# John N. Warfield's

# Systems Science Principles & Laws

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WPOC

# Foreword

Comments, questions, and suggestions related to this presentation are welcome, and may be addressed to:

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# Preface

Warfield's extensive literature and science predominantly addresses **sociotechnical systems**: systems that "involve a mix of technology and people, and depend on a synergistic interaction of these two different kinds of entity for their satisfactory performance." This **science** encompasses:

- **Behavioral Pathologies** of Individuals, Groups, Organizations
- **Logic and Language** (formal logic, mathematics of structure, structural modeling, and languages)
- **Collaborative Abduction** (generation of structural hypotheses; group abduction or hypothesis generation in a group process)

- "**Work Program of Complexity**" is the process developed to implement this science
- "**Interactive Management**" is the principal implementing system

# Overview

I. Warfield's Context for Systems Science

II. Killer Assumptions

III. Work Program of Complexity

IV. Mathematics of Structure

V. Selected Laws
   - A. Law of Triadic Compatibility
   - B. Law of Gradation

VI. Example Application in Domain of Systems Security

VII. Summary

# I. Warfield's Context for Systems Science (1 of 4)

## Systems science seen as filling multiple scientific roles

1. Science of **description**, wherein describing the physical world and interactions between components is enhanced to enable descriptions of problematic situations
2. Science of **generic design**, wherein human design intuition is augmented by methods that stem from neutral sources, rather than specific disciplines (viewed as the integration of a science of description with additional constituents that enable it to support conceptions of future change)
3. Science of **complexity**, wherein human competence can be extended, providing demonstrable results in the service of humanity
4. Science of **action**, wherein clear patterns of behavior are identified; linguistic and infrastructure needs for carrying out such actions are clearly specified
5. Science **open to imports** from other disciplines; incorporates means of identifying and integrating essential components of those disciplines

# I. Warfield's Context for Systems Science (2 of 4)

**'Neutral science'** comprised of **foundations & theory** that lie in the Basic Triad and its derivatives

**'Basic triad'** of all science: **human being, thought, language**

- Human being: develops the science
- Thought: underlies all actions in developing the science
- Language (symbolic representation): used to convey science development to others

**Basic Triad 'Derivatives'**

- A derivative of the human being: Behavioral pathologies which describe dysfunctional human performance when acting alone, in groups, and in organizations
- A derivative of thought: Thought about thought itself (second-order thought)
- A derivative of language: integrated prose and graphics language essential to human understanding, particularly when working with complexity

# I. Warfield's Context for Systems Science (3 of 4)

**'Neutral science'** comprised of **methodology** specifying mode of behavior based on its foundations and theory

**Methodology for Science of Description**

- Nominal Group Technique (NGT)
- Interpretive Structural Modeling (ISM)

**Methodology for Science of Generic Design**

- Friedman and Harary Theorems, as well as Ashby's Theorem of Requisite Variety, apply as quality control components
- NGT used to generate and clarify options; ISM used on set of options to structure an optionatique

**Methodology for Science of Complexity**

- Work Program of Complexity with two major components: discovery and resolution of complexity (discovery involves description and diagnosis, resolution involves design and implementation)

# I. Warfield's Context for Systems Science (4 of 4)

**'Neutral science'** comprised of **methodology** specifying mode of behavior based on its foundations and theory

**Methodology for Science of Action**

- Provides details regarding how to carry out the 'work program of complexity'; includes roles, process details, training requirements, integrated infrastructure, and aspects of credibility (history of practice, identities of successful practitioners)
- Interactive Management considered thoroughly test science of action

**Systems science can attain its full potential when it is perceived as a neutral science, comprised of mutually reinforcing constituents:**

A science of description

A science of generic design

A science of complexity

A science of action

# II. Killer Assumptions

**Killer Assumptions:**

> "A condition of unjustified belief which, if held, will greatly inhibit the likelihood that human beings can resolve complexity."

**Consequent Demands of Complexity**

> "A condition which, if satisfied, will enhance the likelihood that human beings can resolve complexity."

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# Warfield's Killer Assumptions

## & the Consequent Demands for Resolving Complexity

1. Site/Location
2. Scale
3. History
4. Need
5. Source
6. Normal
7. Behavioral Research Findings
8. Knowledge Integration
9. Types of Relationships
10. Representational
11. Formalisms
12. Spatial
13. Linguistic
14. Workplace
15. Scientific
16. Academic Terminology
17. Executive Capacity

# KA 1: Site/Location of Complexity

Back

**KA1 - Complexity is found in the system being observed.**

- To some, it is inconceivable that complexity is not located in whatever system is being observed at a given time.
- This perspective is a legacy from physical science, but it cannot be sustained even in physical science without stretching the point of view unmercifully.

## Demand of Complexity

Recognition of Distinctiveness. Complexity of any given situation lies in the minds of individuals who view and/or are imbedded in a system, rather than in the system itself, and is often distributed among many minds. This fact needs to be recognized as a unique type of learning challenge to the individual/group addressing the situation.

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# KA 2: Scale of Learning

Back

**KA2 - Human learning powers are scale-independent.**

- The human mind has limits [Miller (1956), Simon (1974), Warfield (1988)].
- As the number of distinct components to be considered grows, and interrelationships among them expand, the mind reaches a point where its short-term efficacy ceases to exist.

## Demand of Complexity

Underestimating Complexity. The human being needs to stop the self-delusion associated with the belief that the individual can somehow resolve the complexity by simply thinking about it or focusing attention on it.

## KA 4: Need for Evidence

Back

### KA4 - … Irrelevant, just go to "gurus".

- The history of modern management practice involves concepts and methods set forth by "gurus" that lack any significant empirical evidence.
- Despite a total indifference to empirical evidence, the discovery of Spreadthink provides fundamental insights into why groups fail, and why management impositions on organizations seldom benefit from near-consensus.

### Demand of Complexity

**Careful Choice of Processes.** Respectable scientific evidence needs to be applied in choosing or designing processes to support the resolution of complexity.

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## KA 8: Knowledge Integration

Back

### KA8 - … "Just aggregate multiple disciplines…"

- Simple amalgamation of disciplines will relieve disciplinary shortcomings in considering comprehensive domains.
- Interdisciplinary programs typically are founded in the same kind of Killer Assumptions that are prevalent throughout organizations.

### Demand of Complexity

**Emphasizing Learning Process Efficacy.** Processes need to be designed with heavy emphasis on learning efficacy.

# KA 9: Types of Relationships

Back

## KA9 - … Require no special consideration.

- Historically, knowledge is typically structured around substantive elements, with intuitive choice of the types of relationships among those elements. Relationships that are used tend to lie in the background, being accepted as part of received doctrine.
- The elements typically occupy attention, and the types of relationships are taken for granted.

## Demand of Complexity

**Focusing on Relationships as Bases for Inquiry.** Relationships chosen to study a problematic situation need to have as much prominence in the considerations of the practitioners as do the elements to be related.

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# KA 10: Representational Infrastructure

Back

## KA10 - Adequacy of prose.

- Representation of complexity through common quantitative formalisms from physical sciences is adequate for resolution of complexity.
- The vast majority of practitioners effectively avoid meeting a key demand of complexity – to discover and portray the logic underlying the problematic situation – by limiting themselves to prose, by doing statistical studies, or by associating elements in the problematic situation with equations from physics.

## Demand of Complexity

**Becoming Sensitized to Infrastructure Benefits.** Infrastructure needs to support the discovery and high-quality portrayal of the logic underlying the problematic situation through the use of prose, statistics, and mathematical formalisms.

# KA 15: Scientific Infrastructure

Back

## KA15 - Science is the same as technology.

- It is almost always appropriate to discuss science and technology as though there are no essential distinctions between them.
- Warnings of the hazards of failing to make an appropriate distinction between science and technology have been made by Conant in the USA and by Vickers in England, with negligible impact.

## Demand of Complexity

**Demanding Scientifically-Supported Technology.** Technology used to help resolve problematic situations needs to be blessed with a foundation in science, and not just imposed by highly vocal advocates.

# KA 17: Executive Capacity

Back

## KA17 – Executive Capacity Is Adequate.

The executive has the intellectual capacity to comprehend:

- All of the factors that are relevant to an executive decision
- How the various factors are interrelated in a problematic situation
- What alternatives are relevant when it is time to make a choice
- How to prioritize the alternatives
- At what time action should be initiated

The applications literature of Interactive Management shows very clearly that this assumption is virtually never satisfied.

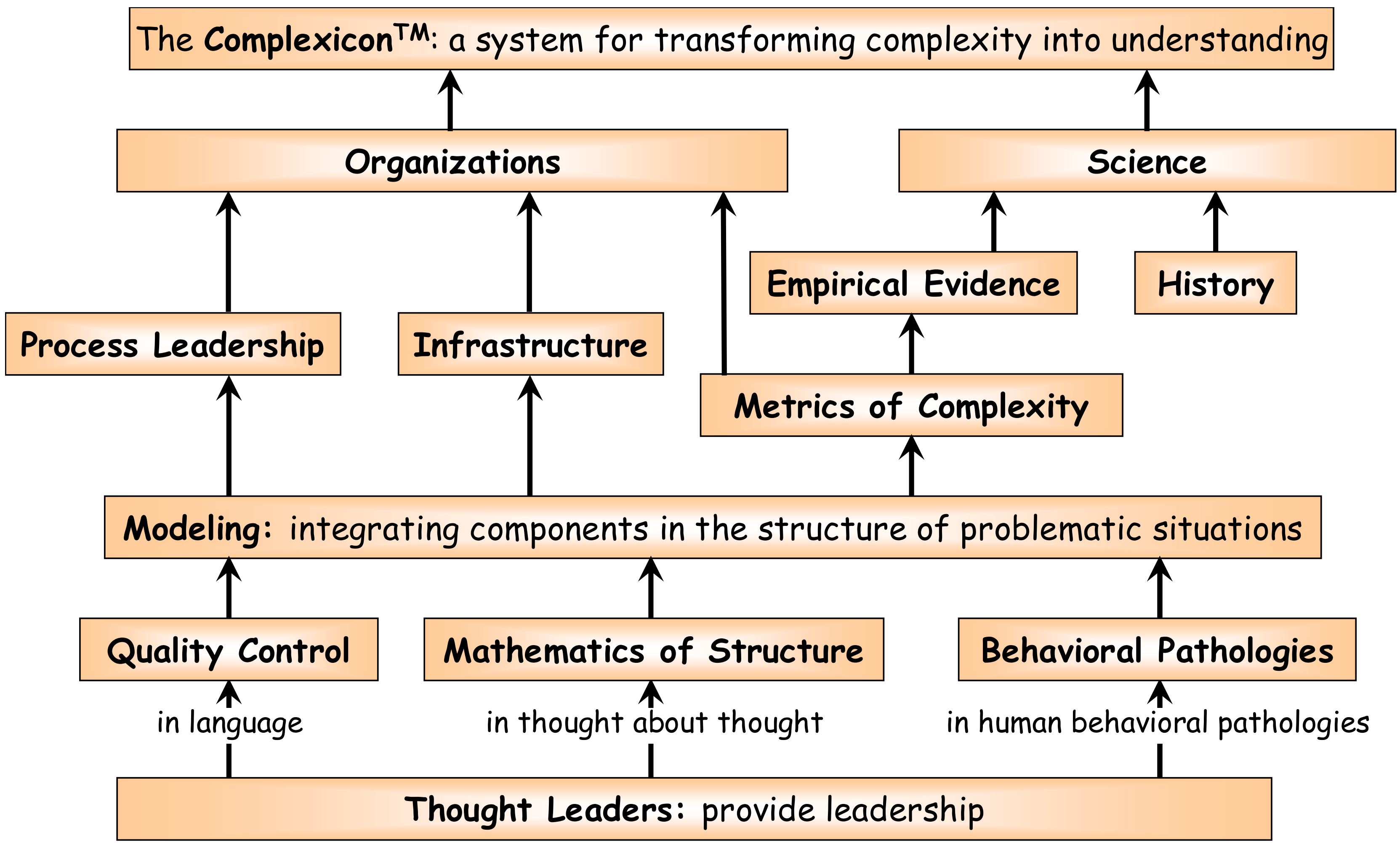
## Demand of Complexity

**Modifying the Role of High-Level Executives.** High-level executives need to be provided with, and take seriously, the products of high-level structural support aligned with the demands of complexity that can inform decisions involving complexity.

# III. Work Program of Complexity

## (process developed to implement the science)

where ↑ = flow of understanding



# Interactive Management (IM)
## (principal implementing system for WPOC)

**Computer-aided, participative process for helping groups work together on complex issues**

**Three phases** for IM: **Planning**, **Workshop**, and **Followup**

IM characterized by the following Portfolios:

- A set of "Success Factors" for each of the 3 Phases
- A set of "Failure Modes" for each of the 3 Phases
- A set of five Success Levels
- A set of well-defined product types
- A set of well-defined processes
- A set of well-defined Roles

IM documentation is specified. Patterns form the core of each of the outcomes.

**Three Outcomes** from IM activity:

(a) **Detailed Definitions** (of a Situation, Issue, or Problem)

(b) **Alternative Designs** (for solving, resolving, or dissolving)

(c) **Choice** (of a preferred alternative)

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# Relevant Behavioral Pathology Studies

| Author(s), Year, Organization | Brief Title |
|---|---|
| Miller (1956), Princeton U.<br>Simon (1974), Carnegie-Mellon U. | Span of Immediate Recall<br>(magical number 7) |
| Lasswell (1960, 1971), Yale U. | Situation Room, 'Observatorium' |
| Tuckman (1965), Ohio St. U. | The Unstructured Four-Stage Group Process |
| Downs (1966) Rand Corp.<br>Downs (1994) Brookings | Predictability of Bureaucratic Behavior |
| Allison (1971), Harvard U. | Groupthink |
| Vickers (1980) | Language Degradation |
| Argyris (1982), Harvard U. | Inertial Hypocrisy |
| Janis (1982), U of CA, Berkeley | Groupthink |
| Warfield (1989), Battelle Mem. Inst. | "Magical Number Three" |
| Alberts (1994), DSMC | Structural Incompetence |
| Warfield (1995) Geo. Mason U. | Spreadthink |
| Kruger and Dunning (1999), Cornell U. | Inaccurate Self-Assessment |

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# Key 'Situation' Metrics of Complexity

## Situation metrics relate to human learning and reasoning

| Name | Description |
|---|---|
| Miller Index | Relates to the number of problems connected to a problematic situation which are generated by the group. |
| De Morgan Index | Relates to the number of distinct binary relationships involved in the problematique development by the group. The aggregate relationships form the problematique. |
| Spreadthink Index | Relates to the differences of opinion among members of an informed group. The individual voting records (generated using the Nominal Group Technique) are aggregated following the generation and clarification of the problem set. |
| Situational Complexity Index (SCI) | This index is formed as the product of the Miller, De Morgan, and Spreadthink Indexes. |
| Aristotle Index | Relates to the number of syllogisms found in the problematique. |

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# V. Selected Laws

**Work Program of Complexity contains two principal components - Discovery and Resolution**

**Discovery** – reflects idea that no one person understands the complexity; includes ***description*** and ***diagnosis***

- Resolves many issues related to behavioral pathologies
- Assists in development of an appropriate object language for the given context or situation

**Resolution** – is initiated once sufficient understanding is achieved in Discovery; includes ***design*** and ***implementation***

- Incorporates recognized need for resources to implement design
- Recognizes that resources are normally found only in organizations due to size and scope of complexity

**The Laws of Complexity** – are typically applied within the WPOC component most directly concerned with the outcome of allocation of behavior between individuals, groups, the organization and processes (See Behavior-Outcomes Matrix)

# Behavior Outcomes Matrix

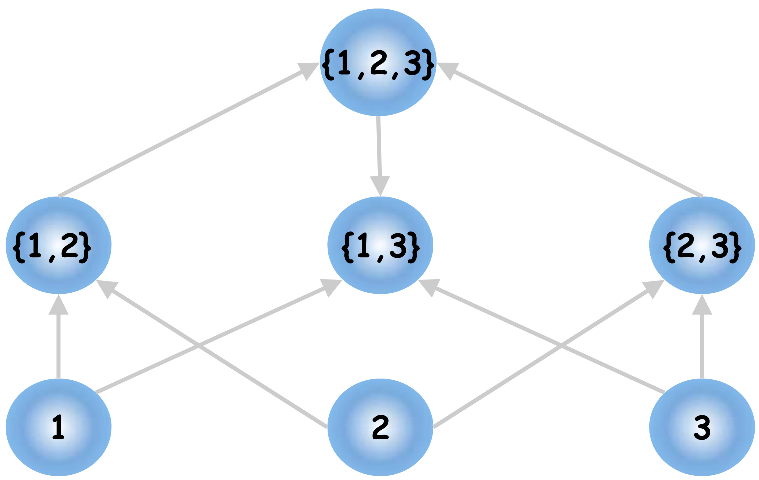
| BEHAVIOR / OUTCOMES | Description | Diagnosis | Prescription (Design) | Implementation |
|---|---|---|---|---|
| **Process** | • Limits<br>• Triadic Necessity & Sufficiency<br>• Universal Priors | • Success & Failure<br>• Universal Priors | | • **Gradation**<br>• Validation |
| **Individual** | • Limits<br>• **Triadic Compatibility**<br>• Small Displays | | • Requisite Parsimony<br>• Requisite Saliency | |
| **Group** | • Limits<br>• Uncorrelated Extremes | • Inherent Conflict<br>• Structural Underconceptual-ization<br>• Diverse Beliefs | • Requisite Variety<br>• Induced Groupthink | |
| **Organiza-tional** | • Limits<br>• Organizational Linguistics<br>• Vertical Incoherence | • Forced Substitution<br>• Precluded Resolution<br>• Vertical Incoherence | | |

# Law of Triadic Compatibility

**Quantifies the limitations of short-term memory as they relate to human decision making**

**The human mind can recall and operate with seven concepts:**

- Three elements
- The four combinations associated with three elements



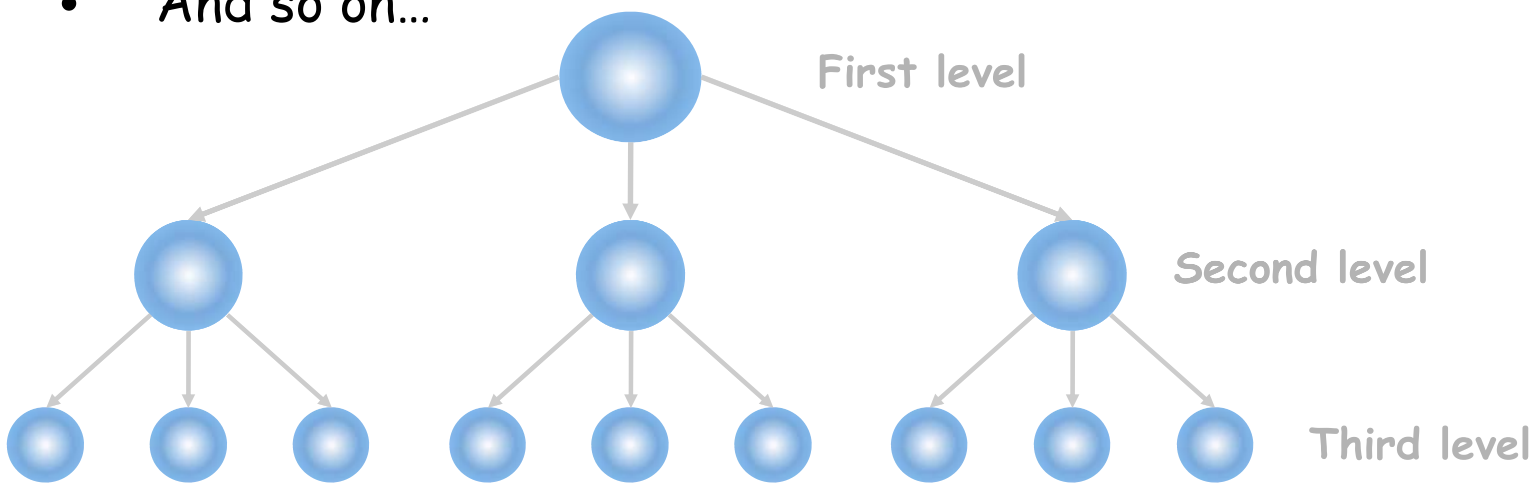

**The human mind is compatible with the need to explore interactions among a set of three elements**

**Capacity cannot be presumed for a set that both has four members, and for which those members interact**

# Corollary to Law of Triadic Compatibility
## Principle of Division by Threes

**Iterative division of a concept as a means of analysis is mind compatible if each division produces at most three components, thereby creating a 'tree' with**

- One element at the top
- At most three elements at the second level
- At most nine elements at the third level
- And so on…



# Law of Gradation

**Any conceptual body of knowledge can be graded in stages, such that there is:**

- One simplest stage
- One most comprehensive stage (reflecting the total state of relevant knowledge)
- Intermediate stages whose content lies between the two extremes

**This law provides guidance to the designer concerning how to perceive any particular Design Situation**

- Design targets may range from the very small, limited-scope to the very large, broad-scope"
- Overt recognition that design situations and targets are themselves graded

# Law of Gradation – JNW Comments

"Generic" does not mean "always required;" it does mean "covering the set of gradations as a whole, subject to judicious restriction commensurate with the grade…"

It ***is not*** the function of a Science of Generic Design to provide a recipe appropriate to every design situation.

It ***is*** the function of such a Science to 'actuate' the designer's professional responsibility to :

- Assess and correlate the gradation in situation and target against the total sweep of the Generic Design Science
- Choose that restricted version of the Science which will be used openly, rather than to accept a restricted version that leads to underconceptualization of the Design
- Provide the means of documentation consistent with what the Situation requires

# VI. Example Application – Systems Security

**Problematique: Growing Need for Security in Systems**

Asset Protection Model (APM) developed to address the use of human expertise from multiple fields, coupled with a recursive design for adaptive computer support

- A common taxonomy does not exist for asset protection, with components of threat, target, and system
- Language differences exist within each of these contexts
- Wide variety of expertise within each application context

**System Science Basis for APM Development**

- Use of Law of Triadic Compatibility
- Use of Corollary of Division by Threes
- Use of Law of Gradation

# VI. Example Application – Systems Security

## Asset Protection Model

(APM) developed to address the use of human expertise from multiple fields, coupled with a recursive design for adaptive computer support

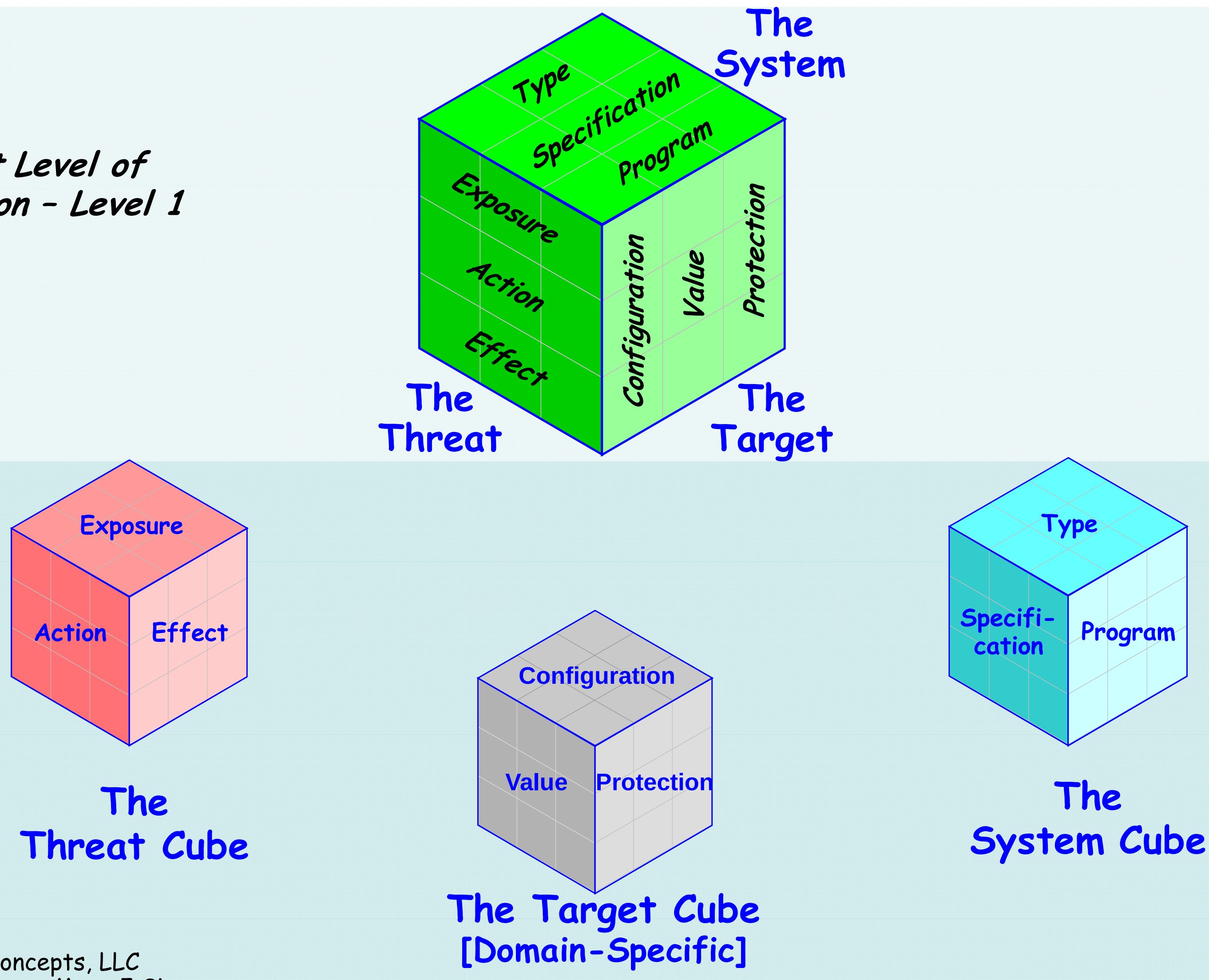
- Common taxonomy created for asset protection (AP)
- 3 AP components are threat, target & system
- 3 threat components are action, effect & exposure
- 3 target components are value, protection & configuration
- 3 system components are specification, program & type

Information Assurance and Cybersecurity Domain chosen to develop instance of 'generic' model

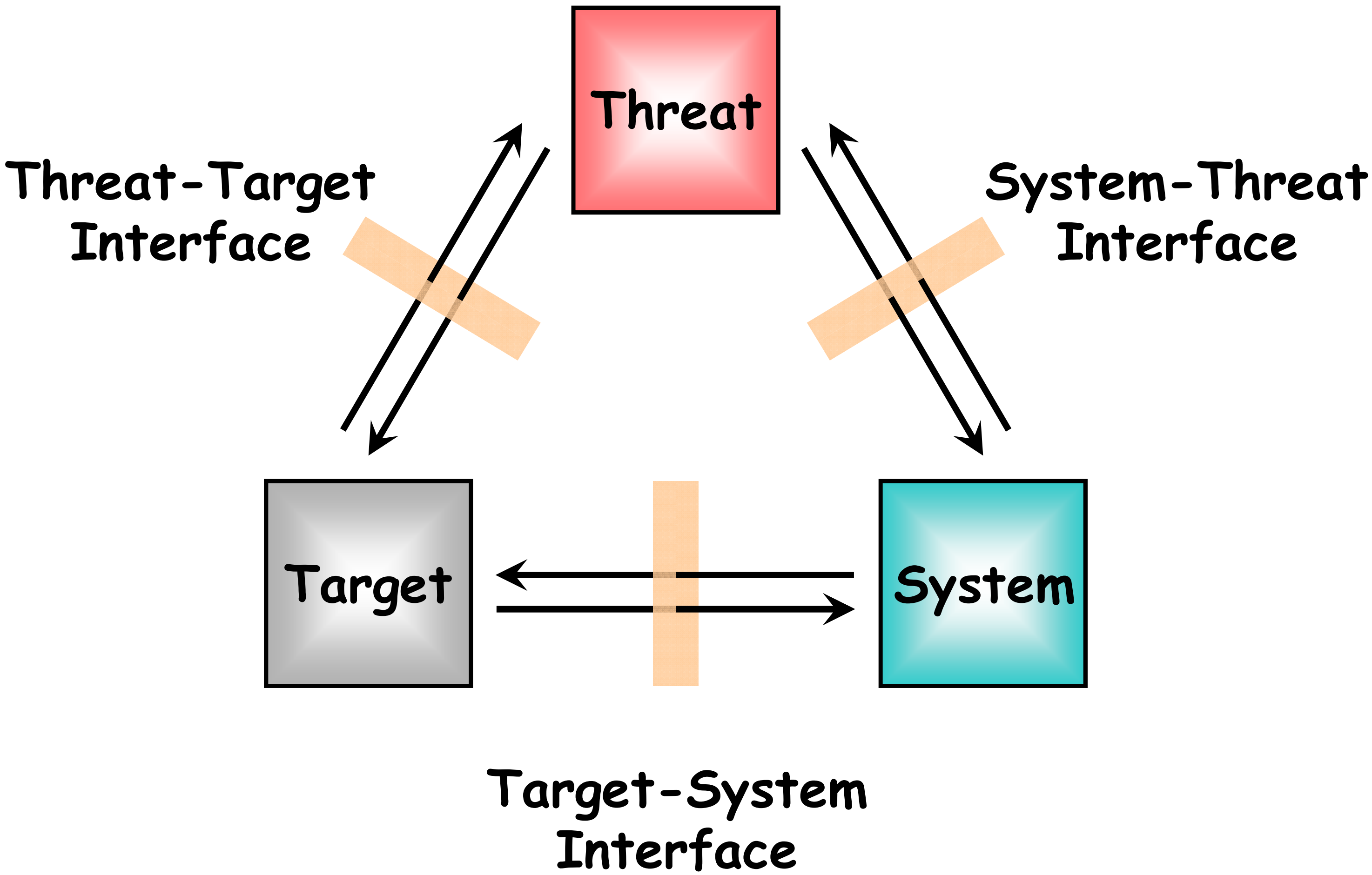
# Example: Asset Protection Model – Systems Security

*Highest Level of Abstraction – Level 1*

*Abstraction Level 2*



# Example: APM - Level One Interface Map



## Information Assurance & Cybersecurity APM Development

Coordinated by the Center for Information Assurance and Cybersecurity at the University of Washington, under the leadership of Dr Barbara Endicott-Popovsky

Invitation extended for Systems expertise & collaboration in ongoing development of the System Cube

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# VII. Summary

**Warfield's Work Program of Complexity for Systems Science**

- Has a rigorous logic, scientifically-derived from historical research and enterprise applications
- Uses carefully defined qualitative and quantitative prose, mathematics, and graphics
- Helps to solicit, evaluate, and prioritize
  - Sets of problem definitions
  - Alternative designs for solving and/or resolving these problems
  - The choice of a preferred alternative.

**For Additional Information:** http://www.jnwarfield.com/