# Can holistic thinking support us in finding innovative solutions for our customers?

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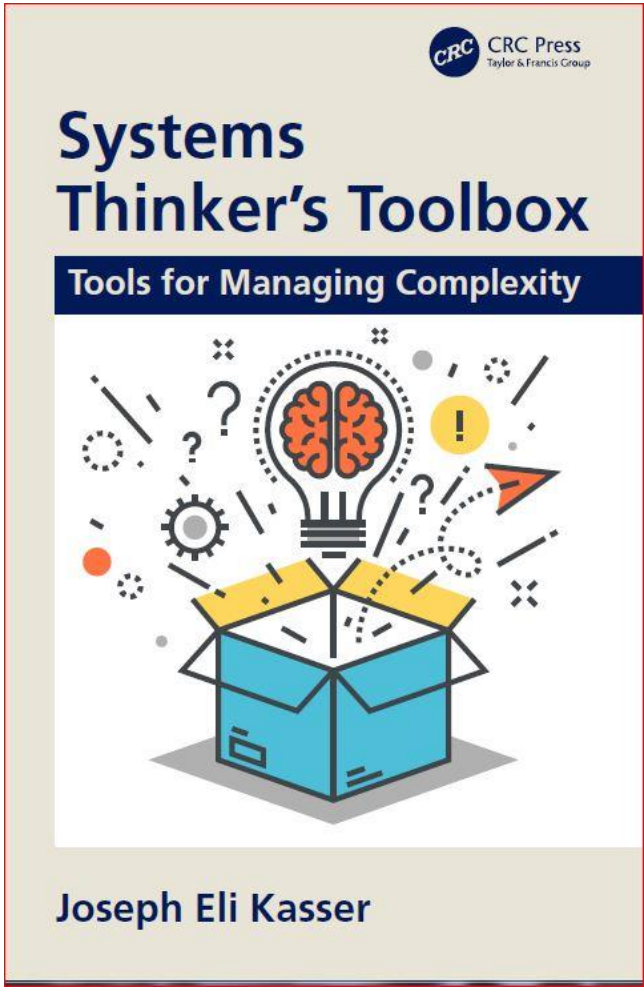
Rev 0.1.3

# Topics

- Problem-solving
- Holistic thinking
  - Systems thinking and beyond
- Tools
- Finding innovative solutions
  - Using the tools
- Questions and comments



# The systems approach to problem-solving

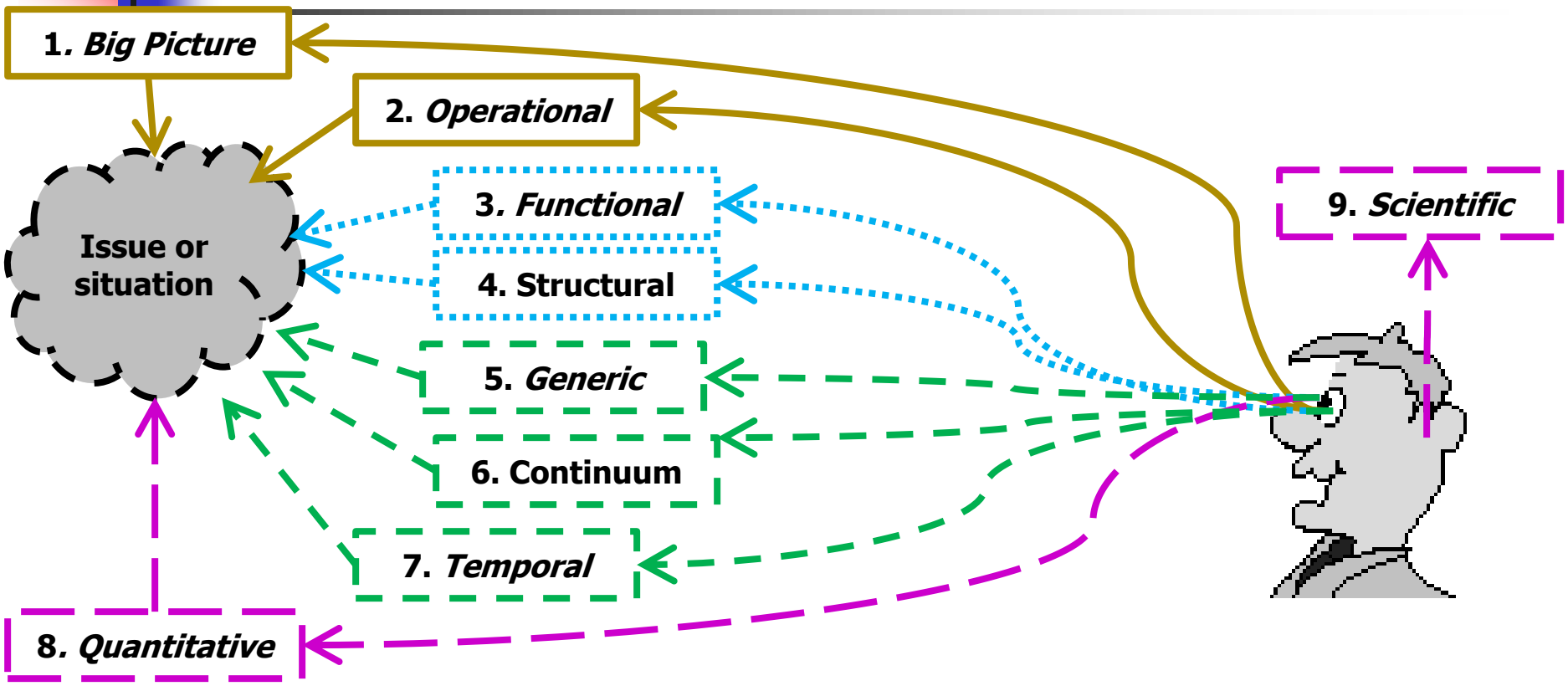
1. Examine an undesirable situation from **a number** of perspectives
   - List actors, issues and relationships
2. Understand the situation
3. Determine root cause of undesirability
   - The problem is to eliminate the root cause(s), not the causes
4. Conceptualize a **number of situations** without the undesirability
   - **feasible** desirable situations, acceptable solutions
5. **Select** one situation
6. Perform the transition from the undesirable situation to the selected Feasible Conceptual Desirable Situation
7. Ensure the new situation does not have any undesirability

**Do this in a systemic and systematic manner**

# Perspectives Perimeter (PP) (TT)

- Provides the advantage of multiple views
- Minimizes communication errors
- Maximizes shared meaning
- Ensures everybody is on the same page or wavelength
- Provides an understanding why there might be misunderstandings and misinterpretation
- Reduces complexity by providing a framework for sets of perspectives
  - List
- Provides a template for storing information
  - Ideal for case studies

# The Holistic Thinking Perspectives (TT)




| External | Internal | Progressive | Remaining |
|---|---|---|---|
| 1. Big picture | 3. Functional | 5. Generic | 8. Quantitative |
| 2. Operational | 4. Structural | 6. Continuum | 9. Scientific |
| | | 7. Temporal | |

# External and internal perspectives

- **External perspectives:**
  - **(traditional systems thinking)**
  1. ***Big Picture:*** the context for the system and any assumptions pertaining to the system
  2. ***Operational:*** what the system does:
     - a black box perspective
     - **Causal loops**
- **Internal perspectives:**
  - **(traditional analysis)**
  3. ***Functional:*** what the system does and how it does it
     - a white box perspective
     - **Causal loops**
  4. ***Structural:*** how the system is constructed and organized

# Progressive and remaining perspectives (beyond systems thinking)

- **Progressive perspectives:**
  5. ***Generic***: where the system is perceived as an instance of a class of similar systems
     - **A systematic approach to finding out of the box solutions**
  6. ***Continuum:*** where the system is perceived as but one of many alternatives; differences
     - **Out of the box**
  7. ***Temporal:*** which perceives the past, present and future of the system
- **Remaining perspectives:**
  8. ***Quantitative:*** the numeric and other quantitative information associated with the system
  9. ***Scientific:*** **a prescriptive perspective**; the hypothesis or guess about the issue, cause and solution

     "e.g. what if we …" ?, " I think that …"

# Benefits of going beyond systems thinking*

| | | | |
|---|---|---|---|
| **Ability to find** similarities among objects which seem to be different<br>Generic perspective | High | Problem solvers | Innovators |
| | Low | Imitators, Doers | Problem formulators |
| **"Ability to find" generally comes from application of *Generic* and *Continuum* perspectives** | | Low | High |
| | | **Ability to find** differences among objects which seem to be similar<br>Continuum perspective | |

* Table based on Gordon G. et al. "A Contingency Model for the Design of Problem Solving Research Program", Milbank Memorial Fund Quarterly, p 184-220, 1974 cited by Gharajedaghi, System Thinking: Managing chaos and Complexity, Butterworth-Heinemann, 1999

# Example: houses

1. ***Big picture*** – location, purpose, assumptions
2. ***Operational*** – scenarios (Use Cases) of weekday morning, afternoon, evening, as well as weekend and holiday activities
3. ***Functional*** – functions performed in scenarios
   - e.g. eating, sleeping, reading, talking, accessing the Internet, etc.
4. ***Structural*** – electrical, plumbing, heating, cooling, etc.
5. ***Generic*** – similarity with other houses and buildings and structures serving same purpose (e.g. tents, apartments)
6. ***Continuum*** – differences from other houses and buildings and structures serving same purpose (e.g. tents, apartments)
7. ***Temporal*** – evolution of houses over time
8. ***Quantitative*** – numbers of rooms, costs, prices, land size, etc,
9. ***Scientific*** – depends on problem/issue

# Example: metro travel paying for travel ticket

- *Structural* perspective


- *Operational* perspective
  1. Card accepted
  2. Card rejected
  3. No connection

     Store and issue ticket

     Accept occasional loss
- *Continuum* perspective
  - Two card cheats

Risk management built in

# Don't Care (TT)

- Simplifies dealing with Objective complexity
- **Systematic thinking tool**
- **Critical thinking tool**
- Requires subject matter expertise
- Removes irrelevant clutter
  - Extracts signals from noise
- Contributes to applying the KISS principle (TT)
- For each idea, is it applicable in the situation?
  - Yes, why?, keep it
  - No, why not?
  - Can it be modified for the situation?
  - Store it for future reference (do not throw it away)

How you process ideas from brainstorming

# Problem Formulation Template (Thinking tool [TT])

1. ***The undesirable situation***
   - as perceived from the HTPs
2. ***Assumptions***
   - assumptions about the situation, problem, solution, constraints etc. that will have an impact on developing the solution
3. ***The Feasible Conceptual Future Desirable Situation (FCFDS)***
   - as perceived from the HTPs
4. ***The problem***
   - how to convert the FCFDS to reality.
5. ***The solution***
   - Remedies the undesirable situation
   - Has to be interoperable with evolving adjacent systems over the operational life of solution and adjacent systems
   - Is made of two interdependent parts
     a. the SDP or transition process that converts the undesirable situation to a desirable situation, and
     b. the solution system operating in the context of the desirable situation.

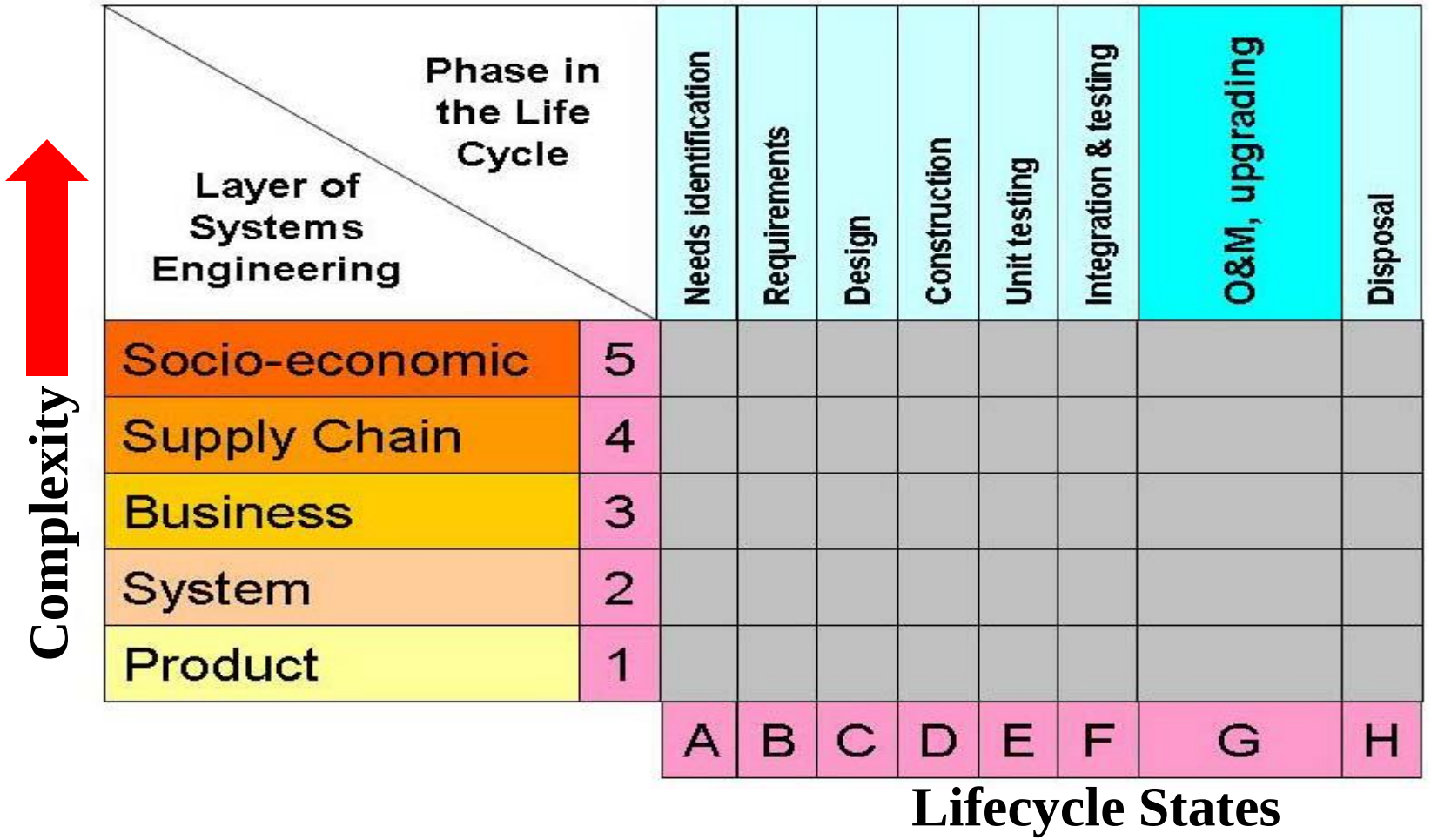
# Finding out-of-the-box solutions

1. ***The undesirable situation***
   - The need to find an out-of-the-box solution to a problem
2. ***Assumptions (innovative idea)***
   - Everyone is working in a box (*Generic* perspective)
3. ***The Feasible Conceptual Future Desirable Situation (FCFDS)***
   - An out-of-the-box solution has been found
4. ***The problem***
   - How to convert the FCFDS to reality.
5. ***The solution*** (*Generic* HTP)
   - Hypothesis: An out-of-the-box solution in one box comes from a solution to the same/similar problem in another box
   - Locate the appropriate boxes
   - Use the "Copy Cat" TT
   - Similar to TRIZ

# Organizing the boxes (*Structural* HTP)

1. By activities in the workplace (HKMF)
2. By knowledge and experience
3. By any other organized framework
4. Look for (as a start)
   - Similarity (*Generic* perspective)
     - TRIZ is one way
   - Difference (*Continuum* perspective)
- Multidisciplinary and experience

# The HKMF

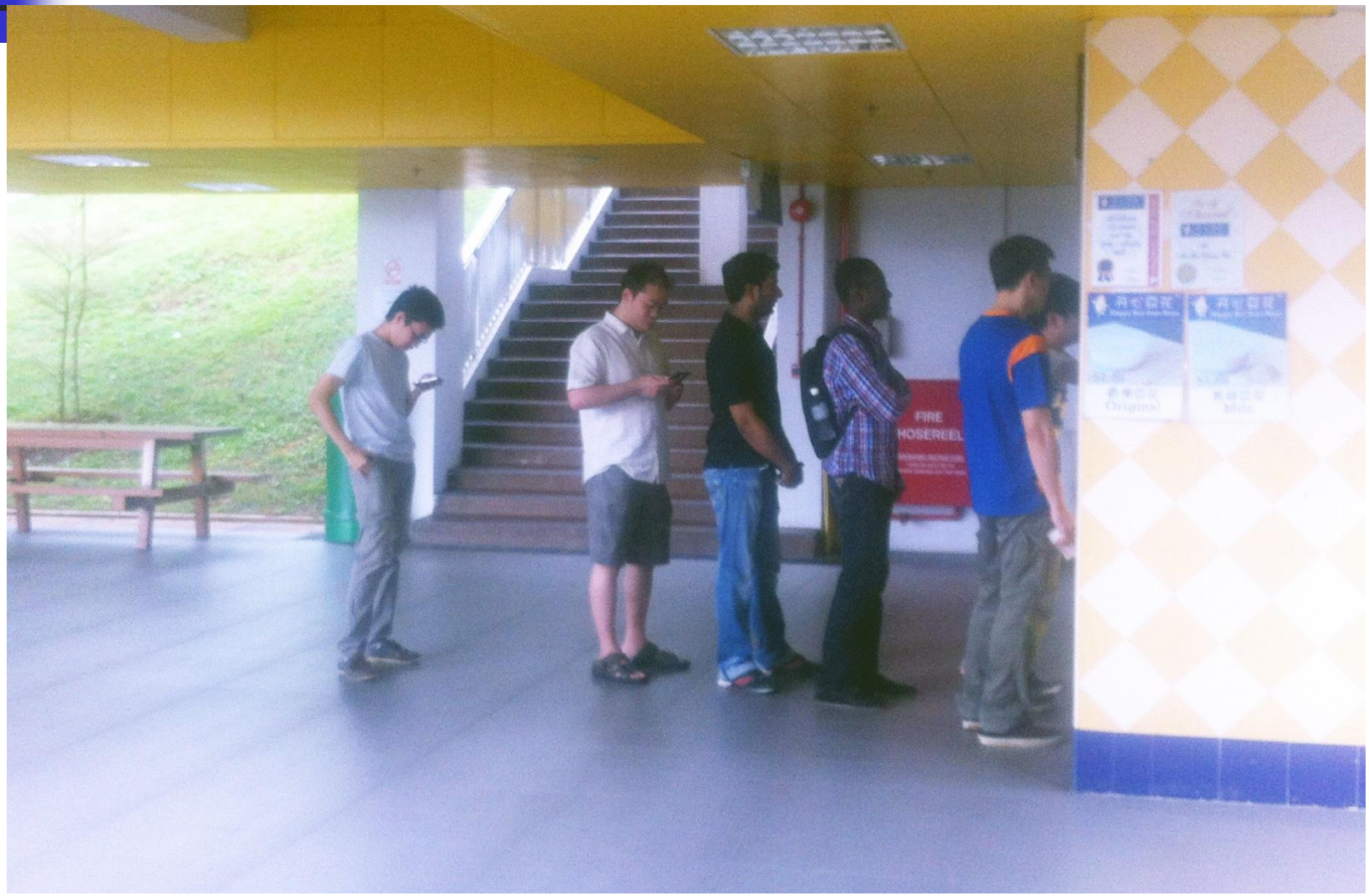


# By knowledge and experience (Table view)

| Domain | Fiction | Arts | Engineering | Sciences |
|---|---|---|---|---|
| Space | | | | |
| Air | | | | |
| Surface – land | | | | |
| Surface – water | | | | |
| Subsurface - land | | | | |
| Subsurface - water | | | | |

- Search horizontally and vertically
- Look at benchmarking candidates
- Look at same function different domain

# Example: kiosk queue problem



# Gaining an understanding The Kipling questions (TT)

- What …?
- Where …?
- When …?
- How …?
- Why …?
- Who …?

I have six honest serving men
They taught me all I knew
I call them What and Where and When
And How and Why and Who

(Kipling 1912)

# Active Brainstorming: (TT)
# HTP Matrix for triggering ideas

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **HTP** | **Who?** | **What?** | **Where?** | **When?** | **Why?** | **How?** |
| **B**ig picture |  |  |  |  |  |  |
| **O**perational |  | | | | | |
| **F**unctional | | | | | | |
| **S**tructural | | | | | | |
| **G**eneric | | | | | | |
| **C**ontinuum | | | | | | |
| **T**emporal | | | | | | |
| **Q**uantitative | | | | | | |
| **S**cientific | | | | | | |

There may not be an immediate answer to every question
**Input tool, not a storage tool**

# Constraint mapping (Dunn, 2012)
# Matrix for triggering ideas

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **Perspective** | **Who?** | **What?** | **Where?** | **When?** | **Why?** | **How?** |
| **Physical** |  |  |  |  |  |  |
| **Legal** | | | | | | |
| **Organizational** | | | | | | |
| **Political** | | | | | | |
| **Distributional** | | | | | | |
| **Budgetary** | | | | | | |
| **Other** | | | | | | |

Other: schedule, etc. use as appropriate

There may not be an immediate answer to every question
**Input tool, not a storage tool**

# Constraint mapping (Dunn, 2012) Active Brainstorming

| | Physical | Legal | Organizational | Political | Distributional (Benefits) | Budgetary | Other |
|---|---|---|---|---|---|---|---|
| Big Picture | | | | | | | |
| Operational | | | | | | | |
| Functional | | | | | | | |
| Structural | | | | | | | |
| Generic | | | | | | | |
| Continuum | | | | | | | |
| Temporal | | | | | | | |
| Quantitative | | | | | | | |
| Scientific | | | | | | | |

Pose Kipling questions in each area of the matrix

# Systemic and systematic use of PPs

- Systemic
  - Reuse of same applicable PPs each time
- Systematic
  - Use Active Brainstorming via Kipling Questions
  - According to the problem-solving process
  - Store ideas systemically and systematically
    - Idea Storage Templates (TT)
      - OARP, FRAT and SPARK

# Typical *Operational* perspective questions

- **Who** is going to operate/administrate it?
- **What** do they need to operate/administrate it?
- Under **what** conditions will it be operated?
- **Where** will they operate it?
- **When** will they operate it?
- **Why** will they operate it?
- **How** will they operate it?
- **How** will they gain access to it?

# Typical *Generic* perspective questions

- **Who** has had a similar problem?
- **What** is this similar to?
- **What** does this remind you of?
- **What** applies to both situations?
- **Where** can I find a similar situation?
- **When** was there/will there be a similar situation?
- **Why** is this similar/different?
- **How** is this similar/different?

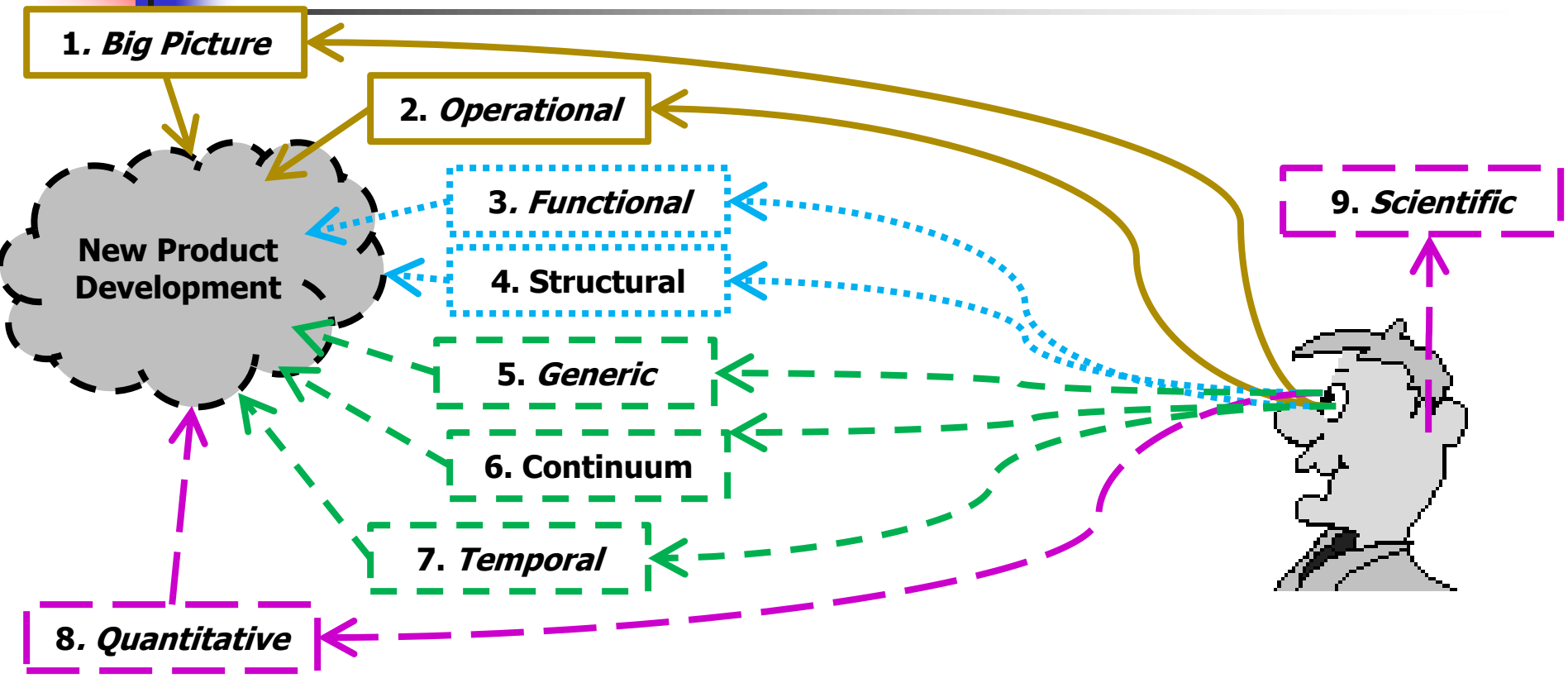
# Exercise

1. (unknown) Can holistic thinking support us in finding innovative solutions for our customers?
2. Formulate problem
3. Examine question from following HTPs
   - *Big Picture, Operational, Functional, Structural, Generic, Continuum, Temporal, Quantitative*
4. Answer Question (yes or no?)
   - *Scientific* perspective

# Problem Formulation Template (Thinking tool [TT])

1. ***The undesirable situation***
   - Don't know if holistic thinking can support us in finding innovative solutions for our customers
2. ***Assumptions***
   - Open minds
3. ***The Feasible Conceptual Future Desirable Situation (FCFDS)***
   - We know if holistic thinking can support us in finding innovative solutions for our customers
4. ***The problem***
   - How to convert the FCFDS to reality.
5. ***The solution***
   - Use active brainstorming to examine application of holistic thinking to new product development
   - Infer answer to question posed in presentation title

# Perceiving New Product Development

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| | | 7. Temporal | |

# *Big Picture* perspective

- Many companies developing products
- Lots of competition
- Shortening development schedules
  - Time to market
- Customers don't always know what they want or need
- Customer's willingness to pay
- Complexity and complex problems

# *Operational* perspective

- Integrated multidisciplinary product development teams
- Following problem-solving process
  - People tackling all three types of problems
    1. Well-structured
    2. Ill-structured
       - **Ill-structured problems cannot be solved (Simon, 1973)**
    3. Wicked

# *Structural* perspective

1. The HKMF
2. Definition of complexity
   - Large number of elements
   - Large number of interactions between elements
   - Unpredictable outcomes in many definitions
3. Structure of problem
   1. Well-structured
   2. Ill-structured
   3. Wicked

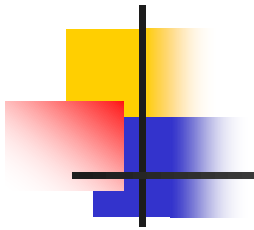
# Structure of the problem

1. Well-structured
   - The existing undesired situation and the FCFDS are clearly identified.
   - May have a single solution (e.g. mathematics)
   - Often more than one acceptable solution
2. Ill-structured
   - Either or both the existing undesired situation and the FCFDS are unclear
3. Extremely ill-structured
   - Wicked and Messy problems

# Wicked problems*

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

* Shum, S. B., *Representing Hard-to-Formalise, Contextualised, Multidisciplinary, Organisational Knowledge*, proceedings of Workshop on Knowledge Media for Improving Organisational Expertise, 1st International Conference on Practical Aspects of Knowledge Management, Basel, Switzerland, 1996.



# *Generic* perspective

- Similarity between
  - Needs
  - Problems
  - Solutions
- Concept of inheritance
- Out-of-the-box solutions

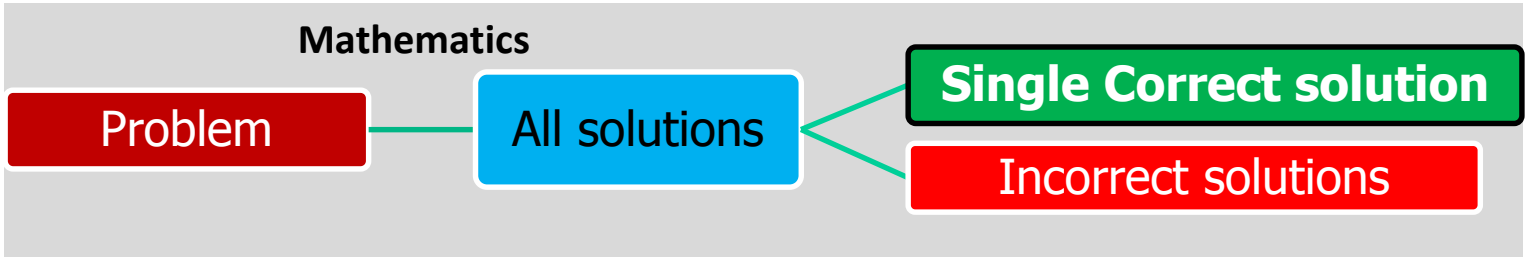
# *Continuum* perspective

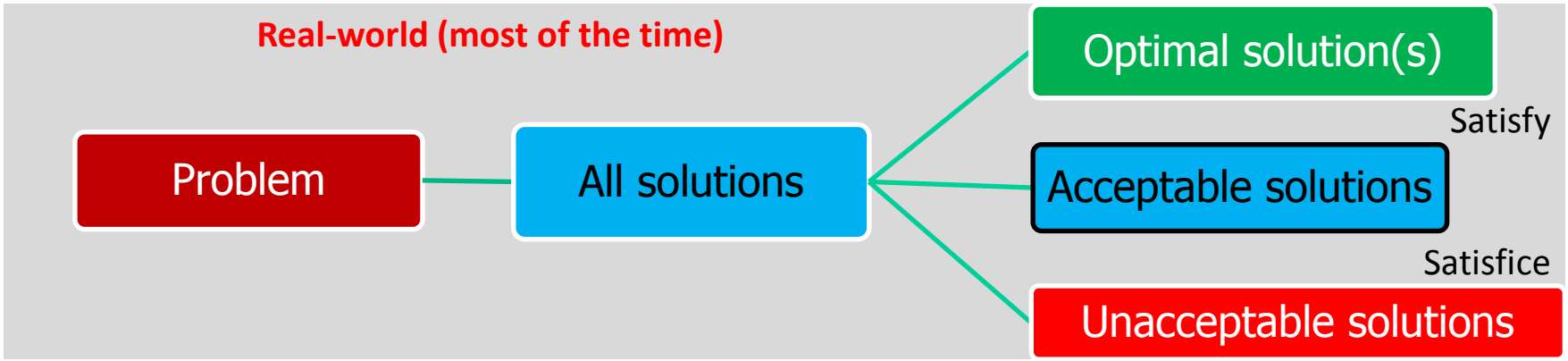
- Difference between
  - What customers want
  - What customers need
- Products (solutions) may be
  - Biological
  - Chemical
  - Procedural
  - Technological
  - Other
  - Combination of above

# Complexity : *Continuum*

1. Two solution paradigms
2. The dichotomy
3. Confusion between complex problems and Wicked problems
4. Complexity can be split into
    1. Objective complexity
    2. Subjective complexity
    3. Artificial complexity
5. Types of problems
    1. Research
    2. Intervention

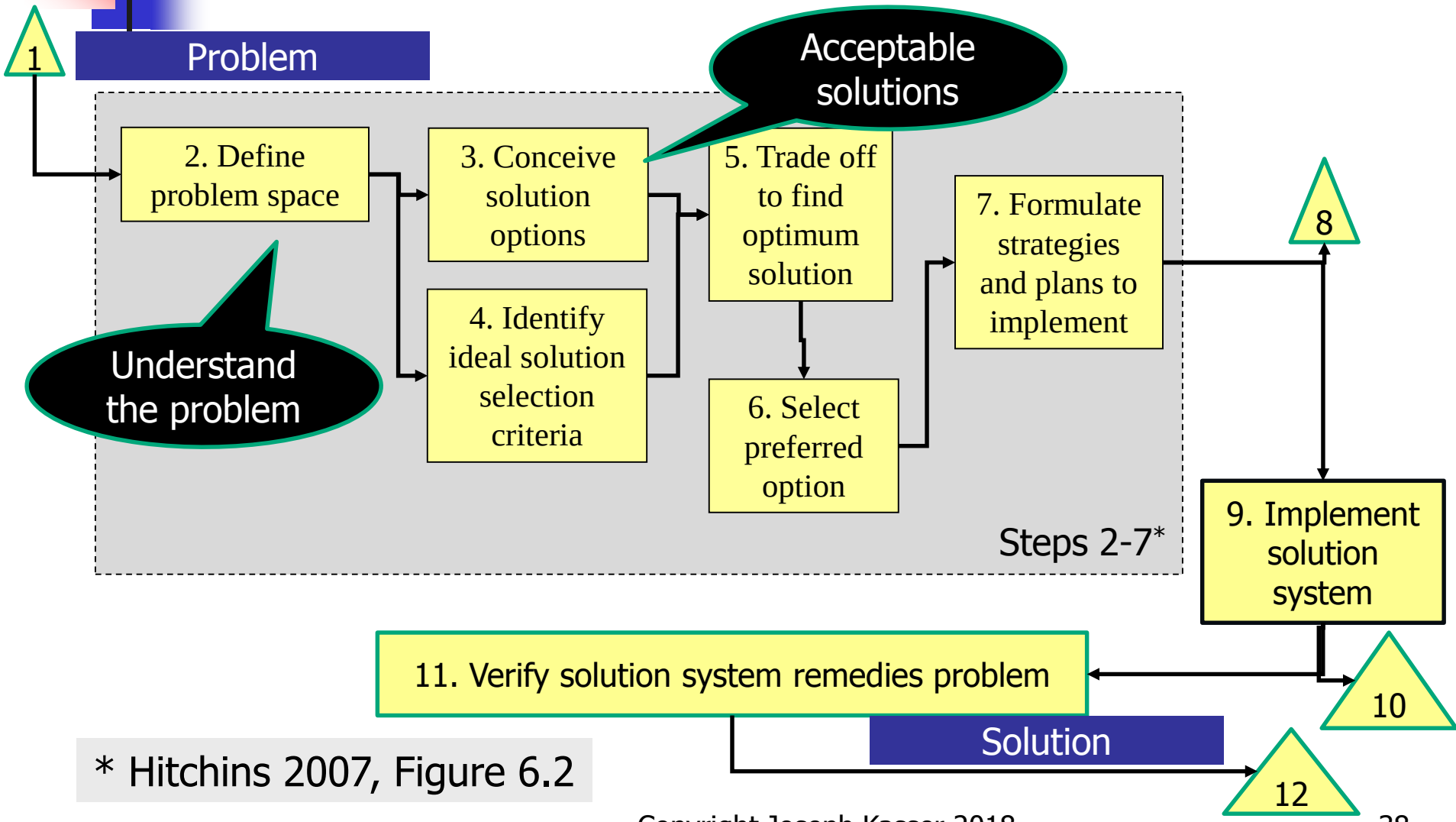
# Two problem-solution paradigms




Linear process

# System Development Process (SDP)
# A systematic problem-solving process
# (*Functional* HTP)




* Hitchins 2007, Figure 6.2

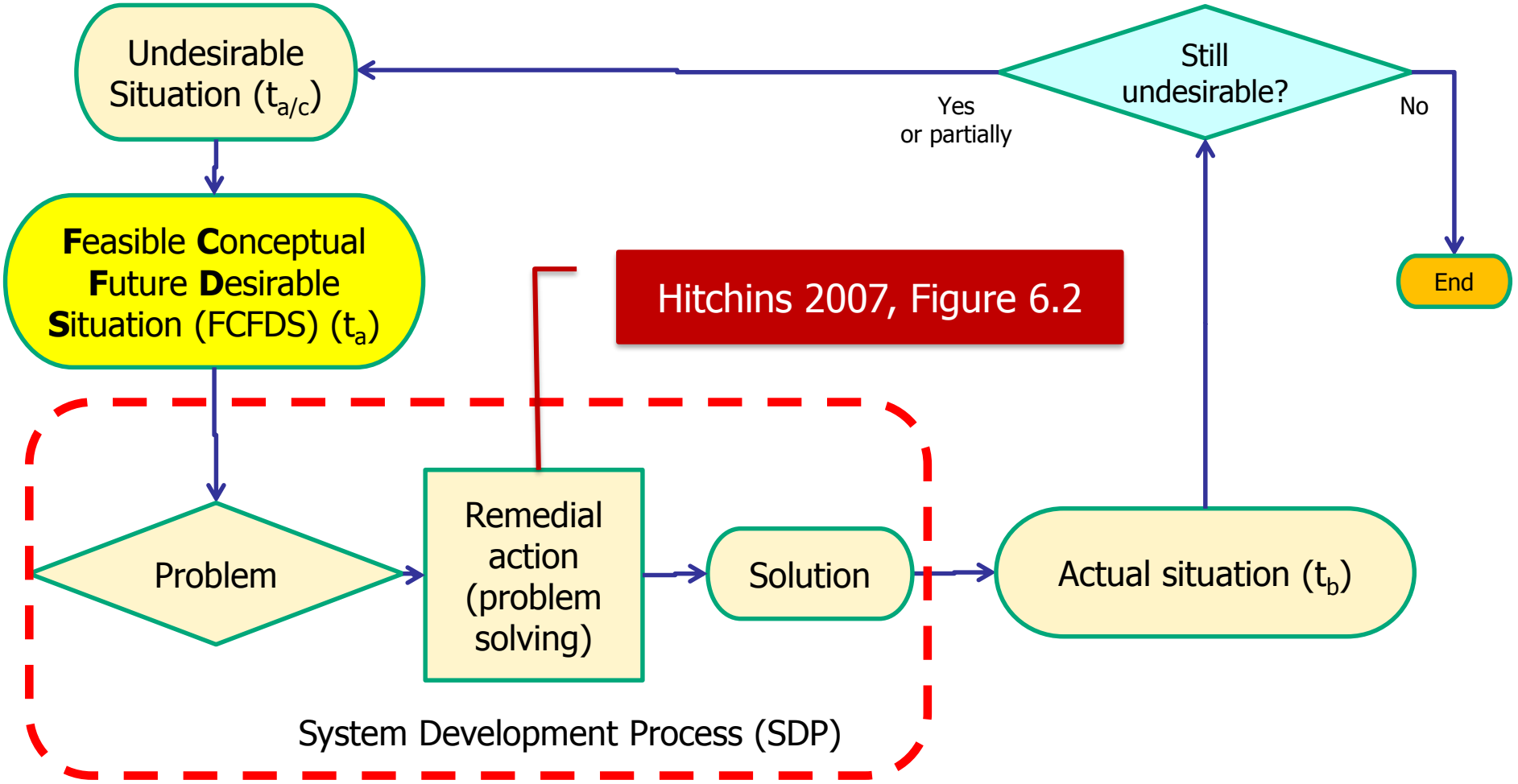
# Design thinking*

1. **Empathize:** Gather facts and get to know about what users do, say, think, and feel. Define the problem space
2. **Define:** Combine the gathered facts, analyze user's unmet needs and begin to highlight opportunities for innovation. Define the problem
3. **Ideate:** Brainstorm creative ideas that address the unmet user needs. Conceptualize solutions
4. **Prototype:** Transform ideas into a physical form to allow experience and interaction with them and, in the process, learn and develop more empathy. Select solution and build it
5. **Test:** Observe and gather feedback to refine prototypes, learn more about the user, and innovate the original ideas. Validate solution
6. **Implement**: Put the vision into effect. Ensure that the solution is put into action and affects the lives of the end Operations and maintenance

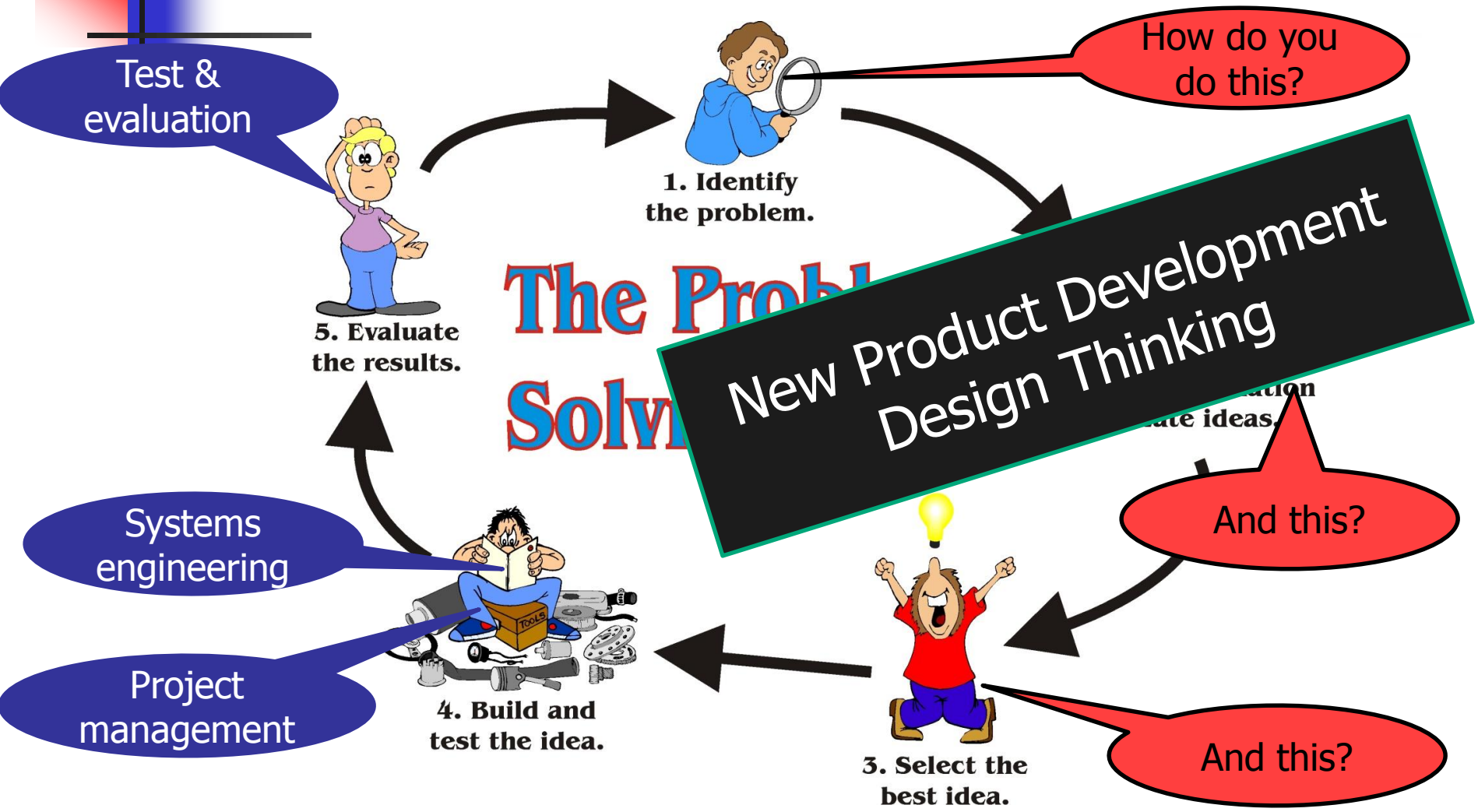
*https://slidemodel.com/templates/design-thinking-powerpoint-templates/, accessed 7 Sept 2018

User involvement

# Holistic extended problem-solving process (functional view - multiple pass)



# The recursive problem-solving loop



# 1. Research problems

1. **The undesirable situation** is either
    1. The inability to explain observations of phenomena
    2. The lack of (need for) some particular knowledge
2. **Assumptions**
3. **The Feasible Conceptual Future Desirable Situation (FCFDS)** is the knowledge often in the form of the supported hypothesis
4. **The problem** is how to gain the needed knowledge
5. **The solution** is the FCFDS
6. **The problem solving process** is commonly known as the Scientific Method (SM), and works forwards
    - From the current situation
    - To the FCFDS in which the knowledge has been acquired
        - You don't know where you are going until you get there

# Approach to dealing with situations
# Scientific Method

8 Descriptive HTPs

Observe

Understand

FCFDS

Research

Formulate problem statement (hypothesis)

Scientific HTP

Remedial action

Test hypothesis

Refuted

Supported

Verify solution system remedies problem

# 2. Intervention problems

1. **The undesirable situation** is when something needs to be changed over a period of time into a FCFDS
2. **Assumptions**
3. **The FCFDS** is the changed situation
   - You visualize where you are going to end up
4. **The problem** is how to realize a smooth and timely transition from the current situation to the FCFDS
5. **The solution** is
   - The FCFDS
   - The intervention process
6. **The problem solving process**
   - *Works backwards* from the FCFDS to the current problematic situation
     - Documenting the realization plans as a *forward process*
       - Starting from the current situation
       - Ending with the deployment of the FCFDS.

# *Temporal* perspective

- Objective complexity of products has increased over time
  - Solutions to increasingly complex needs
- Aggregation of functionality increases over time
  - Electronic components > printed circuits > integrated circuit
  - Daughter boards migrate to mother board for standardized functionality
    - Everything needed in an office pc is on the motherboard

# *Quantitative* perspective

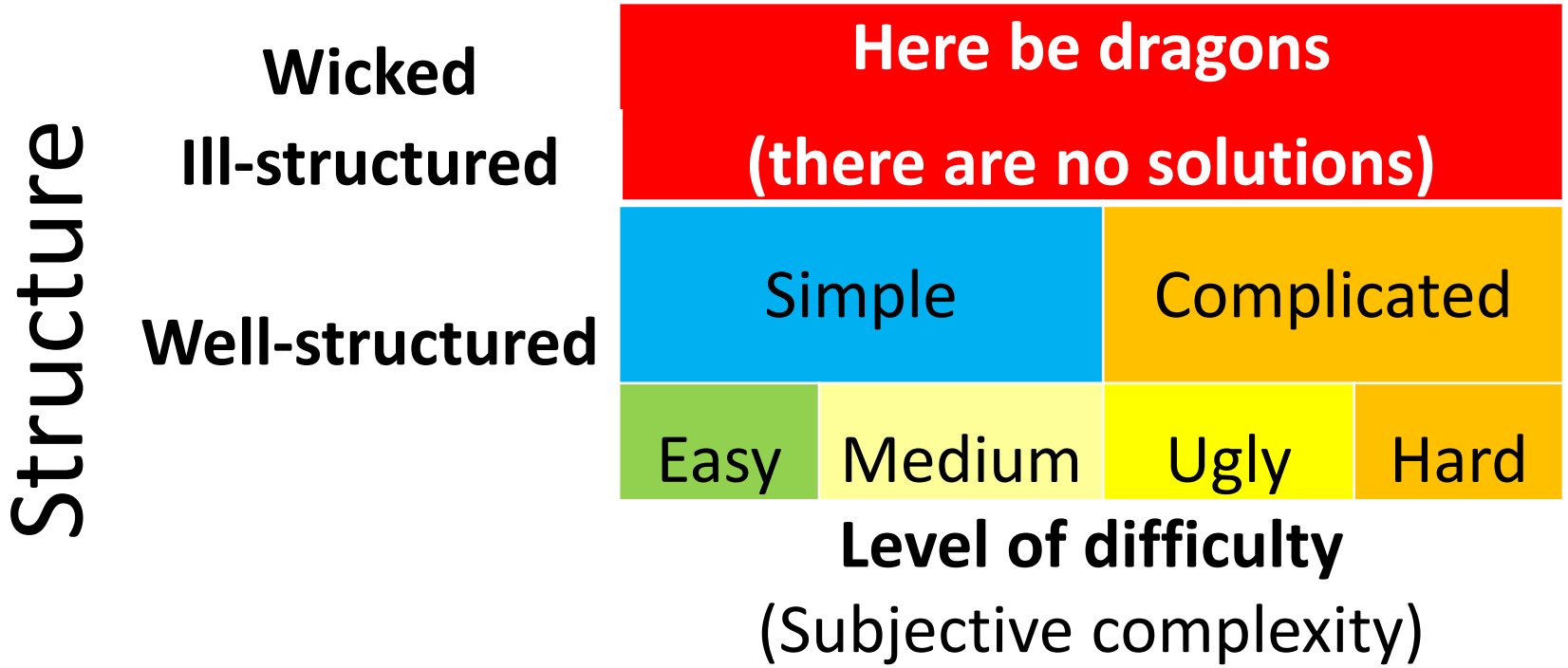
- Levels of difficulty of problem (TT)
  - Subjective complexity
- Customers may not realize the true cost of what they are asking for

# Level of difficulty* (subjective complexity)

1. ***Easy***
   - Can be solved in a short time with very little thought
2. ***Medium***
   - Can be solved after some thought
   - May take a few more steps to solve than an easy problem
   - Can probably be solved without too much difficulty, perhaps after some practice
3. ***Ugly***
   - Will take a while to solve
   - Involves a lot of thought and many steps
   - May require the use of several different concepts
4. ***Hard***
   - Usually involve dealing with one or more unknowns
   - Involves a lot of thought and some research
   - May also **require iteration through the problem-solving process** as learning takes place

* Based on Ford, W., Learning and teaching math, 2010, http://mathmaine.wordpress.com/2010/01/09/problems-fall-into-four-categories/, accessed on 21 September 2015

# Subjective complexity



# *Scientific* perspective

- Problem-solution paradigms
- Difference between need and want
- Dealing with the three problem structures
  - Well-structured
  - Ill-structured
  - Wicked
- Needs can be inherited from class of product/problem

Key insight

# Needs, wants and problems

- Difference between
  - What customers want
  - What customers need

| Customers | | Know what they need: Yes | Know what they need: No |
|---|---|---|---|
| Know what they want | Yes | Well-structured problem | Ill-structured problem |
| | No | Ill-structured problem | Well-structured problem |

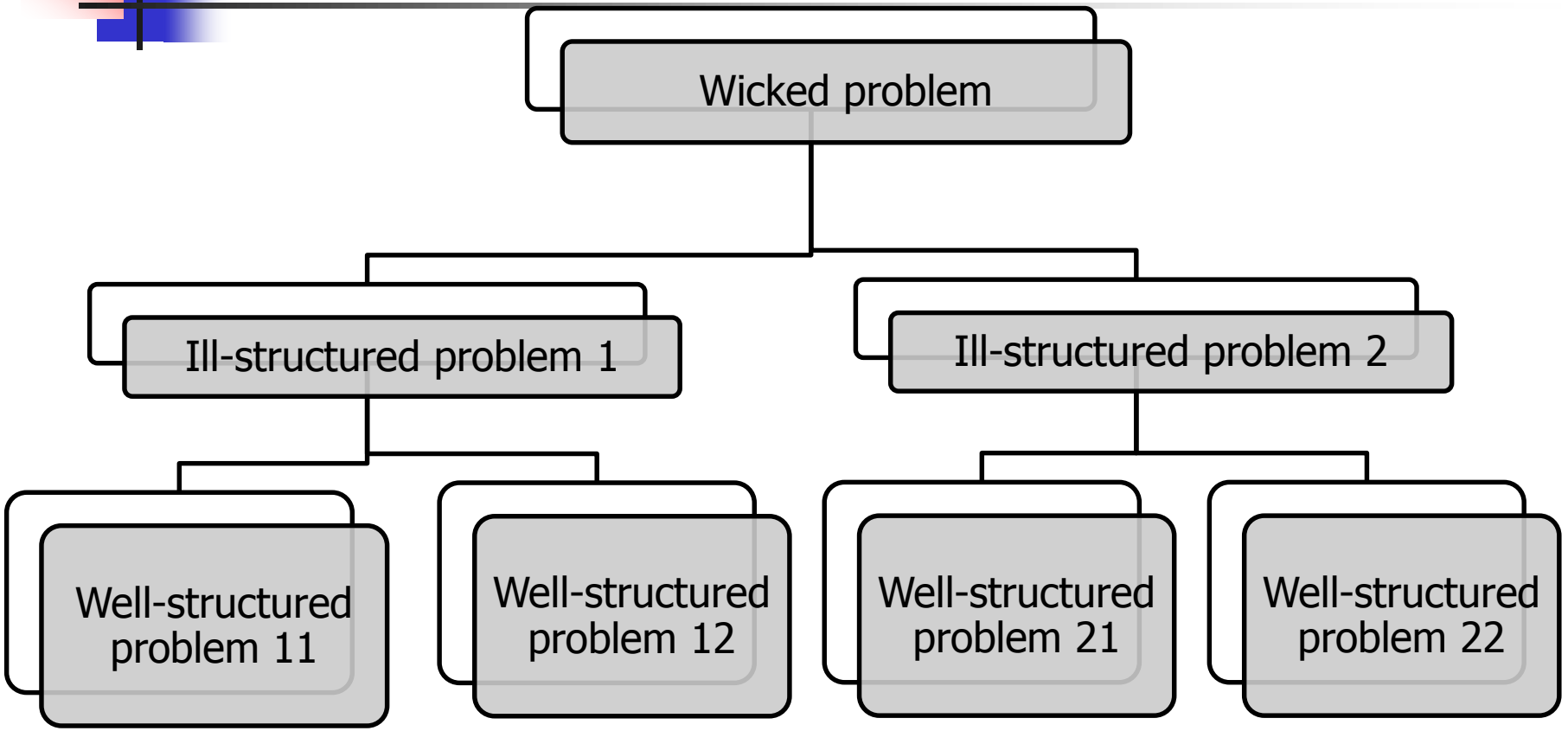
# Needs and wants continuum

- Ideal world
  - Wants = needs
- Real world
  1. Customers know what they need
  2. Customers don't know what they need
  3. Customers want what they need
  4. Customers don't want what they need
  5. Customers want what they don't need
  6. Customers don't want what they don't need

# Bounding the problem

- Confusion between complex problems and Wicked problems (extremely ill-structured problems)
  - Need to separate
- *Ill-structured problems cannot be solved* (Simon, 1973)
- Ill-structured problems have to be converted to a (set of) well-structured problem(s)
- (set of) well-structured problem(s) are/is solved via iterations of the problem-solving loop
  - Prioritize and take action

# Problem decomposition (TT)




*Generic* HTP: system decomposition into subsystems, problem decomposition into sub-problems

# Establishing need

| Customers | | Know what they need | |
|---|---|---|---|
| | | Yes | No |
| Know what they want | Yes | | Ill-structured problem |
| | No | Ill-structured problem | Well-structured problem |

- Convert Ill-structured problem to Well-structured problems
  1. Inherit need from class of problem/product
  2. Use Copy Cat (TT) adjusting for context
  3. Create first concept
  4. Interact with customer
  5. Estimate cost and time to market
  6. Use Systems approach to Design to Cost

# Systems approach to Design to Cost

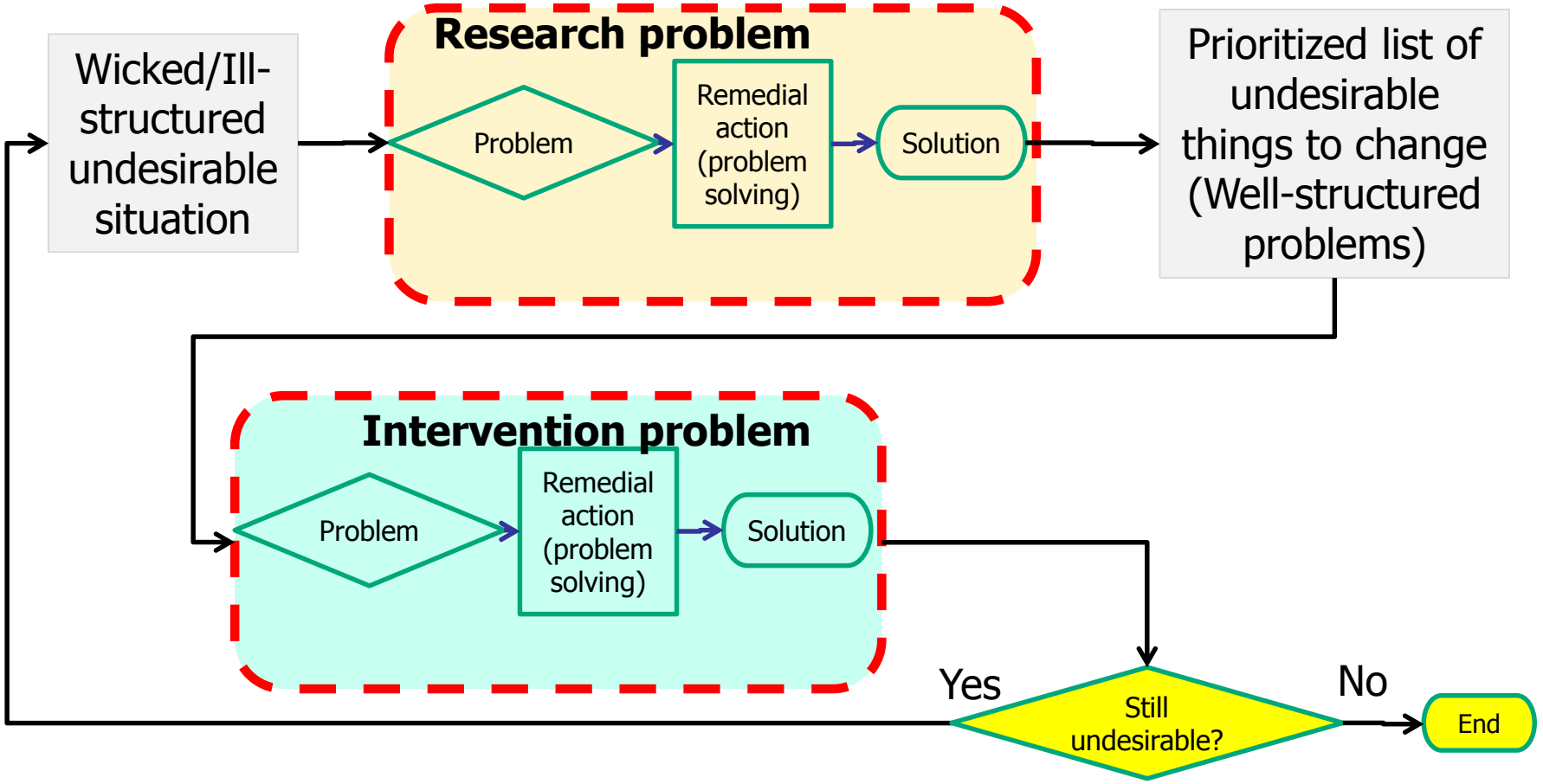
1. Produce initial set of wants (requirement requests)
    1. Prioritize, schedule and cost needed wants
    2. Discuss unneeded wants, if customer/user insist they want it, don't argue (hidden need?), prioritize and cost
2. Once complete, iterate until affordable
    - Remove low priority, and/or high cost wants
        - in conjunction with customer/user
3. What is left becomes the requirements (willing to pay)
4. Schedule product releases

- Can do this with list of wants, or with conceptual designs using priority and cost as section criteria

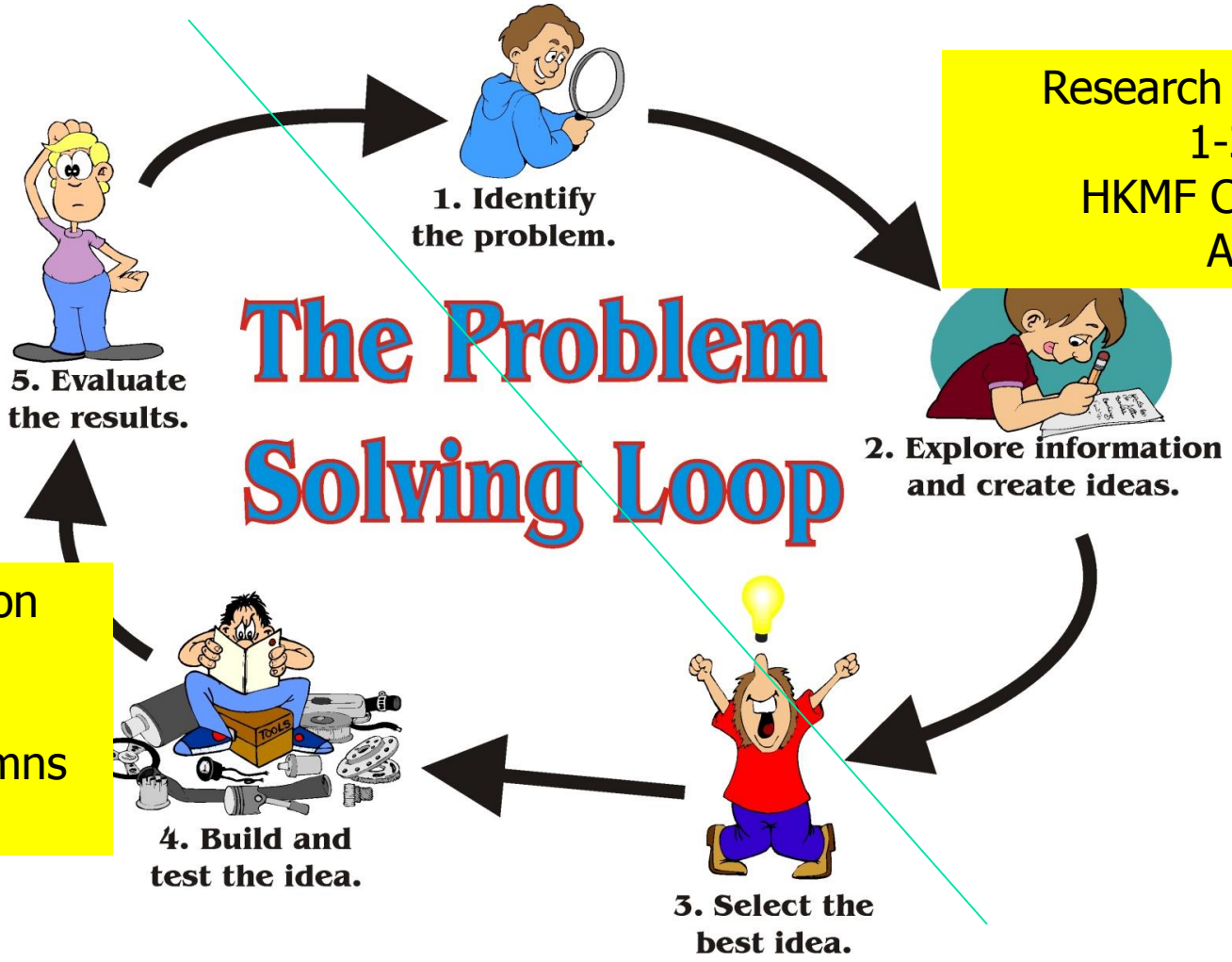
**The customer shall always be satisfied**

# Iterative problem-solving (TT)

- Sequential research and intervention problems



# Anchoring the problems in the loop




Research problem
1-3
HKMF Column
A

Intervention problem
4-5
HKMF Columns
B-F

# Understanding the situation

- Distinguishing between subjective and objective complexity
- Abstracting out non-pertinent aspects of the situation
  - Minimizing artificial objective complexity by
- Understanding the relationships between the parts of the system and the emergent properties
  - Reducing subjective complexity
- Partitioning the situation to optimize the situation (system)
  - Principle of hierarchies (TT)
- Applying the tools and techniques suited for the appropriate layer in the HKMF
- Using multiple partial views of the system instead of complex and complicated single views (TT)

# Example: Camera

1. ***Big picture*** – where cameras are used and for what purpose
2. ***Operational*** – captures images, transported safely, views images, adjusts settings, charges battery
3. ***Functional*** – capturing images, storing images, retrieving images, deleting images, battery charging functions, etc
4. ***Structural*** – camera, camera case, recharger
5. ***Generic*** – painting, sketching and other image capture methods/devices
6. ***Continuum*** – different models of cameras
7. ***Temporal*** – evolution from plates to film to solid state
8. ***Quantitative*** – numbers pixels per inch, lens characteristics, etc
9. ***Scientific*** – depends on problem/issue

# What's the problem?

1. Understanding how a camera works
   - *Functional* and *Structural* perspectives
   - System bounds
     - Camera

Closed system

2. Capturing images
   - *Operational* perspective
   - System bounds
     - Camera and operator
3. Transporting camera
   - *Operational* perspective
   - System bounds
     - Camera, operator and camera case
4. Recharging camera
   - *Operational* perspective
   - System bounds
     - Camera, operator, charger

Four different systems or one system - four views?

# Functional/Structural decomposition

| | Understanding how it works | Capturing Images | Transporting camera | Recharging battery |
|---|---|---|---|---|
| Camera | X | X | X | X |
| Camera Case | | | X | |
| Charger* | | | | X |
| Operator | | X | X | X |

- Low weight need may lead to the separate charger because it is not used at the same time as capturing images

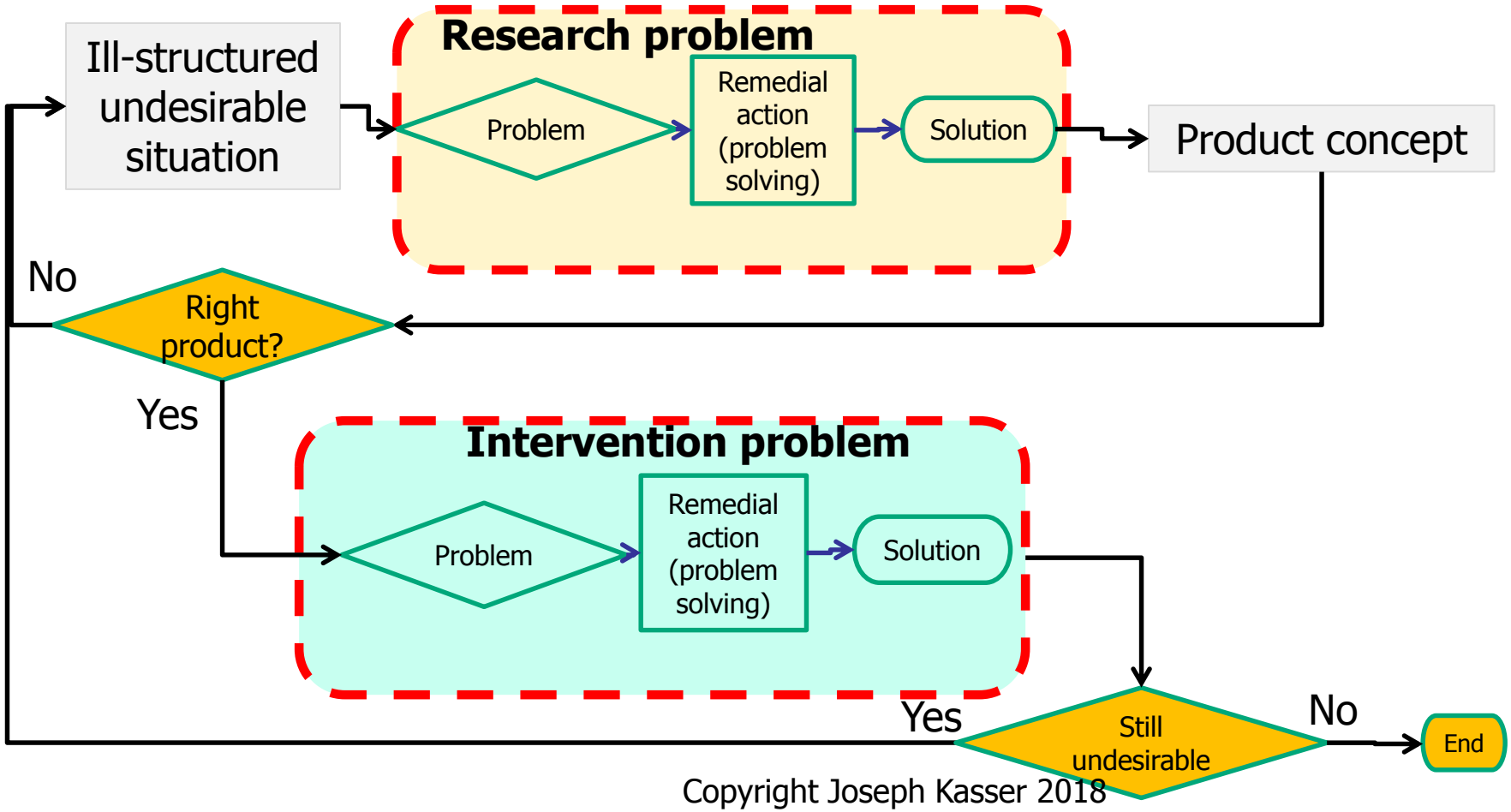
- Traditional approach shows which scenario cares about which components
- Don't care is the reverse
  - Different perspective

# Recommendations

1. Remember what Simon says
    1. *Generic* perspective with child's game
2. Convert Wicked problems and Ill-structured problems to a set of Well-structured problems, prioritize and iterate the problem-solving loop
3. Use Scientific Method to create an understanding of complex situation
4. Use *Generic* perspective to determine/inherit needs

# New product development

- Sequential research and intervention problems



# What contributes to success?

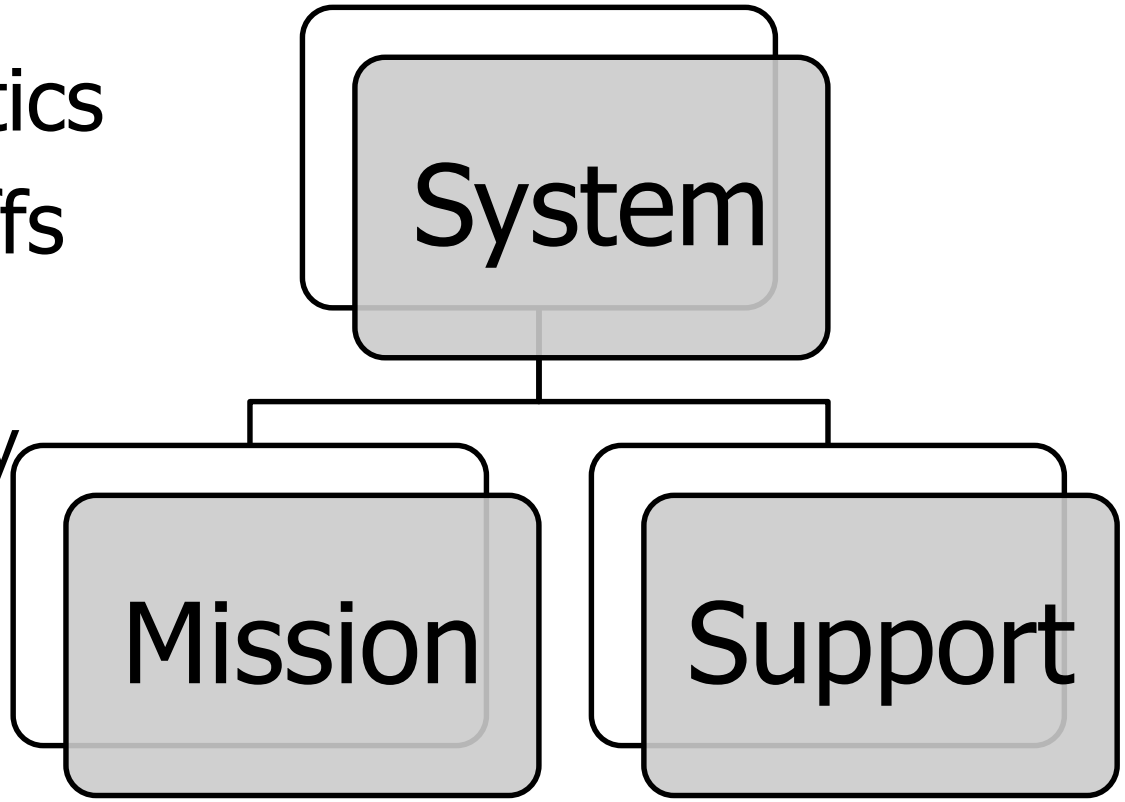
1. Bounding the problem
2. Problem Formulation Template
3. Copy cat
    1. Templates
    2. Process for tacking a problem
4. Compliance Matrix
5. Don’t care
6. Principle of Hierarchies
7. 100+ systems thinking tools

# Templates (TT)

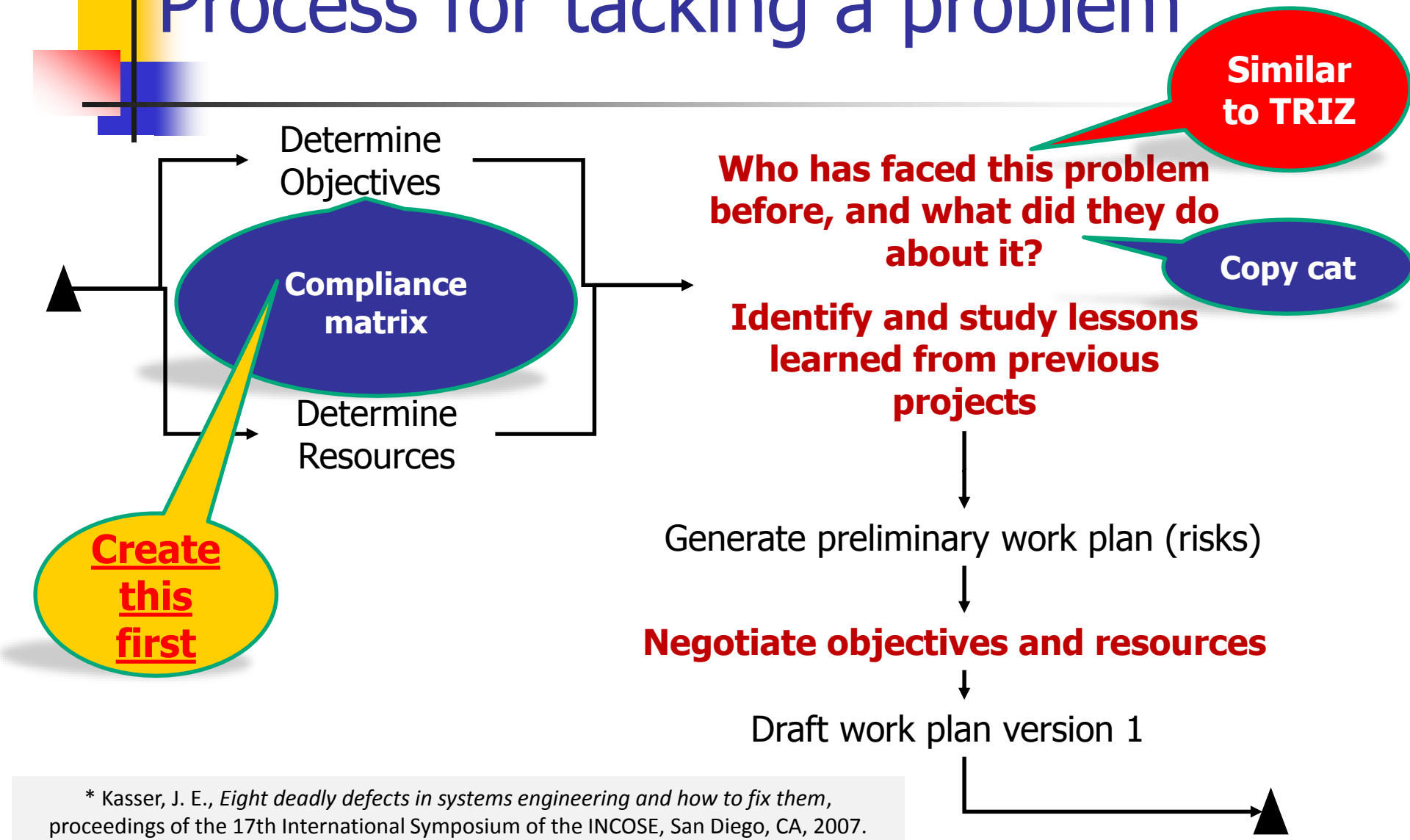
- First thing to look for when starting a project (TT)
  - *Structural* perspective for format
  - *Generic* perspective for content
- Provide reminders for what needs to be in the product
- Similar products can be used as templates (*Generic* perspective)
- Systems engineering document templates available in MIL-STDs and on Internet
- Used to scope and set up products in projects
  - Outlines for books and other documents
  - Presentation outlines in class exercises and professional environments
  - Etc.

# System template

- Builds in logistics
- Allows tradeoffs
  - Reliability
  - Maintainability



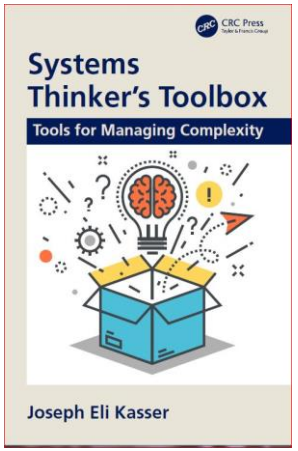
# Process for tacking a problem




* Kasser, J. E., *Eight deadly defects in systems engineering and how to fix them*, proceedings of the 17th International Symposium of the INCOSE, San Diego, CA, 2007.

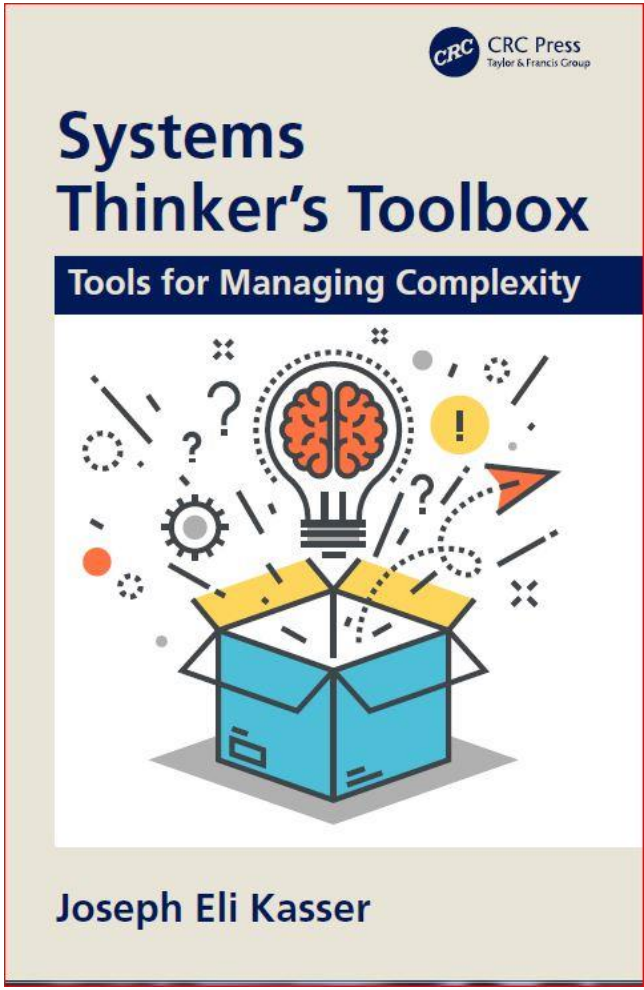
# 100+ systems thinking tools

- Concept maps
- CRIP Charts
- Enhanced Traffic Light Charts
- Golden rules
- Idea storage templates
  - OARP
  - FRAT
  - SPARK
- The KISS principle
- Lists
- Miller's rule
- $N^2$ Charts
- Occam's Razor
- PAM Charts
- Prevention
- TAWOO
- Thank you
- Working Backwards from Solution
- And more



# Summary

- Problem-solving
- Holistic thinking
  - Systems thinking and beyond
- Tools
- Finding innovative solutions
  - Using the tools
- Questions and comments



# Exercise

1. (unknown) Can holistic thinking support us in finding innovative solutions for our customers?
2. Formulated problem
3. Examined question from following HTPs
   - *Big Picture, Operational, ~~Functional,~~ Structural, Generic, Continuum, Temporal, Quantitative*
4. Answered Question (yes or no?)
   - *Scientific* perspective

# Questions and comments?