arises when the concepts of a minimum set of objects, and a closed world, are introduced. Engineers trained to do (or at least think of) comprehensive system analyses may be uncomfortable with restricted thinking. The answer is, “Maybe, but so what? If it does, we now have the tools to address it efficiently.”

Chapter III. Definitions

The basic components of a USIT analysis are objects, attributes and the functions* they support.

1. Object

An object exists of itself and can make contact with another object whereby they can support a function. An unusual object, but a useful one, is **information**.

Object examples

Examples of objects include a **ball**, a **motor** (an assembly of objects is a compound object), a **windshield-wiper blade**, **hinge**, **water**, a **fish** and **information** (e.g., an electrical signal from a **sensor**).

Non-objects include a hole, heat, weight (gravitational force), magnetic field, color and others. These non-object examples are actually *attributes* of objects.

2. *Attribute*

Attributes characterize or distinguish objects. Attributes can exist throughout an object or be localized within it. They are properties described by certain general words. Metrics, or quantifiers, are not allowed as attributes, since USIT strips all problems of numbers, specifications, dimensions, etc.

***Attribute* examples**

Attributes include *shape*, *elasticity*, *color*, *weight*, and *internal energy* among others.

Metrics (i.e., non-attributes) include red (quantifies color), 20 pounds (quantifies weight), 5^{o} Celsius and 12.4 inches among others.

3. <u>Function</u>

Functions modify or prevent modification of attributes.

<u>Function</u> examples

Functions include <u>to change</u> *elevation*, <u>to modify</u> *constants*, <u>to fix</u> *position*, <u>to react</u> *force*, <u>to change</u> *color*, <u>to increase</u> *heat content*, and other actions (while learning they are best worded as infinitives).

(*) **Objects** (**O**), *attributes* (*A*) and <u>functions</u> (<u>F</u>) are sometimes distinguished with bold, italic, and underscored fonts respectively.

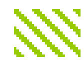
4. “Contact”

Objects make “contact” with each other to influence their attributes. Physical contact is the most obvious form of contact of physical objects. Contact can also occur through the influence of a field of one object on an attribute of another. The region of contact should be treated as a point unless area of contact is an active attribute.

5. Visualization aids

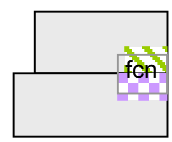
An object can be sketched as a definite outline with indefinite color or pattern.

An attribute can be represented as a color or pattern without an outline.



The combination of these two sketches represents an object with a locally active attribute.

At the point of contact of two objects active attributes support a function (labeled “fcn” in the sketch).



6. Active attributes

Of the many attributes an object may have, only those supporting a function in use are considered to be “active”. Only active attributes characterize an object. Hence, if for example, a chair and a ball have only their respective masses as active attributes, they are equivalent objects because they have no distinguishing active attributes.

Chapter IV. Thinking-aid models

The two models described here are simple, rather intuitive concepts. One emphasizes contact between two objects as a point of focus. The other depicts the rapid process (mostly unconscious) by which we do mental trial-and-error comparisons, testing each concept derived from past experience and instantaneously growing our past experience.

1. The O-A-F contact model

A simple graphic is used to illustrate the contact concept in terms of objects, attributes and functions, as illustrated in Fig. (1).

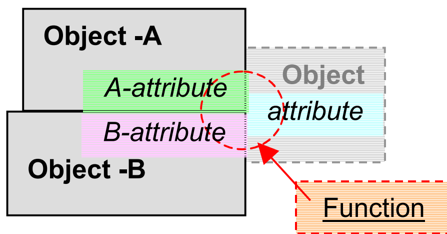


Figure 1. Two objects, A and B, make contact to support a function through an attribute of each. The function modifies or prevents modification of an attribute of an object, A or B or another object.

This model aids the analyst to appreciate focusing on the point of contact of two objects and to identify active attributes at that contact.

2. The electronic feedback model

A common phenomenon of problem solving is a technologist's unconscious and instantaneous mental reaction upon encountering a problem – we try to solve it. The unconsciousness of the act is as though problems somehow unbalance our mental calm and our brains react automatically to resolve the problem and restore a peaceful balance. The seeming spontaneity of our mental processes during problem solving is rather astounding. Many times answers come to the fore of our conscious so quickly that we are unaware of any effort being expended to find them. At other times protracted efforts are required.

Another aspect of the mental process of problem solving, one we can know by introspection, is that most often we solve problems by comparing a given situation with our past experience. As we ponder the problem situation a solution concept comes to mind (from past experience). This is compared with details of the problem to test its viability. If acceptable the problem is solved. If not, we modify the concept and test it again, or we resume our pondering until another concept reaches our conscious. Note that intermediate iterations, ones that produce inadequate concepts, instantaneously imprint the concept and its modification onto our past experience. Hence, past experience is referred to here as dynamic experience – it grows as we exercise it while thinking about a problem.

A third aspect of problem solving is one we may not be so aware of without consciously examining a specific solution procedure. This aspect occurs when we discover a generated concept is not satisfactory, instead of modifying the concept we challenge the problem. This is an extremely important step in problem solving. It is the best way to motivate improvement of problem definition.

An electronic feedback-circuit model can be used to capture these aspects of the mental problem-solving process and others. Such a circuit has the inverted output of an amplifier fed back to its differential input. This modifies the original input signal and forces the output toward zero – a balanced state. The inherent speed of an electronic feedback loop, as it cycles to smaller and smaller imbalance, represents the spontaneity aspect of mental solution-concept generation.

It is the nature of a feedback operational-amplifier circuit to shift its output towards zero, a state of balance. In a feedback circuit two input signals are compared at a summing junction. Their difference is examined for balance, inverted, amplified, and feed back (as an "error signal") to the input to bias it toward a balanced state. The larger the imbalance (error) the larger is the feedback correction, the smaller the imbalance the less correction is required. Our model is shown in Fig. (2). Here two input signals enter a summing junction: one is the problem and the other is the trial solution-concept proffered by our subconscious. If their difference is zero a viable solution has been found. If it is not, the difference is feedback for the next try. In this case, the difference can occur in either of two feedback loops: one involves modification of the inadequate trial concept; the other involves modification of the problem.

This feedback model emphasizes several important features of problem solving.

- First, note that the input representing the problem can derive at any level of the problem definition (from original problem statement to unwanted effect, objects, attributes, functions and the metaphors generated by these).
- Second, our mental past experience is changing dynamically all during the problem-solving process.
- Third, two options exist for feedback information: one is a modified trial concept, and the second is modification of the problem.
- Fourth, looping in a feedback mode is suggestive of making incremental changes in test concepts.
- Fifth, another feature is the inherent speed of the feedback circuit – a feature inaccessible to our conscious.

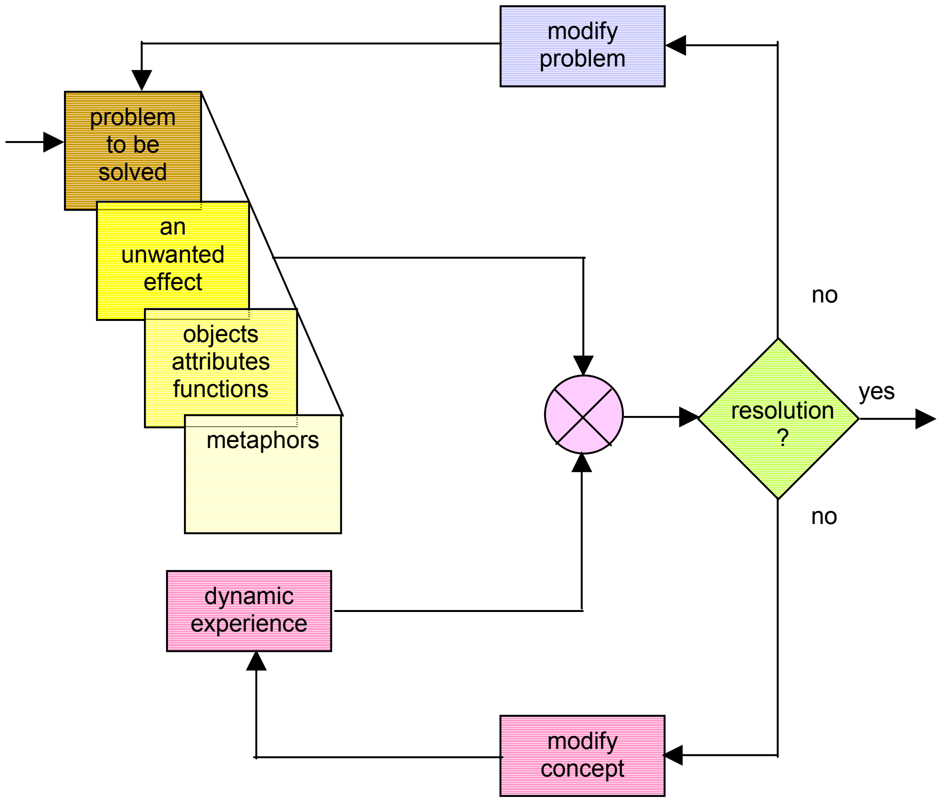


Figure 2. A model of our mental problem-solving process: two inputs, a characteristic of the problem and a trial solution concept drawn from dynamic experience, are compared at a summing junction (circle with crossed lines) and their difference examined to determine adequacy of the trial concept.

Span of USIT

Problem **situation**
… usually begins (unfortunately) with a convolution of several unclear unwanted effects requiring time and effort to sort out.

↓

Problem **definition**
… identifies a single unwanted effect, reduces it to a minimal set of objects, and removes all filters.

↓

Problem **analysis**
… uses structured processes for creating new and unusual vantage points from which to view a problem.

↓

Problem **solution**
… applies formal techniques focused on **objects**, *attributes*, and <u>functions</u>.

Chapter V. USIT flow chart

The USIT flow chart is shown in Fig. (3). Arrows in the chart and the word “flow” in the title may seem to imply that the process is a diode-like one-way flow. Of course, our minds do not function so orderly. In reality our minds jump from place to place more quickly than we may realize. Effort is required, therefore, to keep the flow chart within view, as the process is under way, and make frequent references to it to assure thoroughness and efficiency. Meanwhile, uncontrolled excursions of the mind can be very fruitful when driven by a search for new concepts.

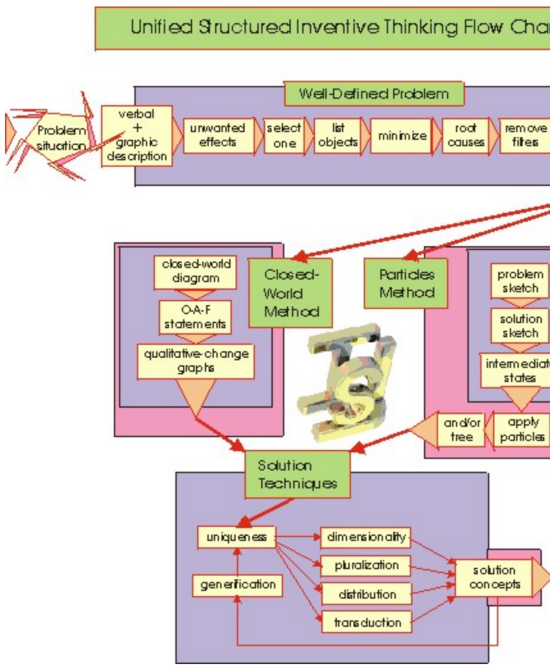


Figure 3. USIT flow chart (see text for discussion).

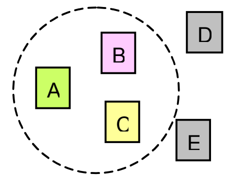
The USIT flow chart is divided into four sections: well-defined problem, closed-world method, particles method and solution techniques. Each section will be discussed in the following chapters.

To be noted here is the detail incorporated in the well-defined problem section. Without adequate attention to this section, all the promises of USIT are at risk.

1. Well-defined problem

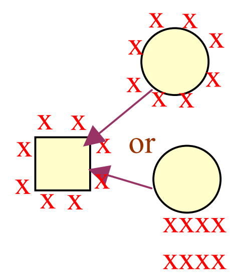
Convolutions of several ill-defined effects typify an initial problem statement. If this complication is not identified and resolved quickly the analyst may languish in a state of uncertainty unable to find a foothold on the problem situation. The well-defined problem section contains steps designed to enable rapid problem definition with effective focus.

2. Closed-world diagram



Once the problem has been defined, two analysis methods are available. One is the closed-world method which is executed with a fixed set of objects; hence, a closed world.

3. Particles method



A second method is the particles method and bears recognizable influence from the smart little people of TRIZ. This has the unusual approach of working back from an ideal solution to the problem situation. Multiple configurations of particles in the final state may be possible, but one is selected for analysis.

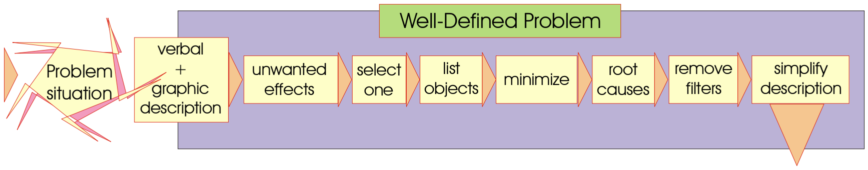
4. Solution techniques

Six techniques for solving problems are contained in this section. Implications of this title also may be misleading. Since the solution-techniques section is placed as the last phase, it might appear that solution concepts are not to be expected until after problem analysis is complete. As pointed out earlier, solution concepts are to be expected at all points throughout the USIT process. Solution techniques come into play as a concerted effort to exercise specific approaches to discover yet more solution concepts not found earlier in the exercise.

5. Divisions of the flow chart

Three major divisions of the flow chart (levels) are shown in the drawing: Well-defined problem; Closed-World Method / Particles Method; and Solution Techniques. This illustrates the emphasis placed on these sections in teaching and practicing USIT. It is recommended to devote one third of the time allotted for solving a problem using USIT to creating a well-defined problem, one third to analyzing it (closed-world method and particles method), and one third to applying solution techniques.

Yes, it is recommended to allocate a fixed amount of time to the task. At the end of this period the results to that point can be evaluated. Then it can be decided whether certain sections might be fruitfully revisited. Remember, a major goal of USIT is efficiency: don't waste time.



Chapter VI. Well-defined USIT problem

We begin USIT with a problem situation from which we must extract a well-defined problem. Whatever the form of the initial information it should be put into written sentences and graphic sketches to start the problem. Photographs, blue prints, hardware and on-site visits to the problem's location also provide beneficial information.

Two kinds of thinking cues are captured in the first step of the well-defined problem section: verbal and graphic metaphors. Through the rest of this section these metaphors are simplified and improved.

1. Verbal and graphic descriptions

Verbal and graphic descriptions are done quickly to capture relevant information without concern for perfection. More often than not the result of this step will not be a single, well-defined problem – the initial target of USIT. Be sure these two descriptions capture the problem situation; if they don't, iterate the process.

2. Unwanted effects

The verbal and graphic descriptions are examined for unwanted effects, as many as can be identified. Each unwanted effect is a problem; but, not necessarily one worth focusing on.

3. Select one unwanted effect

The unwanted effects are listed, ranked, and one is selected. From here on, it is the problem to be addressed. Once a single unwanted effect is selected, it may be profitable to rework the verbal and graphic descriptions to eliminate unnecessary details.

4. List objects

Make a list of objects that contain the newly selected problem. They should already be contained in the verbal and graphic descriptions.

5. Minimize

The list of objects is minimized to just those objects necessary to contain the problem. Pay attention to object-object contacts where the unwanted effect exists.

6. Root causes

To be well defined, a problem's descriptions must contain root causes. When not available, USIT provides a tool for finding *plausible* root causes.

7. Plausible root causes tool

A USIT plausible root-cause analysis, Fig. (4), begins with the statement of an unwanted effect at its topmost level. The next level contains the minimal set of objects of the problem. Each object is examined for contributory causes of the unwanted effect; several may be identified. Each cause is then considered to be an unwanted effect and more basic causes are identified. Each branch is terminated when an attribute is reached. The lowest level causes are examined to identify other supporting attributes. These are listed under each branch. Every attribute is a plausible root cause, and a point to ponder for solution concepts.

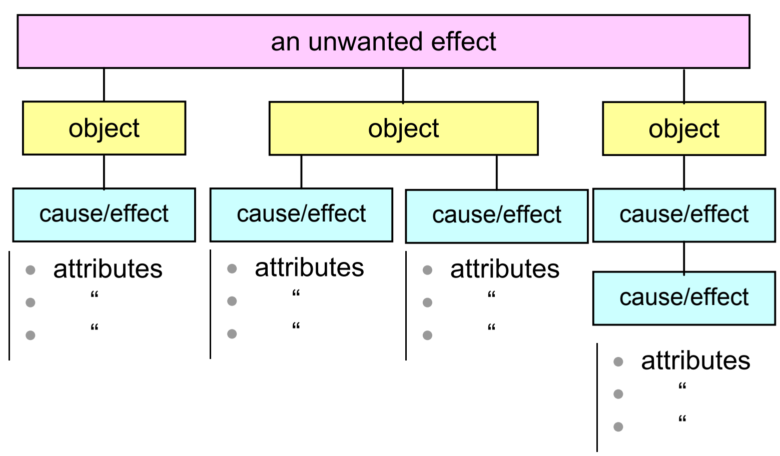


Figure 4. Plausible root-causes analysis: the closed-world objects are examined individually to identify causes by which each supports the unwanted effect. Each cause becomes a potential effect for a more basic cause. Several cause/effect layers are possible. Causes are then analyzed according to their supporting attributes.

Reduction to root-cause attributes does not produce uniform results; each analyst will discover different depths of root causes depending on personal experience and training. Uniformity is not a goal. Rather the plausible root-causes tool assists the analyst in reaching the lowest depth of fundamental understanding he/she is capable of or interested in. This becomes the working level for the rest of the problem solving exercise. The goal is accessible depth and maximum breadth.

8. Remove filters

Postponing judgment of solution feasibility is a well-known recommendation for innovative problem solving. USIT goes a step further and requires all filters to be removed from the problem-solving process. Since USIT is a pre-engineering phase of problem solving, and emphasis is placed on conceptual solutions, no specifications, dimensions, numerical data or other quantitative metrics are allowed. Customer wants, management needs, and business-type boundary conditions are filters also to be removed. Time spent, during innovative problem solving, worrying about filter criteria is time wasted – a corporate loss. Filters are needed to rank and select problems and again to rank and select solution concepts. They play no useful role during the process of innovative problem solving.

9. Simplify description

Simplification of problem description is ongoing during production of a well-defined problem. The goal is to translate an original problem description, with its engineering details, into a conceptual description made up of generic metaphors. This enables depth of understanding with thought provoking images conducive to discovery of innovative concepts.

10. Two methods for problem analysis

Once a well-defined problem has been constructed, we turn to problem analysis for additional opportunities to see the problem differently. Two methods are available, the closed-world method (CW-method) and the particles method; either can be used for any problem.

While learning USIT and honing one's skills, using the CW-method is recommended for problems having a solution but in need of a better one. It is recommended to use the particles method for problems having no solutions. Later it will become of interest to try both methods on the same problem.

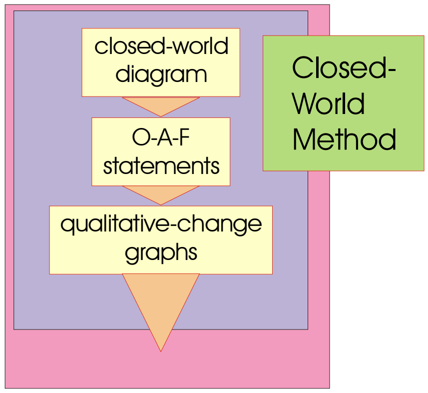
> A common situation for a corporate technologist is to be given a malfunctioning subsystem and asked to fix it; i.e., to redesign it so that it functions as desired. It most likely is also required to produce a new design that does not require modification of the parent system – a so-called "drop-in" solution. The closed-world of a minimal set of objects is an effective mental environment for this exercise.

11. A well-defined problem exercise

Your company manufactures spark plugs for internal combustion engines. Your manager calls you in and says, “Our customer is dissatisfied with our product – fix it!” He then dismisses you and departs for vacation. How can you make a well-defined problem out of this ill-defined one?

(To work on this exercise you do not have to be an automotive engineer. Simply understand the functions of a spark plug and its components. Then assume a manufacturing process and proceed.)

1. Draw a sketch of a spark plug and label all of its parts (for information visit the web or an encyclopedia). Keep it simple.
2. List all of its objects.
3. List every unwanted effect in this product that you can think of that could bother the customer.
4. Rank these unwanted effects from the most troublesome to the one of least concern. Use whatever criterion you wish for the ranking, but have a criterion.
5. Select the top ranked unwanted effect. State it as a problem to be solved using names of objects in the statement.
6. List the objects.
7. Minimize the list of objects to just those needed to contain the selected unwanted effect.
8. Do a plausible root-cause analysis of the unwanted effect.
9. List any filters appearing in your problem statement.
10. Write a new problem statement without filters and with only the minimum set of objects. Use metaphors.
11. Draw a sketch of the new problem situation.



Chapter VII. Closed-world method

A closed-world analysis is confined to the minimum set of objects in the well-defined problem. The analysis begins with examination of the system of the cw-objects from the perspective of a properly functioning system. This is accomplished in the cw-diagram.

1. Closed-world diagram

A cw-diagram begins with one of the cw-objects selected as the most important object and placed at the top. The remaining subordinate objects are connected with the top object using functional links (as illustrated in Fig. 5).

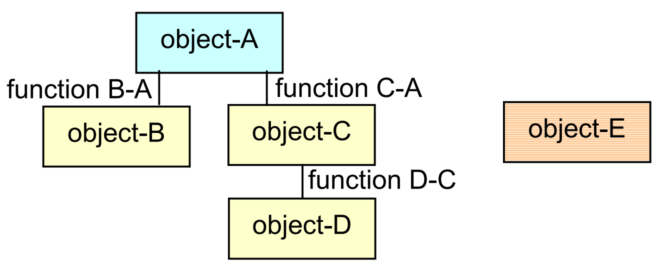


Figure 5. A cw-diagram having four functionally connected objects and one unconnected object.

Criteria for assembling a cw-diagram have been designed to force a fresh perspective.

- Functions must be desirable functions.
- An object can appear only once in a diagram.
- An object is a proper subordinate if removal of its superior renders its function unnecessary.
- An object can initiate only one function: consequently, branching downwards is allowed but branching upwards is not.

- If no functional connectivity exists, the object may belong in another cw-diagram, or simply remain alone. A stand-alone object, for example, might be a neighborhood object.

Functional links in the diagram represent desirable links since the cw-diagram analyzes not the problem but the system working properly as designed.

2. O-*A*-F statements

Experience shows that most students have little trouble using the concept of objects, with the possible exception of **information** as an object. Functions also are readily grasped. But, active *attributes* can cause difficulty. Object-attribute-function statements can be used to mitigate this difficulty. A good place to use them is between the cw-diagram and the qualitative-change-graph (the next topic). They are also effective with the plausible root-causes exercise. Their purpose is to assist the analyst in identifying active attributes and to bring attention to their fundamental connectivity with objects and functions.

O-A-F statements follow the O-A-F-contact model described in chapter IV. At a point of contact we know what the objects are and the functions present. We need to identify active attribute pairs, one from each object that supports a function. O-A-F statements can be used to analyze both desirable and undesirable functions or effects.

Full sentences can be used to express O-A-F statements or, a quicker method, a simple table of the components in the same order.

O-A-F sentence template:

Attribute of **object-A** interacts with *attribute* of **object-B**
to (function) change/maintain *attribute* of **object-(X)**.

Example: Writing on paper with a fountain pen has several points of contact. One involves the split pen point and the paper. *Pressure* of the **paper** interacts with *elasticity* of the **pen point** to broaden the *gap* of the **pen point** (allowing ink to flow).

O-A-F table:

attribute	object-A	attribute	object-B	function	attribute	object-x
pressure	paper	elasticity	pen point	to spread	gap	pin point

Difficulty experienced when first encountering attributes as key elements in problem analysis is indicative of their unfamiliarity. This is just the kind of new and atypical vantage point USIT searches for. Try them you'll like them!

3. Qualitative-change graph

A very effective device from the Israeli's SIT method is the qualitative-change graph. It has been modified in USIT to utilize the minimum set of objects and their active attributes. The cw-method began with examination of a properly working system depicted in the cw-diagram. The qc-graph, by comparison, examines the malfunction of the system – the problem.

An unwanted effect is plotted on the ordinate and active attributes of the cw-objects on the abscissa of a simple linear graph. The unwanted effect is described as "getting worse" in the upward direction of the axis. A sloping straight line represents the trend connecting an active attribute with the unwanted effect. This is not a mathematical analysis; rather, it simply shows if increasing an active attribute causes the unwanted effect to increase or decrease. It is convenient to make two graphs to separate reciprocal relationships for ease of reading; in one increasing attributes increase the unwanted effect, in the other decreasing attributes cause the unwanted effect to increase (see Fig. 6).

A qc-graph shows a problem characteristic, a mapping of an attribute on an unwanted effect, having a finite slope. A "qualitative change" occurs when the problem characteristic can be moved to zero slope. This leads to two recommended solution attempts. One is to produce a qualitative change by eliminating the causal attribute. The other is to consider the problem characteristic as evidence that the causal attribute is "working against us" and find a way to make it work for us.

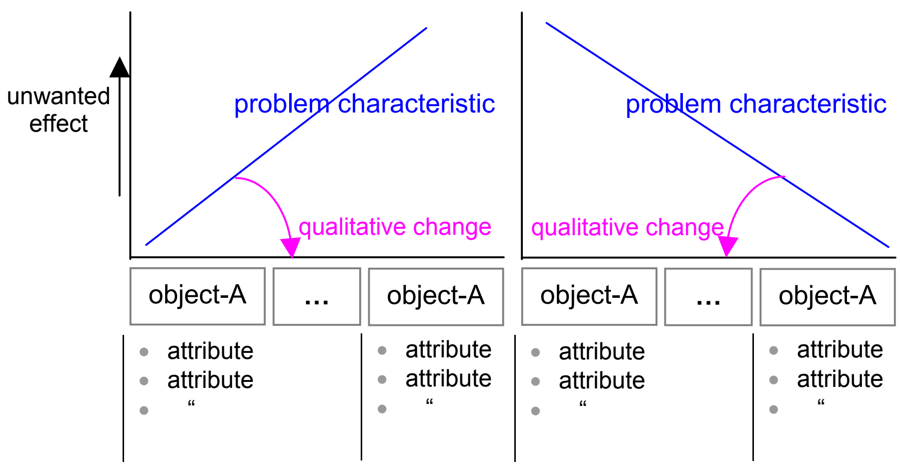


Figure 6. Two QC-graphs showing how changes in attributes of the minimum set of objects are related to changes in the unwanted effect.

From QC-graph to solution concepts:

- eliminate a causal attribute, and
- make a causal attribute work for you.

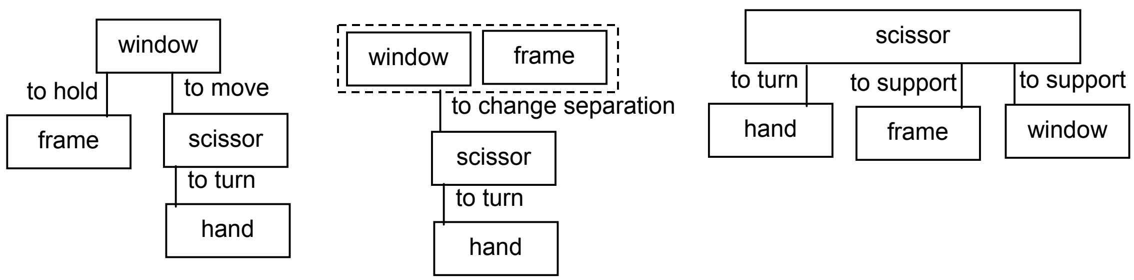
Once the cw-analysis is completed the analyst moves to the solution techniques.

4. Closed-world method exercises

1) A shirt to be pressed, an ironing board, a person, and an electric iron form a system designed to produce a wrinkle-free shirt.

   - Construct a cw-diagram of this system.
   - Change the iron to a steam-iron and construct another diagram.

2) A mechanical window opener has a scissor-jack connecting the window with its frame. A handle is rotated by hand to operate the scissor jack and reposition the window. Which cw-diagram below best describes this system?



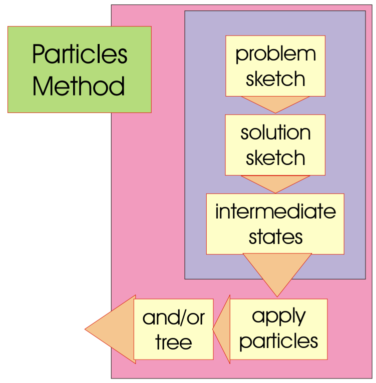
3) Two wires are wrapped around a screw on an electrical switch. Write two or more O-A-F statements for two different points of contact of these objects.

4) A cup of hot tea rests on a small mat, which is resting on a table.

   - List the active attributes of the cup.
   - List the active attributes of the mat.
   - List the active attributes of the table.

5) A map-light placed in the roof of an automobile illuminates the area of the driver's seat, and is operated by a switch on the dashboard.

   - List the objects of this system
   - If an unwanted effect is inappropriate area of illumination, list the minimum set of objects to contain this problem.



Chapter VIII. Particles method

The particles method analyzes a problem from its ideal solution back to its unwanted effect. This is done quickly using simple sketches as graphic metaphors. Prior to this reverse analysis, a morph cartoon is constructed describing the transition.

An ideal solution is one that does its job perfectly, costs nothing and doesn't exist! An example – the coffee cup holder embossed in the back of the glove-compartment door of a modern automobile.

1. Morph cartoon

A sketch is made of the problem situation using simple representations of the minimum set of objects. A second sketch is similar but depicts the ideal solution. Intermediate sketches are added, if needed, to complete a logical morphing from the ideal solution back to the problem situation.

Figure 7. A morph cartoon showing a transition from the problem situation to its ideal solution.

An example is shown in Fig. (7) without intermediate sketches. To these sketches particles are added in, on, or around areas where a modification is required to effect the morphological change. Particles are shown as x's in Fig. (8). As indicated in the figure, particles have been added around the oval in the problem-situation sketch. In the ideal-solution sketch the particles are assembled to the side, having completed their task. They could also have been left in place. One or the other location may seem more logical in a given situation; in either case, the selected configuration is analyzed.

Figure 8. Particles have been added to Fig. (7) to indicate where change is required.

Further analysis is now limited to the particles. Don't analyze areas having no particles – stay focused!

2. And/or tree

It remains to determine how the particles accomplish the desired solution. Particles are treated as though they have magical properties and can do anything physical, chemical, biological, or mathematical that makes technological sense to the analyst. Whimsical effects are not allowed. The analysis proceeds from the ideal solution to the problem situation. Details are charted in a logical and/or tree diagram. The and/or tree structure is shown in Fig. (9).

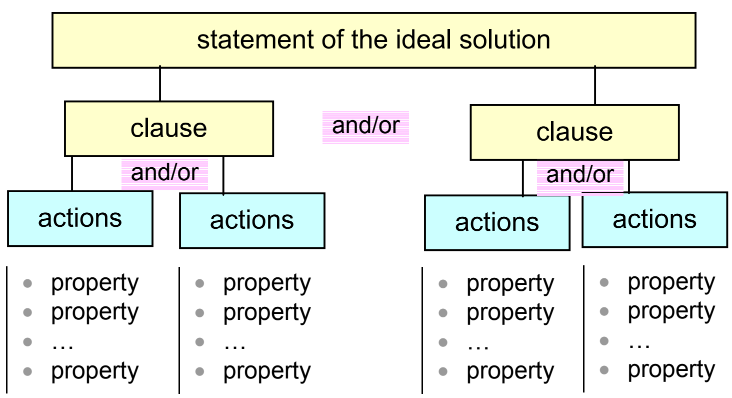


Figure 9. The QC-method's and/or tree. Note, the shaded "and/or" placeholders will be either "and" or "or" in a given tree, not both.

The top level of the and/or tree is a statement of the ideal solution; compound statements are recommended to broaden options. For example: "the hole is given a square cross-section ***and*** passes all the way through the parallelepiped", see Fig. (7). At the next level, the compound statement is broken into its clauses, each to head a new branch of the and/or tree.

Beginning with the ideal solution sketch and examining each clause in turn, the analyst asks what are the particles doing in that sketch to accomplish the clause in question. These are inserted in the and/or tree as "actions" of particles. Moving to the left in the morph cartoon, the next sketch is examined for new actions of the particles that support the actions identified in the previous sketch. Thus, actions become columns with branches of actions supporting actions. When the branches of actions are completed in the problem situation sketch, the solution process has been completed metaphorically.

Other clues to solution concepts can arise from tree branches addressing particles' initiation and termination. To reduce complexity of the original and/or tree these can be done as separate structures. At issue here is how did the particles get where there are in the problem situation sketch and what happened to them when they finished their tasks? These questions are the same for every problem so a boilerplate and/or tree can be used (see Fig. 10).

3. Creation/annihilation boilerplate

As shown in Fig. (10), the boilerplate has two sections, one addressing how the particles came to be, and the other how they were terminated. To use the boilerplate, the analyst simply lists properties the particles would need to have …

- been present where needed,
- been put there,
- gotten themselves there, and
- been created there.

For their termination, the analyst lists properties needed if the particles …

- remain in place,
- are removed,
- leave of their own accord, and
- are annihilated.

The seeming anthropomorphic properties are intentional to achieve unusual perspectives.

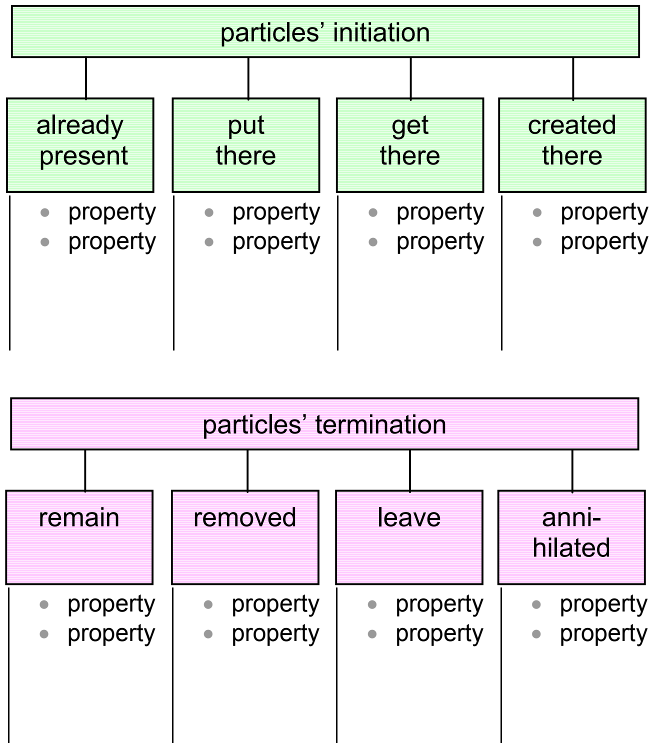


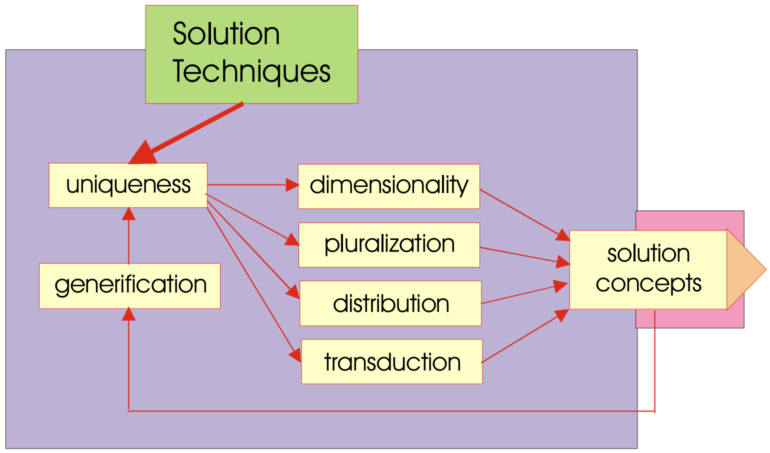
Figure 10. Particles’ initiation/termination boilerplate for an and/or tree.

The and/or tree is completed by examining terminal actions of each branch and listing all possible properties of the particles that are implied by their actions.

As the process of finding solution concepts from the and/or tree unfolds, actions of the imaginary particles will become functions of cw-objects and their properties will become active attributes. Anded-attributes, especially those between different clauses, are good starting points to spark ideas for solution concepts. Anded-attributes implying contradictions are potent starting points as well. From here, the analyst works through the and/or tree examining pairs of attributes to discover solution concepts.

Complete examples of the cw-method and particles method are to be found in the textbook. [1]

Having completed the particles method and searched solution concepts in the process, one begins to apply the USIT solution techniques.



Chapter IX. USIT Solution techniques

The analyst, upon reaching this stage of the flow chart, should have multiple solution concepts already listed. We now employ structured solution techniques to enable visualization of the problem situation in even more variations for finding additional solution concepts. With practice these techniques become an unconscious mode of thinking. Consequently, upon reaching this stage of the methodology, one often discovers that the techniques have already been used subconsciously. However, the techniques are still addressed formally to assure thoroughness.

Students quickly become aware of redundancies in results of the solution techniques. Concepts found by one technique might also have been discovered using another. Such redundancies simply illustrate how different metaphors take root and produce different results in different minds, or in the same mind (metaphors can have overlapping spheres of influence).

Confinement to the minimal set of objects is a very creative constraint. [1, 3] However, it sometimes comes to mind that an additional object might offer a new solution opportunity. In this case, it is an effective strategy to immediately assume the presence of the new object, find solution concepts it allows and the associated attributes it brings. Once the new concepts have been tabulated, search for more creative solutions by eliminating the extra object. Eliminate the object and consider how to activate the newly identified attributes within the minimal set of objects.

It is recommended that uniqueness be examined first, and then the other solution techniques can be used in any order.

1. Uniqueness

Uniqueness is nothing more than identifying and listing characteristics of the problem that are unique to the problem – the features that make a problem different from an otherwise similar one. These perspectives can be effective vantage points. This sounds simple. However, it became evident that students claim to understand the concept of uniqueness in lectures but cannot employ it in practice. A simple graphic approach was devised to mitigate this difficulty.

After listing the obvious uniqueness of a problem (or after giving up) two graphic techniques can be employed. One is to examine the functions (in the CW-diagram) in space (spatial uniqueness) and the other is to examine them in time (temporal uniqueness).

Spatial uniqueness focuses on function locations.
The sketch used in the well-defined problem has the minimum set of objects and contains the problem. By examining this sketch for characteristics that distinguish these objects from some another situation, the analyst may discover solution concepts. Features to look for are the *locations* of functions; this means to find the points of object-object contact where the functions are active.

Temporal uniqueness focuses on function activation/deactivation.
A simple time-line plot showing functions as rectangles only when the functions are active is very informative. Here we may see disjoint activities, overlapped activities and multiplexed activities (see illustrations in Fig. 11).

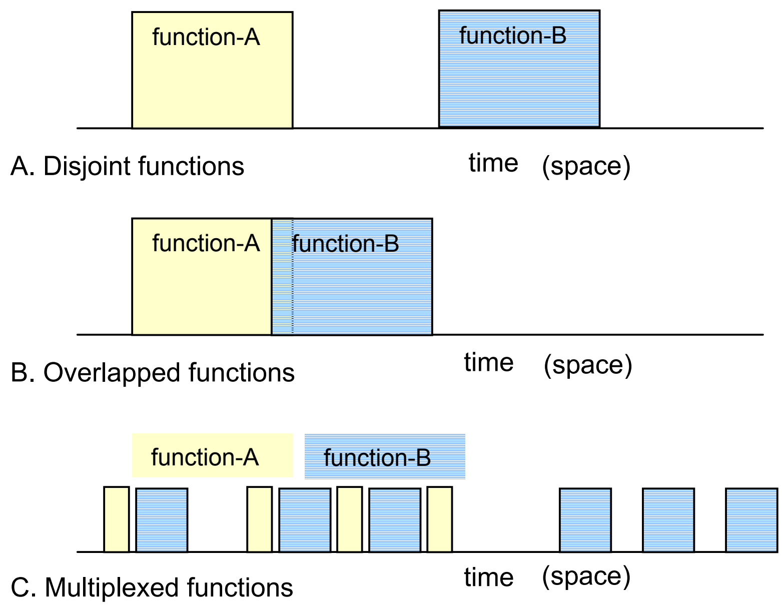


Figure 11. Two functions shown in various unique arrangements of activity: (A) disjoint, (B) overlapped, and (C) multiplexed in several ways.

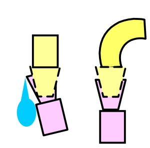
As unique features are discovered their alternatives should be pondered for new concepts. For example,

- If functions are disjoint, try reversing, overlapping, and multiplexing them.
- If functions are overlapped, try reversing, separating, and multiplexing them.
- If functions are multiplexed, try reversing, unifying, and overlapping them, as well as creating/changing/destroying their periodicity.

Now visualize Fig. (11) as though it were a linear spatial plot with time replaced by a distance attribute (separation, length, or other spatial connotation). In a metaphorical way one can now examine the spatial plot for functions that could be separated, overlapped, or reversed spatially. They could, as well, be multiplexed in the sense of turning them on at different locations.

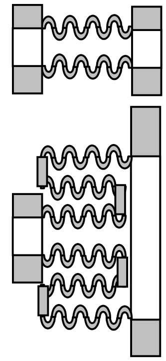
Spatial-uniqueness-type solutions

- A flexible seal leaked. The overlapped functions, to seal and to flex, were separated to solve the problem.



- After lathering her hands the mechanic scraped away the grime still remaining. The separated functions to lather and to scrape where overlapped in grit-impregnated soap.

- Two steel vacuum chambers were joined by a short section of flexible pipe that developed fatigue cracks. The flexible pipe was multiplexed into several equal lengths of different diameters and welded together at their alternate inner ends to form one piece having the same overall length. Adequate stress relaxation was achieved to prevent fatigue. (This concept might also be found through pluralization.)



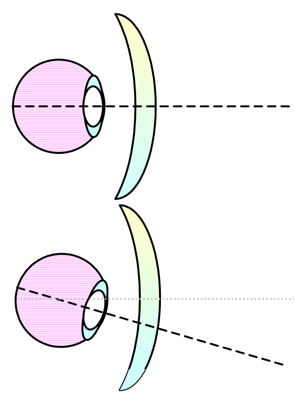
The order of exercising the remaining solution techniques is not important. Notice how each technique brings new perspectives of the problem by emphasizing the different fundamental components of USIT (objects, attributes and functions).

2. Dimensionality

Dimensionality focuses on *attributes*. Both QC-graphs and and/or trees bring to light the relevant attributes for solution concepts. Using dimensionality the analyst is asked to consider turning off and turning on attributes in strategic locations and time periods. Attribute mapping is also considered; this means to map one attribute onto another (e.g., time onto space).

Dimensionality-type solution

- Viewing distant and near objects through eyeglasses involves looking through upper or lower portions of the lens respectively (spatial uniqueness – angle of viewing). By turning on the attribute of *focal length* to different degrees in different *locations* of the lens (or mapping of focal length onto position), the continuously variable focal-length lens concept may be found.



3. Pluralization

Pluralization focuses on **objects** allowing their multiplication and division (pluralization) to obtain new objects for different uses.

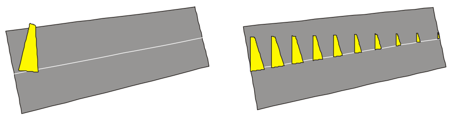
Objects in the closed world can be multiplied to make as many copies as desired, including very large numbers (think of an infinite number). This is a reasonable approach to a real-world problem because one often deals with manufacturing environments where many copies of an object are readily available.

In pluralization objects can also be divided into parts and the parts used differently. Parts can be divided infinitesimally (think of molecules).

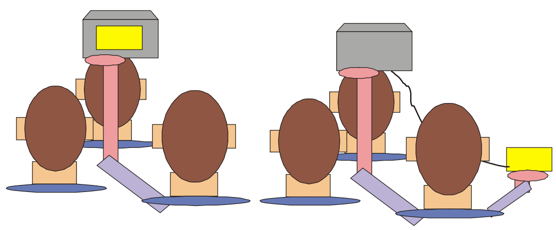
Addition and subtraction of objects is allowed where addition involves a neighborhood object. Subtraction allows removal of an object. Addition and subtraction, for some analysts, may be metaphors for other mathematical concepts such as integration and differentiation, respectively.

Pluralization-type solutions

- Multiplication: One iridescent colored cone placed along a

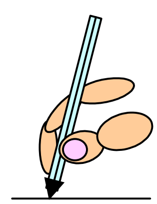


  roadside serves as single-point cautionary sign; hundreds of them can sustain the information for miles.
- Division: Digital cameras and video cams held at arm's length, to photograph over the heads in a crowd for example, become difficult, if not impossible, to know where



  they are being pointed. Root cause is that the monitor is part of the camera. The camera can be divided into parts, one of which is the monitor. The monitor can be held in one hand in full view while the camera is held overhead, the two being connected by a cable. (RCA CC9390 digital camcorder, "Popular Science", October 2001, p15.)

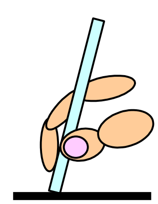
4. Distribution



Distribution focuses on <u>functions</u>. Using the CW-diagram, the analyst literally moves a function to a different pair of objects and asks what the new arrangement implies. That is, what must now be done to the objects' attributes to support the function?

Distribution-type solution

Drawing with a pencil: hand holds wooden shaft, wooden shaft holds pencil-lead, pencil-lead marks paper. If the function <u>to hold</u> **pencil-lead** is moved from **shaft** to **paper** scratch painting comes to mind as well as carbon tracing paper (a thing of the past).



5. Transduction

Transduction focuses on A-F-A links. An important feature of the O-A-F contact model is its two built-in A-F-A links (One is bolded in Fig. 12).

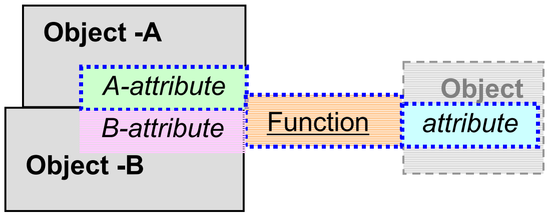


Figure 12. Two A-F-A links are evident in the O-A-F contact model; the upper one is emphasized with a bold dotted line.

Transduction suggests thinking of paths from one object to another involving chains of one or more A-F-A links. This is effective when initial and final attributes are evident but their functional connectivity is not. Insertion of another link may resolve the problem. Chains also can be built involving additional objects.

Physical effects, such as piezoelectricity, should be thought of as A-F-A transduction links.

Transduction-type solution

- Removing spider webs with a brush forms a sticky deposit of webs on the brush that can be difficult to remove. The problem situation has webs stuck on a brush. Its solution has webs unstuck from the brush.

  O-A-F statement: *stickiness* of **web** interacts with *chemical affinity* of **brush** to adhere forming a *web-coated* **brush**.

  The causal A-F-A links are *stickiness* - to adhere – *web-coated* and *chemical affinity* - to adhere – *web-coated*; both can be investigated for solution concepts.

  A transduction solution path could look like

  A – F – *A* – F – *A*
  Stickiness – to adhere – *web-coated* – F – *web-free.*

  Stickiness, web-coated and web-free are attributes of surfaces. Web-coated and web-free are, in this problem situation, the same surface. The linking unknown function in the above solution path could be to separate the surfaces. How can that be done? It comes to mind to insert a "sacrificial" object that can be stuck to the web on one side and not on the other -- a coating, one that has no chemical affinity to the brush. For example, a dust of small particles could be blown onto the web.

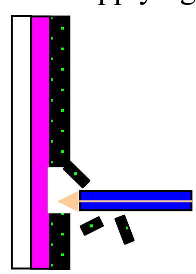
This solution concept has introduced a third object not in the closed world. To remain in the closed world, the "dust" must be gotten from its objects – the brush probably has non-sticky parts, such as its handle. Hence, divide the handle into parts and grind a part of it into a dust. This USIT conceptual solution might be engineered into a real-world product having a brush containing a supply of talcum powder in its handle and a simple mechanism for dusting it onto a web before wiping the web onto the brush.

6. Generification

Recall from the feedback thinking model that the mind makes incremental changes to past experience to find new concepts. Generification as a solution technique simply revisits each solution concept already found and uses it as a template to spark new ideas. Before using an already found concept it is generalized; meaning it is reduced to its basic phenomenology; i.e., to what makes it succeed as a solution concept.

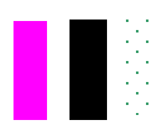
Generification-type solution

A problem solved recently using the generification solution technique concerned poorly sticking paint in a scratch-paint recipe. The recipe requires first applying colored crayons densely to a sheet of paper. Then a few drops of detergent are mixed into a black water-soluble paint, which is spread onto the colored sheet with a sponge brush. When dry, the painted sheet is ready for scratch painting. The recipe mentions that the detergent was added to improve paint adherence for some mysterious chemical reason. The recipe did not indicate how many drops of detergent or the volume of paint. Attempts to use the recipe produced unsatisfactory results – the paint chipped.

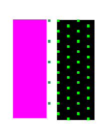


It was decided that the given recipe represented a known solution to a problem whose root cause was given. This solution concept could be generified into a template for other solution concepts.

The existing closed world consists of three objects; crayon, paint and detergent. The function of detergent is to improve bonding of paint to crayon, hence, it is assumed to be an object between paint and crayon. This phenomenology needs to be understood in order to form a generalized solution. We turn to the uniqueness technique for such insight.



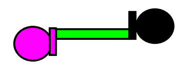
Unique characteristics of these objects include wax-like crayon, water-like paint, and a detergent molecule bonding to both. Spatial uniqueness shows the detergent to be dispersed throughout the



paint but to be active only at the interface where it bonds paint to crayon. How does it work?

A detergent molecule has the unique feature of two active but dissimilar sites; one is polar and the other is non-polar.

From high school chemistry we learned that similar molecules like each other (are miscible) and dissimilar molecules do not (are not miscible). This means that the polar site likes to bond to polar molecules like water while the non-polar site likes to bond to non-polar molecules like wax.



Now we have a solution template. To avoid cracking and chipping the paint needs to be bonded to the crayon more tightly than to itself. An interfacial layer of molecules having two active sites, one polar and the other non-polar, can provide stronger bonding than direct crayon-paint bonds. This is the solution concept, the rest is engineering. In this case, one engineered concept was to put a thin coat of detergent onto the layer of crayon and dry it. Then the layer of paint, having no detergent in it, was applied – with excellent results.

All solution concepts are opportunities for generification.

Chapter X. How to apply USIT

Like other structured systems we've learned in our academic and professional careers, USIT is a discipline. It takes time to learn, time to experiment with, and time to become an adept practitioner. Fortunately, the whole trip is one of satisfying intellectual challenge.

Some suggestions may be helpful to ease the process of becoming a USIT practitioner:

- Think of problems and solutions you encounter in terms of objects, attributes, and the functions they support. This is the starting point of all USIT. Adopt it as a mode of thinking.
- When solving problems and puzzles pay attention to how thought provoking are specific steps – experiment with each:
    - Simplification of a problem statement to essential elements by stripping away useless information.
    - Conceptual analysis and solution based on fundamental phenomenology before addressing engineering details – i.e., elimination of metrics.
    - Focus achieved by reducing a problem situation to a single well-defined unwanted effect.
    - Focus and innovative-type thinking produced by limiting analysis to a minimal set of objects.
    - How often solution concepts arise as soon as root causes are identified.
    - How concentration on root causes forces one to address fundamental phenomenology.
    - Changing technical or commercial names of object to metaphors.
    - How clear thinking improves with writing words and making sketches of a problem situation.
    - How new concepts arise out of unconventional analyses.

As they say, "The proof is in the pudding." So, start solving your technical problems in a disciplined manner using the unified structured inventive thinking methodology.

Chapter XI. Conclusion

This overview gives the full scope of USIT but not its depth. However, one practiced in conceptual problem solving should be able to understand the tools described here. Lacking are in-depth examples and their discussions. It was not the intent of this book to delve into such depth – it is an overview. The textbook [(1)] is a resource for that information, as well as the Ntelleck web site [(4)]. Courses taught at your company or institution are available through Ntelleck, LLC. (See www.u-sit.net)

USIT trainers and those preparing to be trainers should find this overview a useful reference. The book plus the reverse engineering examples on the web [(4)] are recommended for this audience.

Of course depth and understanding come with experience – so, solve problems at every opportunity and remember, …

… "To be creative U-SIT and think."

Ed Sickafus
Ntelleck, LLC

Appendix A. Miscellaneous exercises

1. What solution technique(s) might have led to an automatic garage-door opener concept?

- What unwanted effect(s) did it resolve?
- If more than one, which is the most undesirable?

2. An unwanted effect of a computer mouse is to move it but see no corresponding motion of the cursor on the monitor.

- Identify the objects of this system.
- Make a sketch.
- Do a plausible root-causes analysis.

3. Zippers on jackets can be difficult to engage before being zipped.

- Devise an automatic or self-engaging system.

4. Describe the following effects as transduction A-F-A links:

- piezoelectricity
- magnetostriction
- boiling of a liquid

Appendix B. Additional resources

Books

1. Unified Structured Inventive Thinking – How to Invent" by Ed. Sickafus, Ntelleck, LLC, Grosse Ile, MI, USA, ISBN 0-965-94350-X, 488 pp, hard bound (see www.u-sit.net).

In this textbook 26 problems and puzzles are discussed and analyzed to different degrees for 16 different aspects of USIT. Most problems leave some parts unfinished to provide classroom exercises for instructors and students.

2. "Unified Structured Inventive Thinking – an Overview" by Ed. Sickafus, Ntelleck, LLC, Grosse Ile, MI, USA, e-book and paperback.

3. "Creative Cognition – Theory, Research, and Applications", R.A. Finke, T.B. Ward, and S.M. Smith, The MIT Press, Cambridge, 1992.

Websites

4. Essays, lectures, example problems, exercises, puzzles, and USIT Q's & A's can be found at www.u-sit.net. Questions about USIT are welcome as are suggestions for USIT discussion topics.

5. Dr. Roni Horowitz, Tel-Aviv, Israel, has an ASIT web site with on-line training at www.start2think.com

6. Professor Toru Nakagawa, Osaka Gakuin University, Osaka, Japan, maintains a TRIZ and USIT site in Japanese and English at www.osaka-gu.ac.jp/php/nakagawa/TRIZ/eTRIZ/. Translations of some USIT material into Japanese is available here.

Register for USIT website updates.

Ntelleck's USIT website is a resource for in-depth information on USIT: developments, essays, example problems, exercises, news, etc. You can register your email address and be automatically informed when new materials are added to this website. Send your name, city, country, and email address to Ntelleck@ic.net to register for this service. You are also invited to send questions about USIT for discussion on the web site.

Appendix C. USIT Textbook Order Form

Please copy this form, insert mailing information, attach your check, and mail to

Ntelleck, LLC, PO Box 193, Grosse Ile, MI 48138 USA

(Credit-card service is not available.)

Unified Structured Inventive Thinking – How to Invent

by E. N. Sickafus

Order Form **USIT**, ISBN 0-965-94350-X, 7” x 10”, 488 pp, hard bound, $84.50

Last name: ________________________________ First name: ___________________ M.I.: ___

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City: __________________________ State: ______ Postal Code: _________ Country: ________

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No. books: ____ @ $84.50 = $ ____.____

Less quantity discount*............- ____.____

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4 - 6	5%
7 - 12	10%
13 – 24	20%

Sales tax: add 6%,

if delivered in Michigan +____.____

Shipping and handling** ....+ ____.____

Total: $ _____.____

Destination	Air (4-7 days)	Surface (4-6 wks)
USA	$7.50	$6.00
Africa, Asia, S. America	$29.00	$14.00
Australia, New Zealand	$26.00	$14.00
Europe	$24.00	$14.00
Canada, Mexico	$23.00	$14.00
Central America	$20.00	$12.00

Order must be prepaid in U.S. dollars.

Send check ☐, money order ☐, or

Bank draft in U.S. dollars ☐ made payable to **NTELLECK, LLC**,

and mail to PO Box 193, Grosse Ile, MI 48138 USA

Appendix D. License Agreement

AGREEMENT

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ISBN 0-9659435-1-8, in PDF format

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This eBook describes a methodology for assisting the discovery of solution concepts to design- and other technical-type problems. None of the example solution concepts has been engineered, tested, or verified in any way by Ntelleck, LLC. No warranty or guarantee is offered or implied for any solution concept discussed herein.