Modelling Sustainable Systems and Semantic Web

Modelling Contradictory Requirements in TRIZ

Lecture in the Module 10-202-2309
for Master Computer Science

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Notion of a Technical System

(V. Petrov, 2020)

A **system** is a set of *elements* which are *interconnected* and *interact with each other*, which form a *unified whole* which has *properties* that are not already contained in the constituing elements considered individually.

Such a property is referred to as a **system effect**, **synergy**, or **emergence**.

Synergy is the overall effect of the interaction of two or more factors, characterised by the fact that this overall effect clearly exceeds the effect of each of the components and their simple sum.

TS as Reduction to the Essential

The reduction to the essential ...

... focuses on the following three dimensions:

(1) Delimitation of the TS from the outside against an *environment*, reduction of this relationships to input/output relations and guaranteed throughput (Purpose and ability to work).

(2) Delimitation of the TS from the inside by grouping parts as *components*, reducing their functioning on a "behavior control" via their interfaces.

(3) Reduction of the relationships in the TS itself to *causally essential* ones.

Technical Systems and Antecedence

The TS in the World of Technical Systems

The description of a TS is only possible based on descriptions of other (explicitly or implicitly given) TS. The description is anteceded ...

(1) ... by a vague idea of the (working) input/output characteristics of the environment.

(2) ... by a clear understanding how the components work beyond their pure specification.

(3) ... by a vague idea of cause and effect relationships in the system itself, that precedes the detailed modeling.

Components and Objects

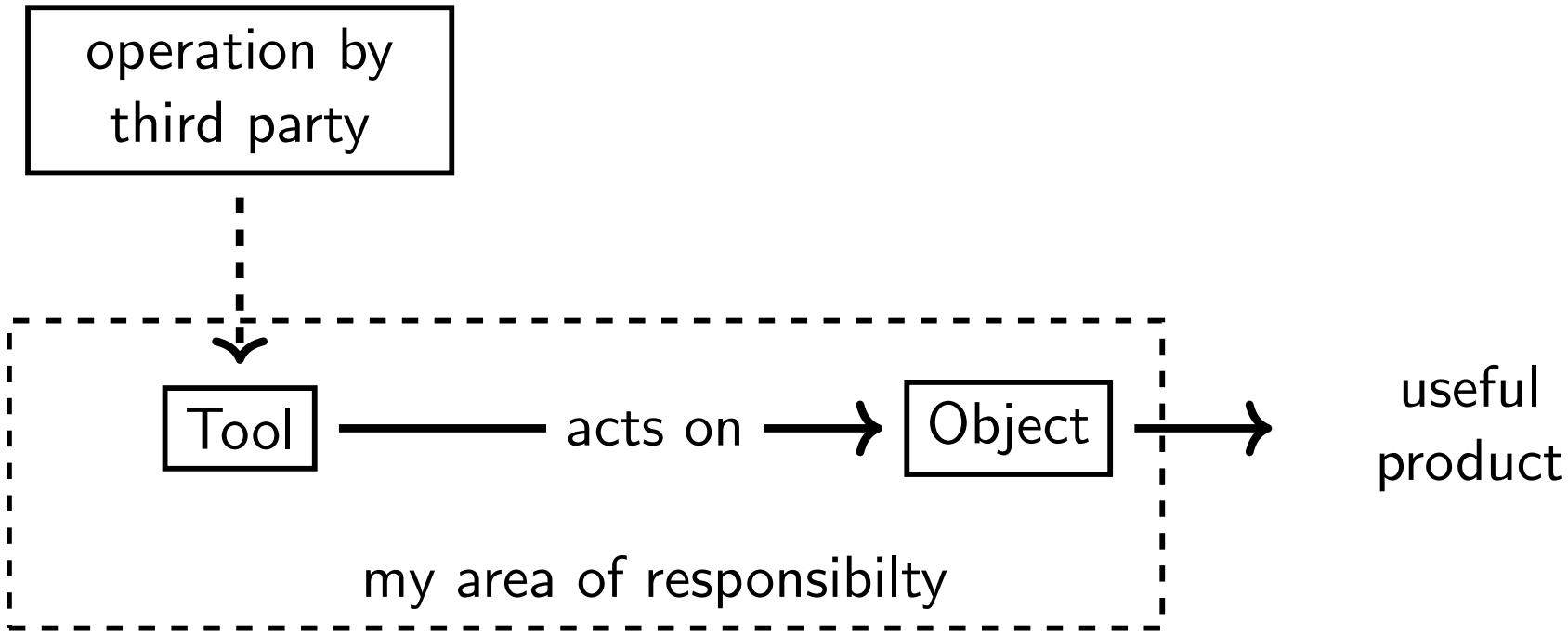
(Szyperski 2002)

- Components are again systems.
- They can be self-developed or purchased from third parties.
- It is not necessary to purchase the whole component, it is sufficient to use the *service*.

This happens in many cases: A component is available in the system with its functional specification as a black box, the operation of the component (provision of the function) is carried out by a third party, out of *their* area of responsibility, the function has an effect on "my" objects in *my area of responsibility*.

- Thus the distinction according to Szyperski: components encapsulate functionality, objects encapsulate system states.

The Minimal Technical System in TRIZ



Dotted frame = the minimum technical system

Dotted arrow = is addressed in Szyperski, but not in TRIZ

Components and Environment

Components (especially those operated by third parties) are thus pointers to other places in the *world of technical systems* and thus represent only another form of the "relationship of a system to the environment".

The question arises whether aspects (1) and (3) in the list of the "reductions to essential" (component and neighboring system) can be unified in such a way.

On the other hand, the question arises how to incorporate the concept of the object into the overall logic.

We will leave both questions open at this point.

Modelling of Systems

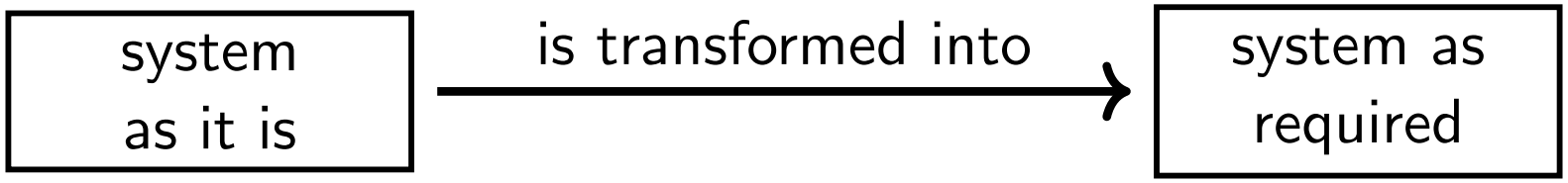
Two problems:

(1) Build a new system

(2) Transform an existing system

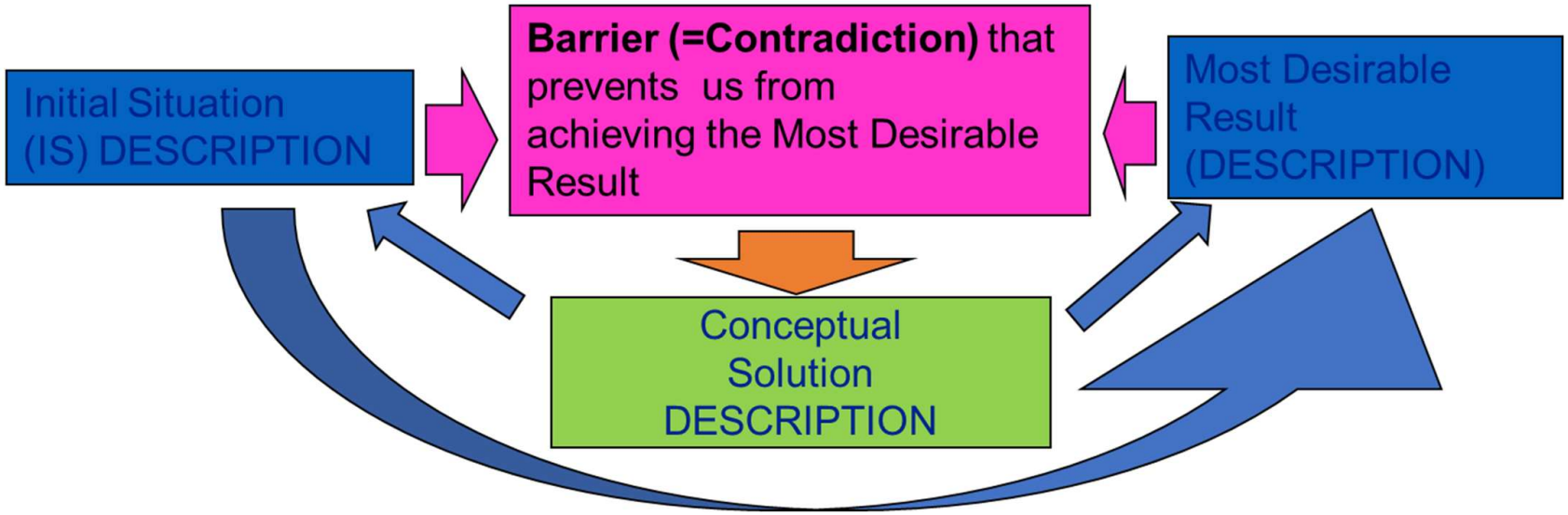
(1) can be considered as a special case of (2), since any need for a new system comes with at least *rough ideas* about that new system, thus also under (1) there is at least a *rough description form* of the system to be created as antecendence.

Modelling of Systems



This basic scheme fits not only technical systems, but also the modelling of social, socio-ecological and cultural systems, hence it is sufficiently universal.

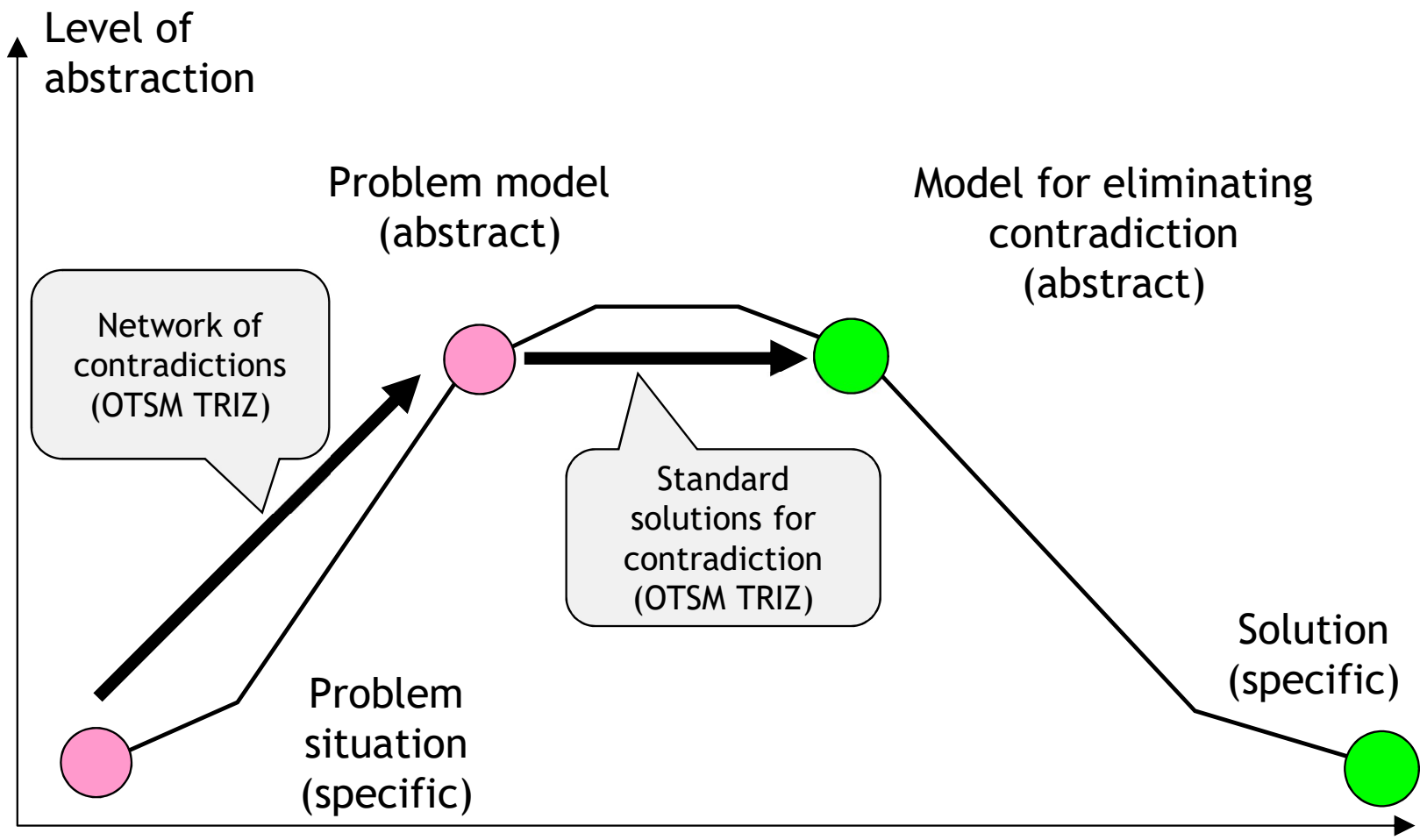
The “Tongs” MODEL



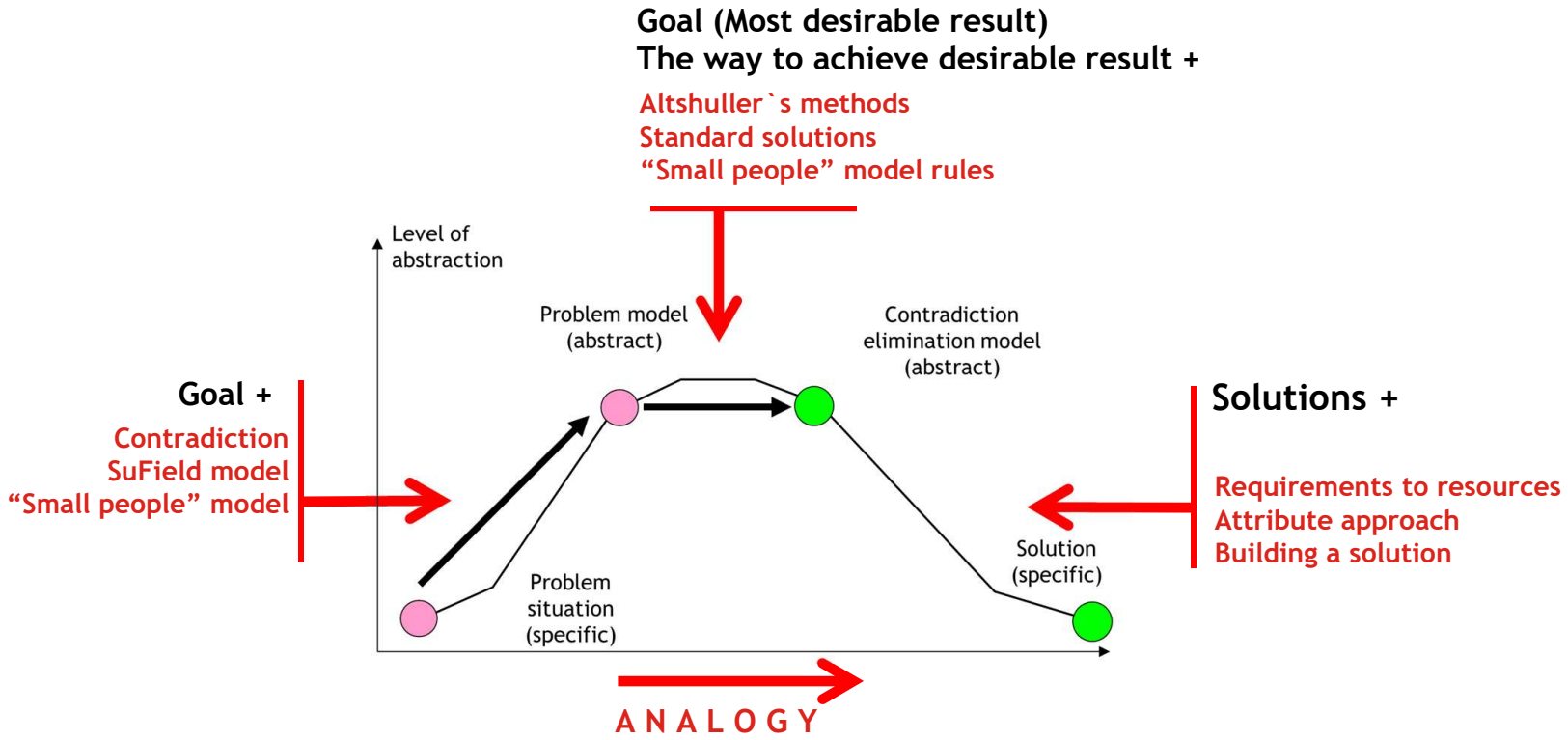
A specific barrier we should overcome is the root of a specific problem.
The root of the barrier is a hidden CONTRADICTION.

What is the root of a contradiction?

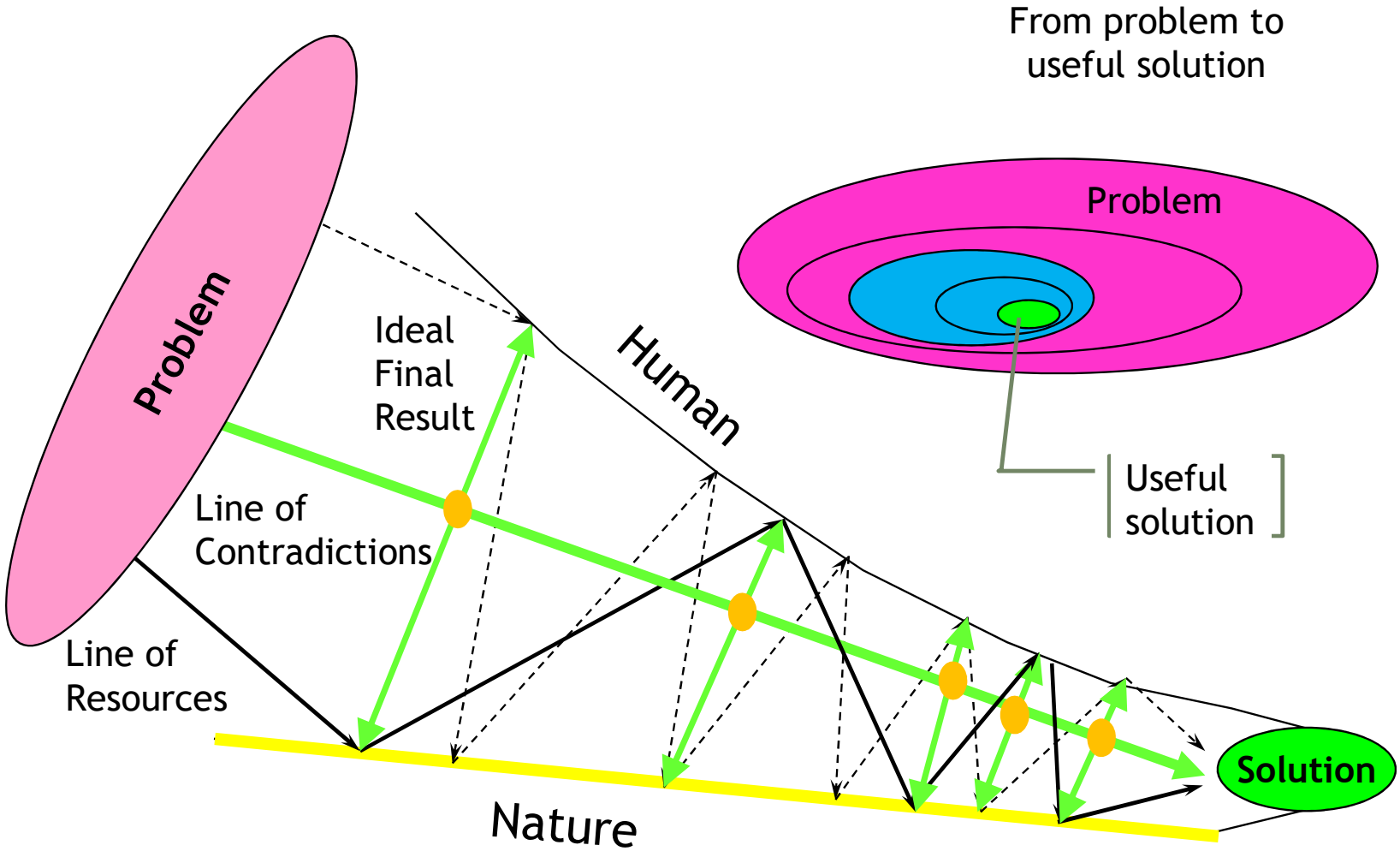
The «Hill» MODEL



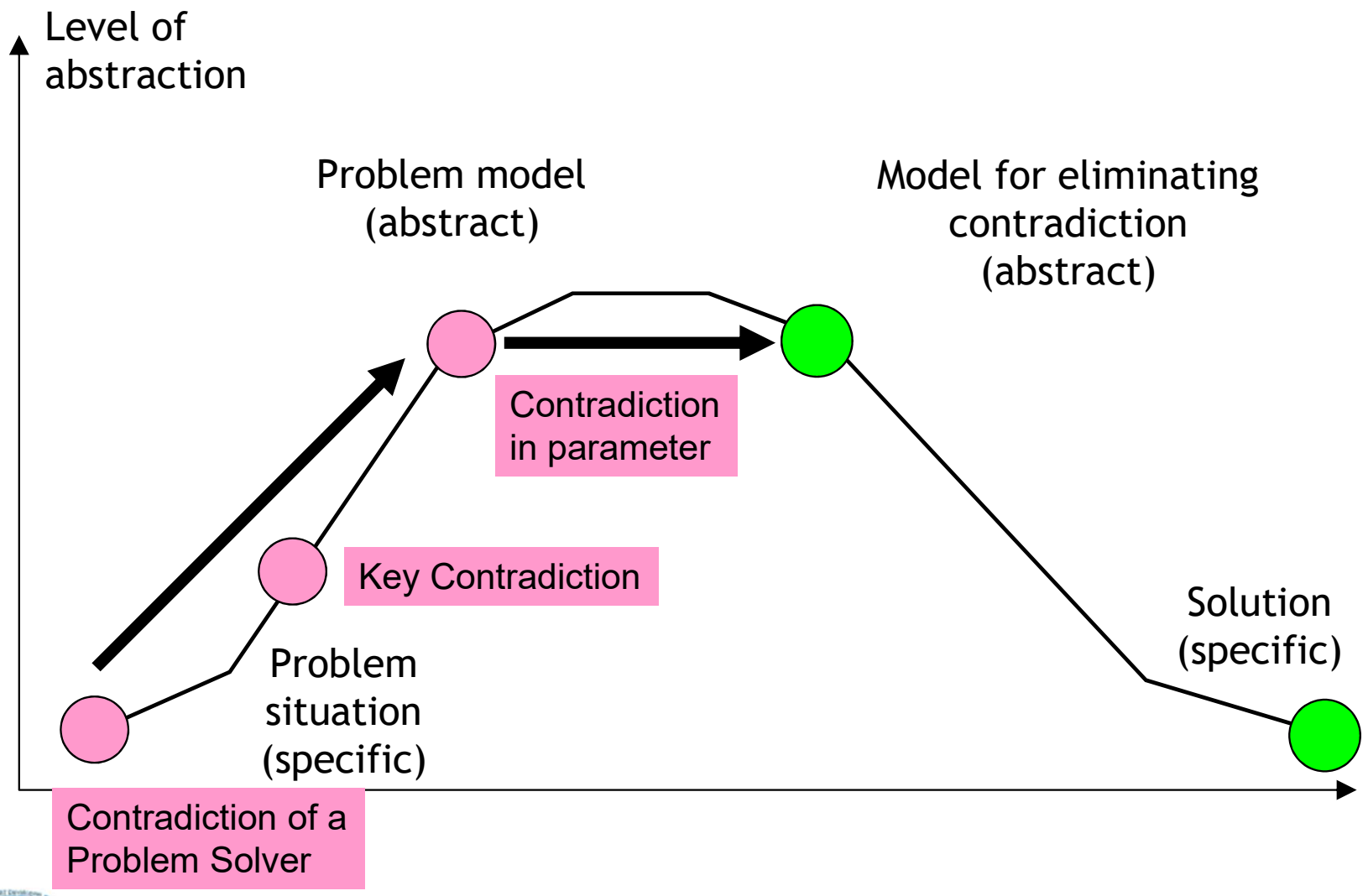
The «Hill» model. Shpakovsky's interpretation



The “Funnel” MODEL



The “Contradiction” technology



THE AXIOMS OF WORLD VISION

Axiom of Unity. *The world is a whole and unique system that evolves in accordance with objective laws of all the sub-systems.*

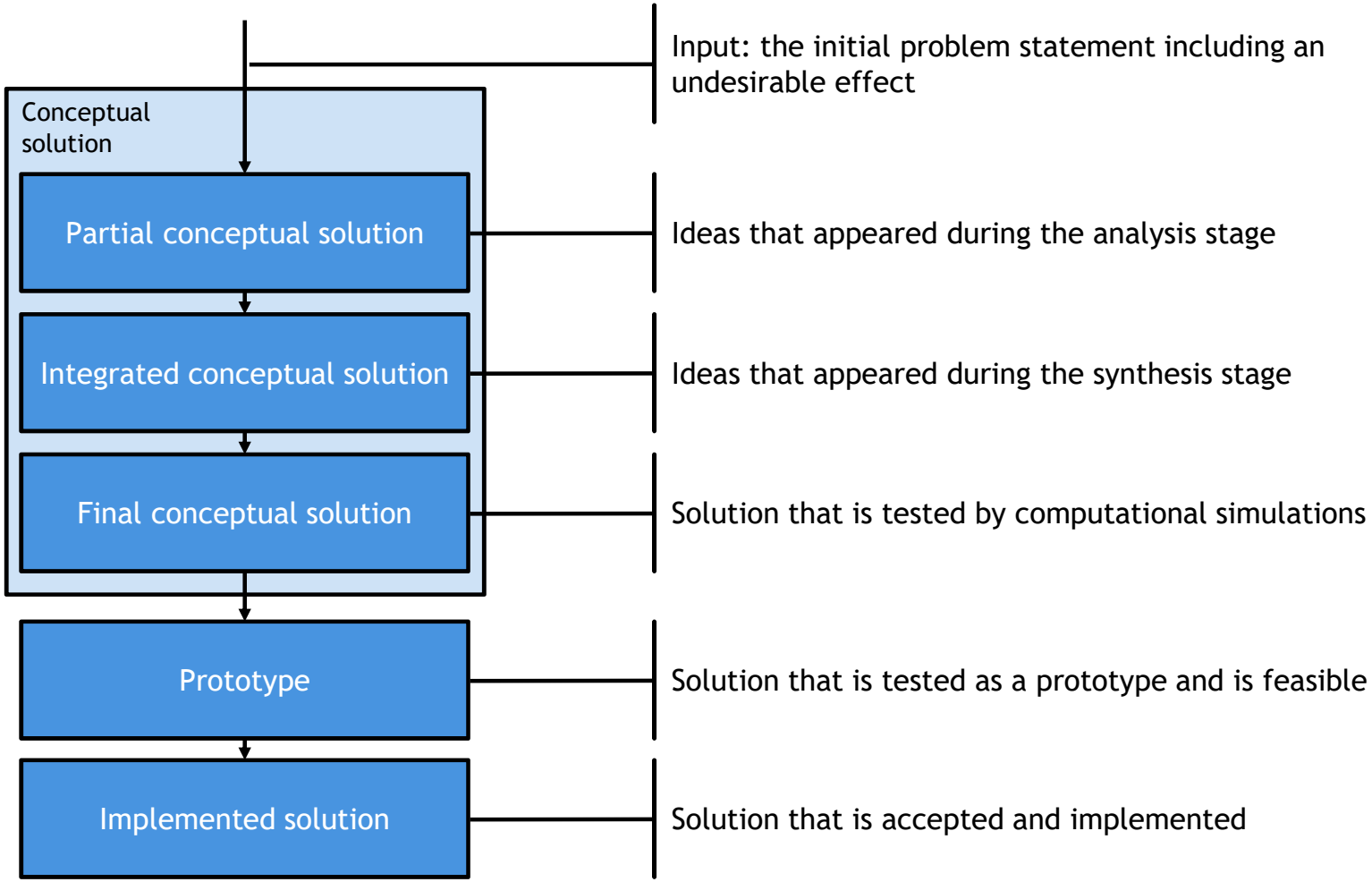
Axiom of Disunity. *The world is a set of different systems, each of them evolving in accordance with its specific laws.*

Axiom of Connectedness Unity and Disunity. *The way the law is manifested in a specific situation is defined by its resources.*

Consequences:
Unity and diversity of the world are governed by the resources used by different systems. Any resource is subject to both general laws and specific laws defined by their specific properties.
General objective laws are manifested differently in specific situations. This difference depends on the nature of the interplay between the law and the specificity of the situation.

N. Khomenko, R. De Guio. *2010. OTSM System of Axioms*

The technology “Line of Solutions”



TRIZ and ARIZ

TRIZ is not just a theory, but proposes a precise algorithmic procedure as a methodology to be applied.

There exist several variants of this algorithm ARIZ (Algorithm for the Solution of Inventive Problems), the "official" one is ARIZ-85C, which is based on a version published by Altschuller in 1985. Others (D. Zobel) see little progress compared to ARIZ-77 (a version published by Altschuller in 1977) and recommend this somewhat simpler approach.

We use AIPS-2015 (Algorithm for the Correction of Problematic Situations), a version in the tradition of OTSM-TRIZ, which is also used in the Minsk TRIZ-Trainer.

TRIZ-Trainer – the First Stage of the Solution Process

The first stage of the solution process provides an accurate model of the "system as it is" that needs to be transformed to solve the problem. This phase consists of three steps

(A) Contextualise the problem. The system as a black box.

(B) Analyse and model the structural and procedural organisation of the "system as it is" – the "machine" in the terminology of the TRIZ-Trainer.

(C) Identify and localise the central contradiction, determine the operational zone and operational time, i.e. where and when the contradiction occurs, and establish possible hypotheses about the causes of the conflict.

From these hypotheses a task is formulated, which in the second stage is analysed in more detail.

TRIZ-Trainer – the First Stage of the Solution Process

First section "Clarification of the circumstances":

1. Identify the system to be examined as a black box and give it a "speaking name", from which the semantics of the system can already be roughly understood – what is the "useful product"?
2. Identify the *main useful function* (MUF) of the system. Investigate, if necessary, what *purpose* the system serves in the supersystem and, if applicable, determine the throughput required to operate the system (input required from the upper system for the functioning of the system).
3. Formulate the existing problem, which prevents the specification compliant behaviour of the system in the supersystem – the "undesired effect".

TRIZ-Trainer – the First Stage of the Solution Process

Second section "Conflict in the system":

4. Determine the components of the machine (the structural organisation of the system) as well as its mode of operation (the procedural organisation of the system). Often it is sufficient to focus on one of the two questions.
   Follow the general structure pattern "energy source, engine, transmission, tool, action, object being processed, useful product plus control".
   Here it is important to describe the main useful function (MUF) of the system, even if the problem is located in one of its components, because the resources used in the system are grouped around the MUF.

TRIZ-Trainer – the First Stage of the Solution Process

5. This MUF is in some relation to the "effect that cannot be completed without problems".
   This effect, as well as its relationship to the MUF, is now to be determined more precisely as the core of the conflict to be resolved.
   In this analysis, in particular the place and time of the conflict must be more precisely determined in order to prepare for possible later separation by time or place as as basic methods of resolution.

TRIZ-Trainer – the First Stage of the Solution Proces

Third section "Formulation of a hypothesis":

- Through a more detailed analysis of the "causes of conflict", one or several hypotheses of general nature are formulated, what measures in the sense of the *Ideal Final Result* would solve the problem.
  One of these approaches is formulated in more detail as a "task" for the second stage of the solution process in order to work on it with suitable TRIZ tools.

The Ideal Final Result

The **ideal final result** (IFR) describes the "system as required" as *target* of the transformation, without initially caring whether the formulated result can be realised in practice. In the further solution process, the obstacles to be overcome on the way to the IFR are identified and, based on the TRIZ methodology, strategies are developed how to overcome these obstacles in practice.

The IFR is one of the basic concepts of TRIZ. The IFR is an orientation in the sense of a "concrete utopia", which essentially determines the target corridor on which the further solution process concentrates in its second stage.