Open Innovation Platform
University - Enterprise
Collaboration

Hands on Problem Solving

LUT Summer School
July 25-29, 2016
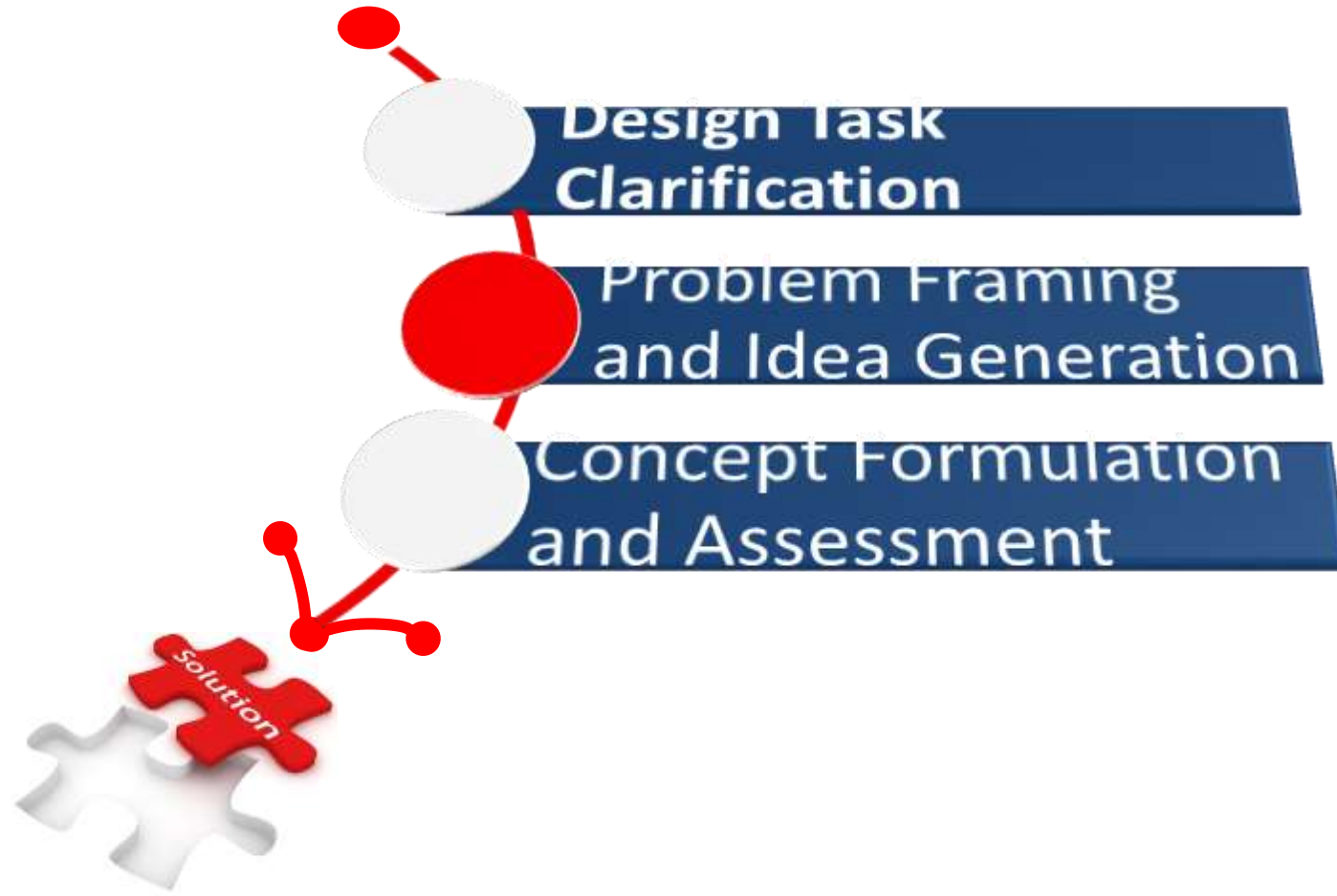
Gaetano Cascini

Introduction

WHERE ARE WE NOW?

Design Task Clarification

Problem Framing and Idea Generation

Concept Formulation and Assessment
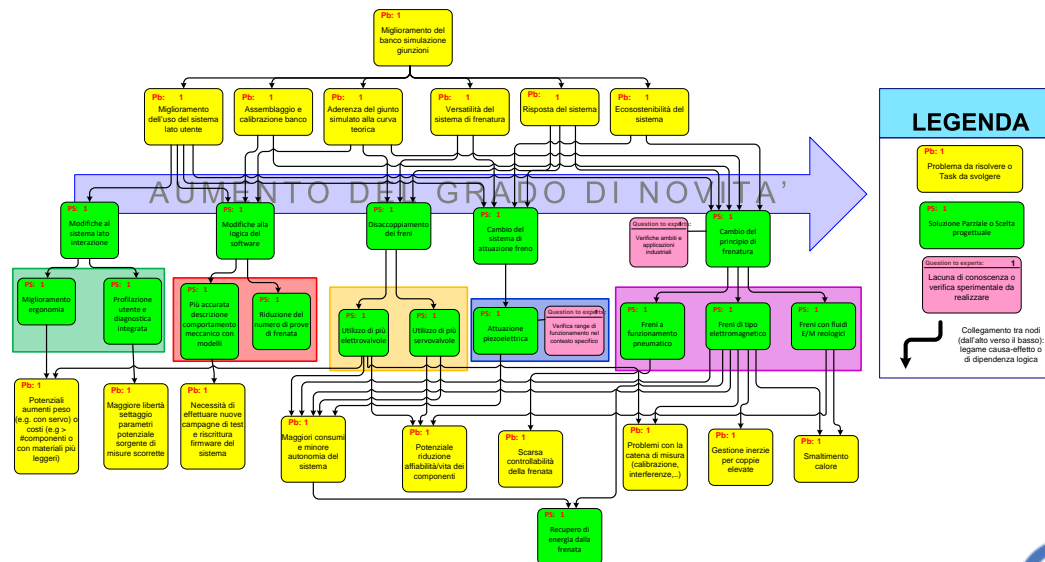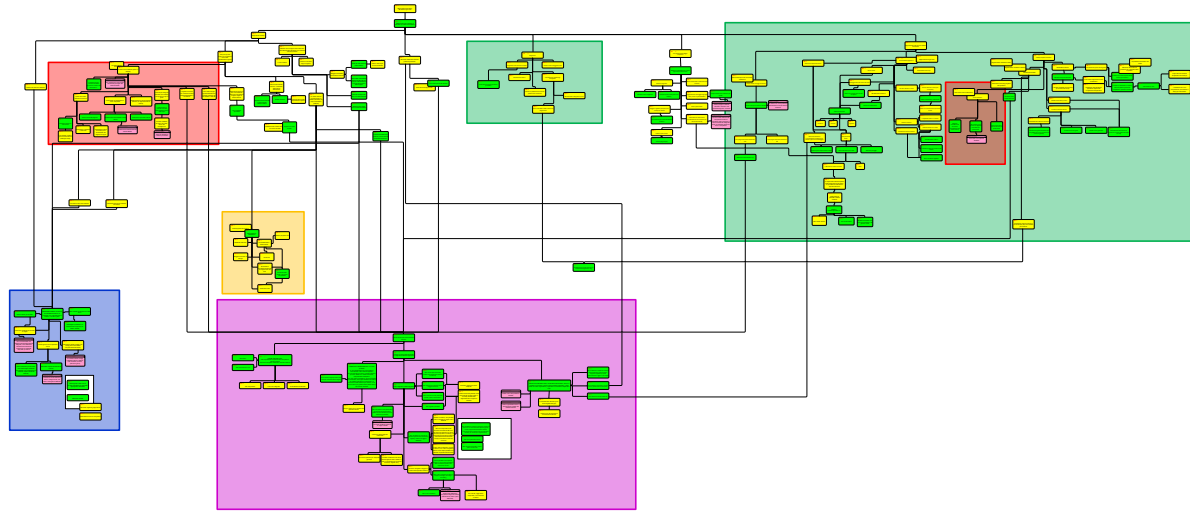
Solution

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Outline

- Dealing with conflicting requirements
    - From the Network of Problems and Partial Solutions to TRIZ solving tools
    - Example strategies for overcoming design conflicts

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Network of Problems and Partial Solutions

Theory of Inventive Problem Solving

The architecture of TRIZ is based on:

- **Three Postulates:**
  - Postulate of Objective Laws of Systems Evolution
  - Postulate of Contradiction
  - Postulate of Specific Situation

- **Main models:**
  - Models of the problem solving process
    - Hill model (abstraction-embodiment)
    - Tongs model (from current situation to ideality, barriers identification)
    - Funnel model
  - Description of systems, problems, solutions
    - ENV model
    - Model of function
    - Substance-Field Model
    - Model of contradiction
  - "System operator" (multi-screen approach)
   - Round about problems
    - Resources search

- **Instruments:**
  - ARIZ (Algorithm of Inventive Problem Solving), main instrument of Classical TRIZ for Non-Typical Problems, which integrate all others TRIZ instruments
  - System of Inventive Standard Solutions
  - Pointers to Physical, Chemical, Geometrical Effects

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Contradictions

■ System evolution implies the resolution of contradictions, i.e. conflicts between a system and its environment or between the components of the system
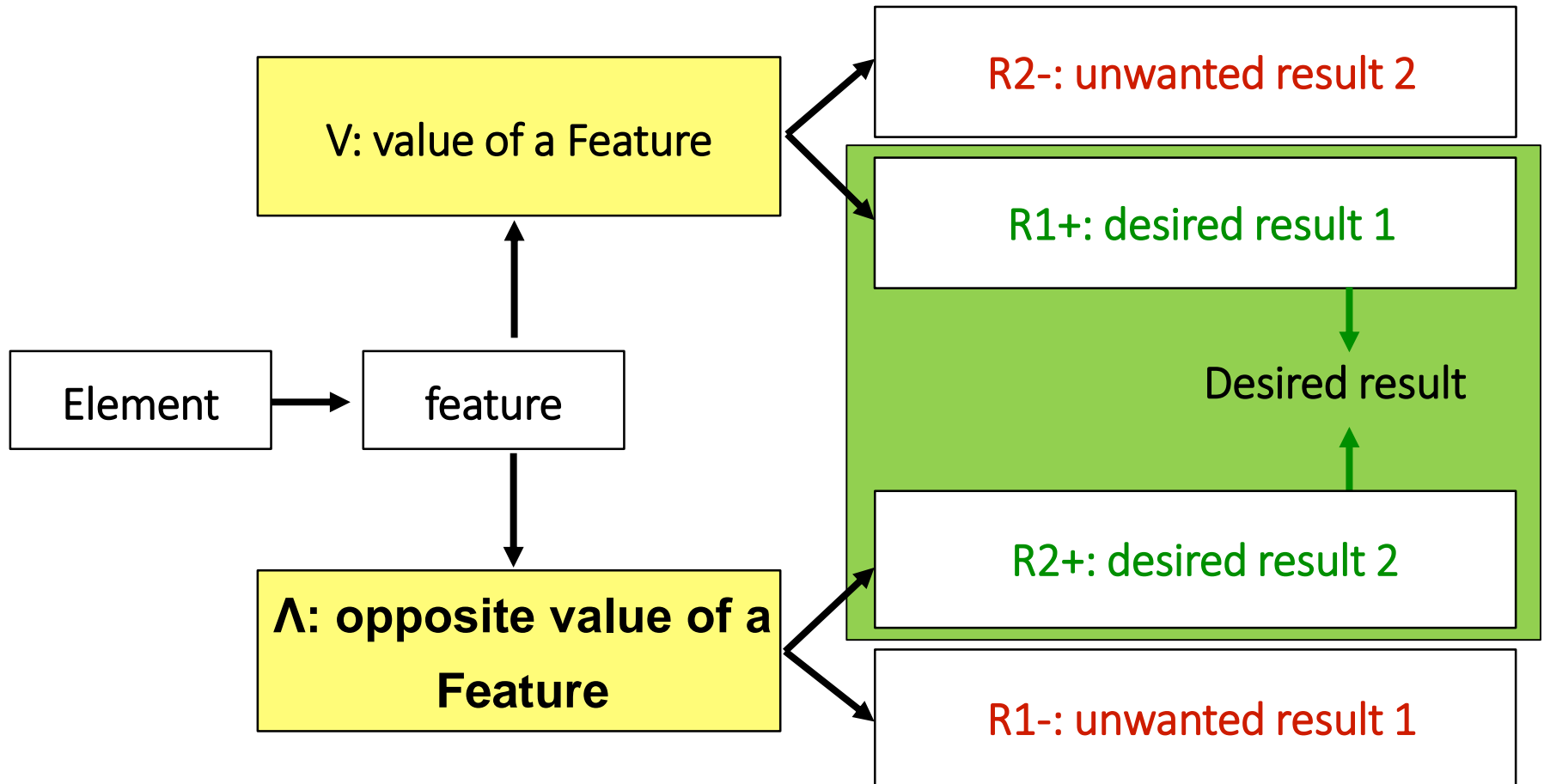
> Problems from different domains, sharing the **same contradiction**, can be solved by means of the **same solving principles**
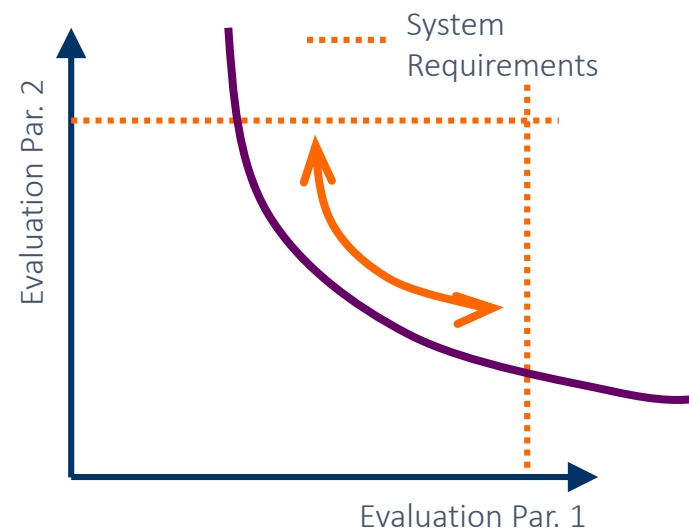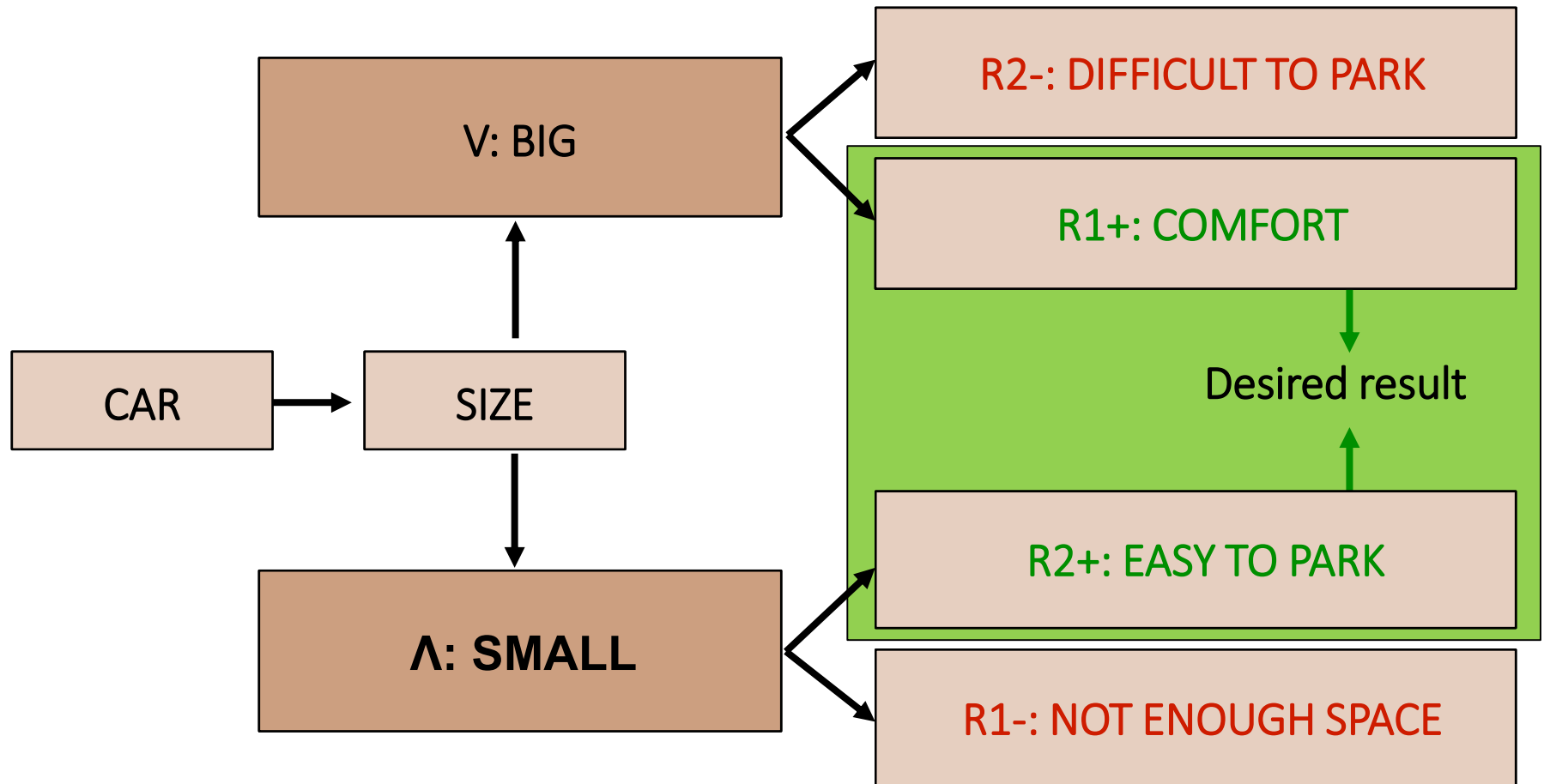

Conclusions for practice:

❖ To solve a problem we should **first discover underlying contradictions**

❖ To achieve maximum benefits, **contradictions should be resolved, not compromised**

❖ Overcoming contradictions is a driving force behind technology evolution. Resolving contradictions, instead of compromising or optimizing, results in breakthrough solutions

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Contradictions

V: value of a Feature

Element → feature

Λ: **opposite value of a Feature**

R2-: unwanted result 2

R1+: desired result 1

Desired result

R2+: desired result 2

R1-: unwanted result 1

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Contradictions

V: BIG

CAR → SIZE

Λ: SMALL

R2-: DIFFICULT TO PARK

R1+: COMFORT

Desired result

R2+: EASY TO PARK

R1-: NOT ENOUGH SPACE

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Techniques to Resolve Physical Problems

- As a matter of principle, a physical contradiction can be resolved by three strategies:
  - Separation of the contradictory requirements (see Separation Principles)
  - Satisfaction of the contradictory requirements (by Technology Substitution)
  - Bypass the contradictory requirements

Separation

Satisfaction

Bypass

Contradictory Requirement

Contradictory Requirement

Contradictory Requirement

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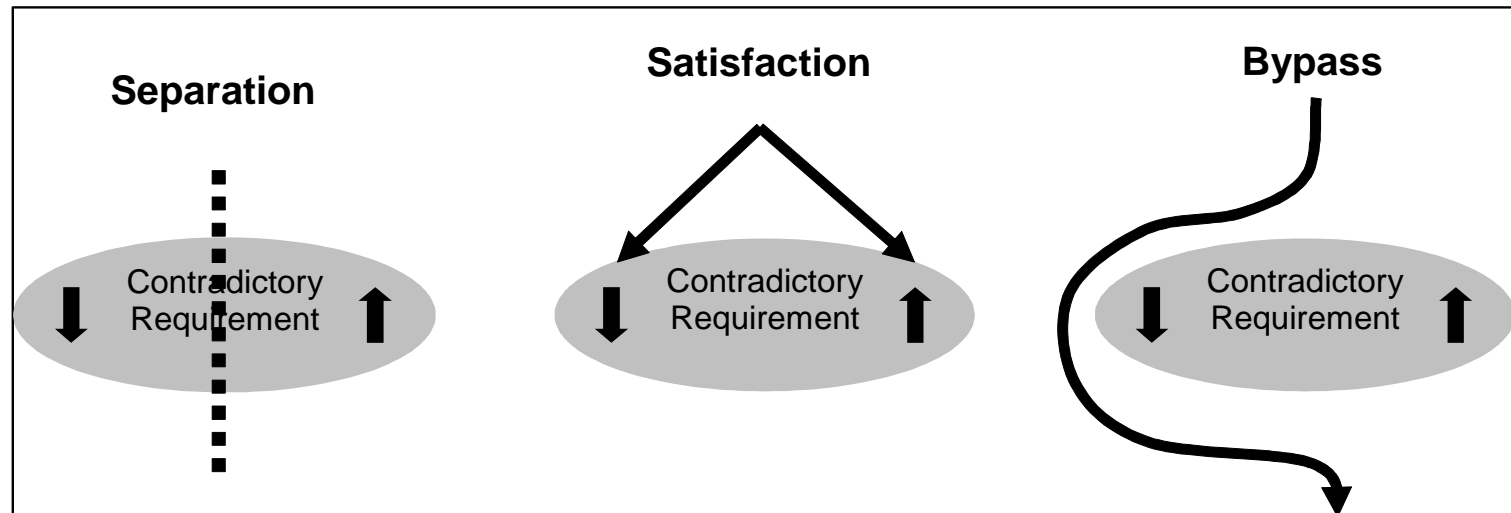
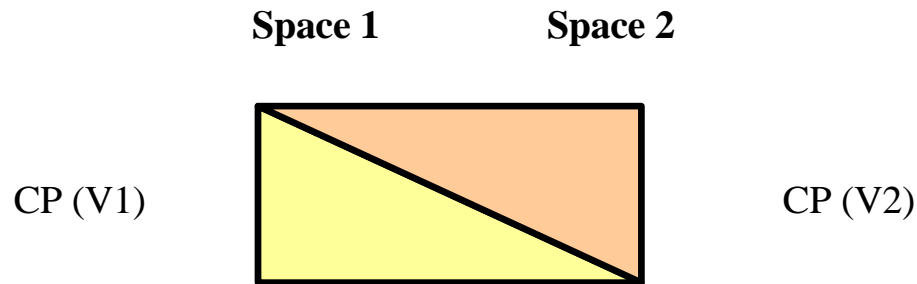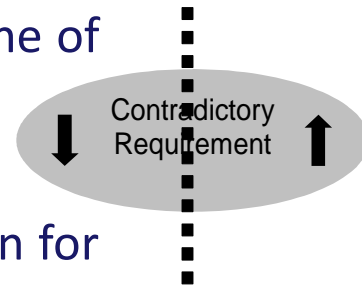# Techniques to Resolve Physical Contradictions

Separation in Space

Separating in space means answering to this question:

"Do we really want the contradictory Feature of the Element to assume the value V and the value Λ in the whole Operational Zone of the Contradiction?"

If this answer is NO, a Separation in Space is a candidate direction for solution.

Separation

Contradictory
Requirement

Space 1   **Space 2**

CP (V1)   CP (V2)

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Techniques to Resolve Physical Contradictions

Separation in Space

Separation

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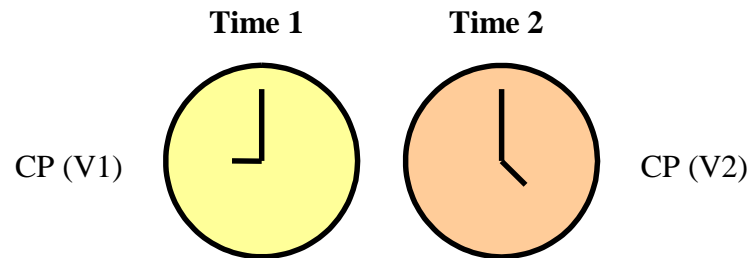
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Techniques to Resolve Physical Contradictions
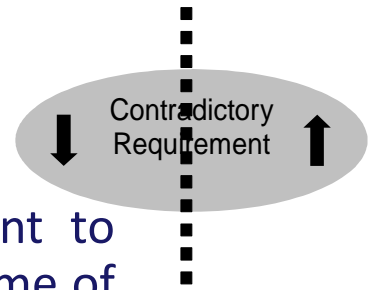
Separation in Time

Separating in time means answering to this question:

"Do we really want the contradictory Feature of the Element to assume the value V and the value Λ in the whole Operational Time of the Contradiction?"

If this answer is NO, a Separation in Time
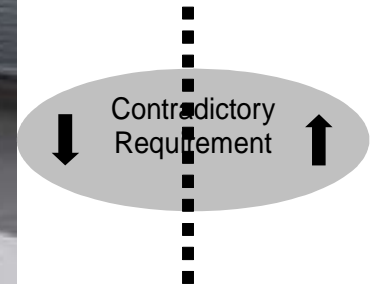
is a candidate direction for solution.

Time 1   **Time 2**

CP (V1)   CP (V2)

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Techniques to Resolve Physical Contradictions

Separation in Time
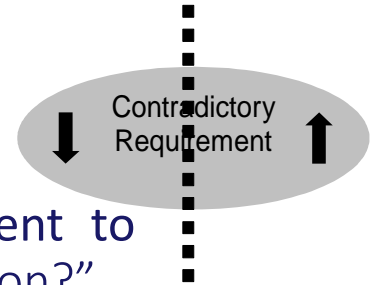

Separation

Contradictory Requirement

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Techniques to Resolve Physical Contradictions

Separation upon Condition

Separating on condition means answering to this question:

> "Do we really want the contradictory Feature of the Element to assume the value V and the value Λ under any operating condition?"
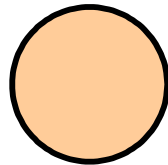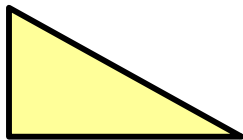
If this answer is NO, a Separation upon Condition is a candidate direction for solution.

Contradictory Requirement

Condition 1   **Condition 2**

CP (V1)   CP (V2)

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Techniques to Resolve Physical Contradictions

Separation upon Condition

Separation

Contradictory Requirement

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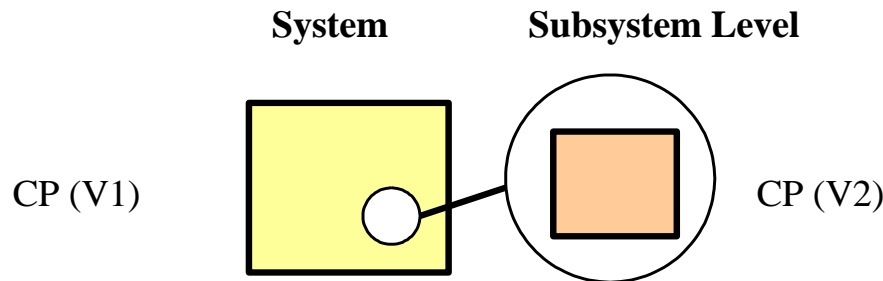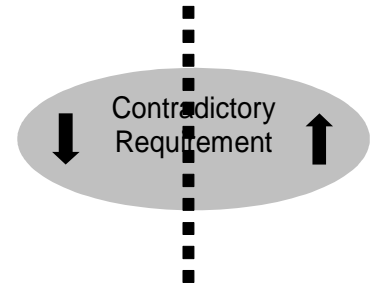# Techniques to Resolve Physical Contradictions

Separation between Macro and Micro Level

Separating between macro and micro level means answering to this question:

"**Do we really want the contradictory Feature of the Element to assume the value V and the value Λ both at system level** and in its parts/subsystems?"

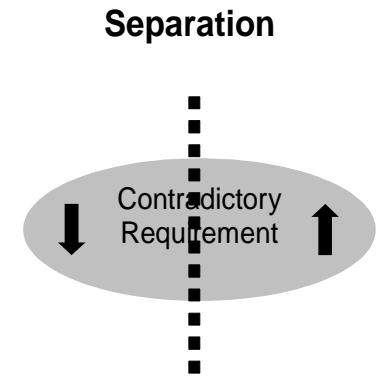If this answer is NO, a Separation between macro and micro level is a candidate direction for solution.

Separation

Contradictory Requirement

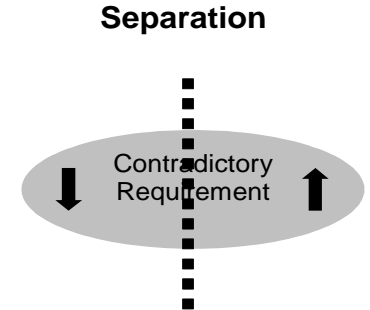**System**   **Subsystem Level**

CP (V1)   CP (V2)

Techniques to Resolve Physical Contradictions

Separation between Macro and Micro Level

Separation

Contradictory Requirement

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Techniques to Resolve Physical Contradictions

Separation Principles and Inventive Principles

Separation

- In space: 1, 2, 3, 17, 13, 14, 7, 30, 4, 24, 26
- In time: 15, 10, 19, 11, 16, 21, 26, 18, 37, 34, 9, 20
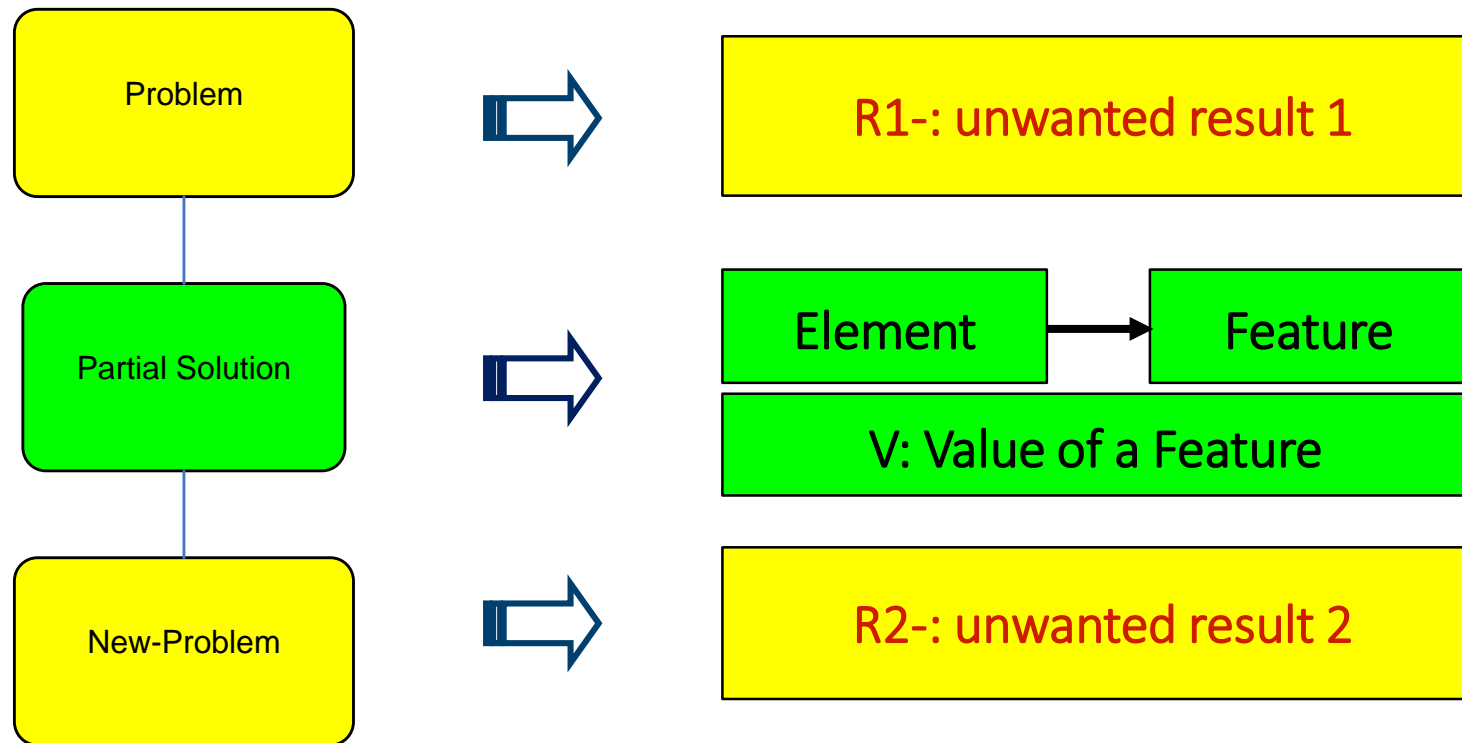- On condition: 35, 32, 36, 31, 38, 39, 28, 29
- Macro-Micro level

Contradictory Requirement

1. Segmentation
2. Extraction
3. Local Quality
4. Asymmetry
5. Consolidation
6. Universality
7. Nesting
8. Counterweight
9. Prior Counteraction
10. Prior Action
11. Cushion in Advance
12. Equipotentiality
13. Do It in Reverse
14. Spheroidality
15. Dynamicity

16. Partial or Excessive Action
17. Transition Into a New Dimension
18. Mechanical Vibration
19. Periodic Action
20. Continuity of Useful Action
21. Rushing Through
22. Convert Harm into Benefit
23. Feedback
24. Mediator
25. Self Service
26. Cop...
27. Disp...
28. Repla...

29. Pneumatic or Hydraulic Construction
30. Flexible Membranes or Thin Films
31. Porous Material
32. Changing the Color
33. Homogeneity
34. Rejecting and Regenerating Parts
35. Transformation of Properties
40. Composite Materials

Complete list and directions at:
http://www.triz.co.kr/TRIZ/frame.html

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Problems Decomposition With TRIZ

Identifying Contradictions from the Network of Problems:

Problem	➡	**R1-: unwanted result 1**
Partial Solution	➡	**Element** → **Feature** / **V: Value of a Feature**
New-Problem	➡	**R2-: unwanted result 2**

TRIZ Model of Contradiction

V: value of a Feature

R2-: unwanted result 2

R1+: desired result 1

Element → feature

Desired result

Λ: opposite value of a Feature

R2+: desired result 2

R1-: unwanted result 1
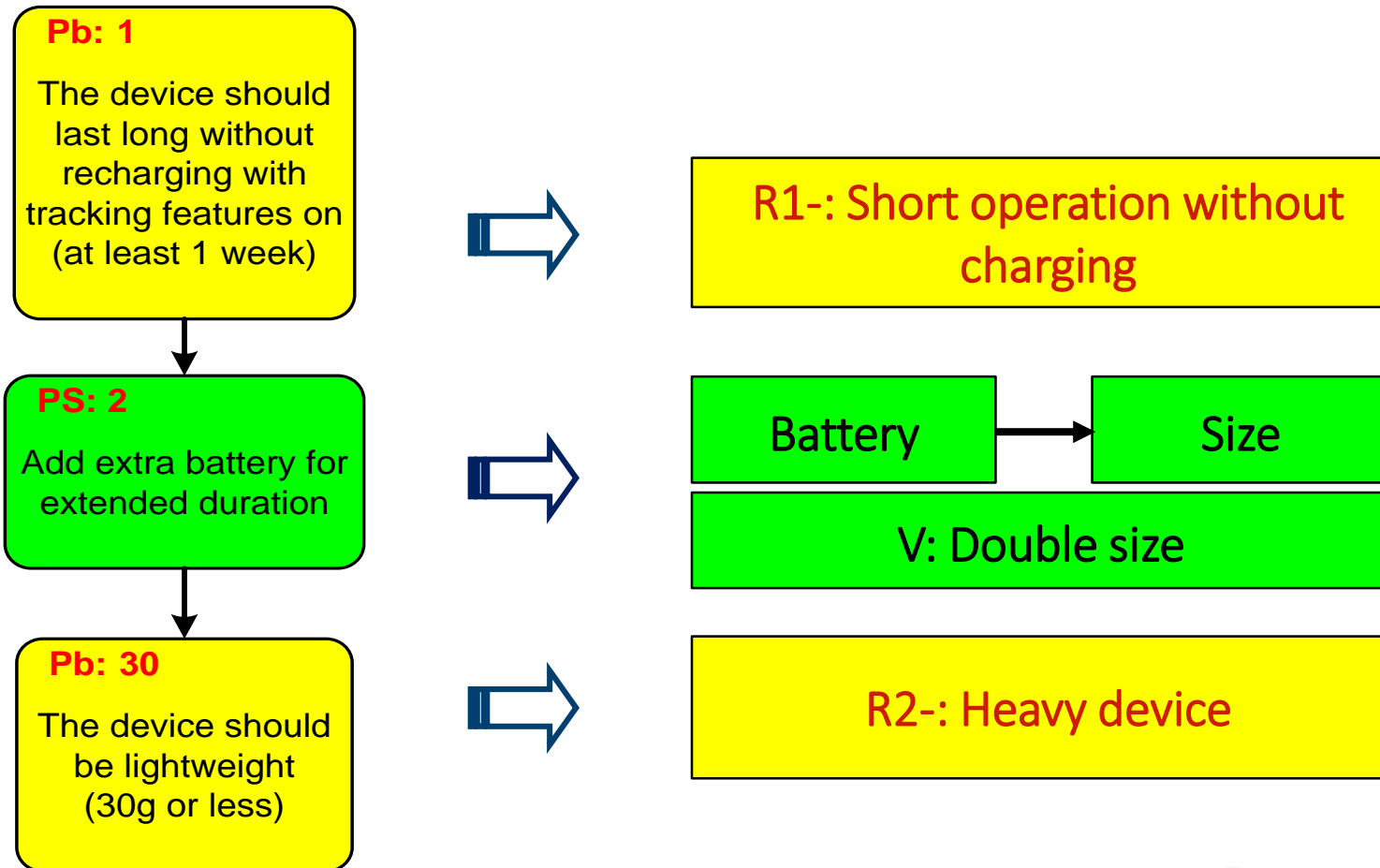
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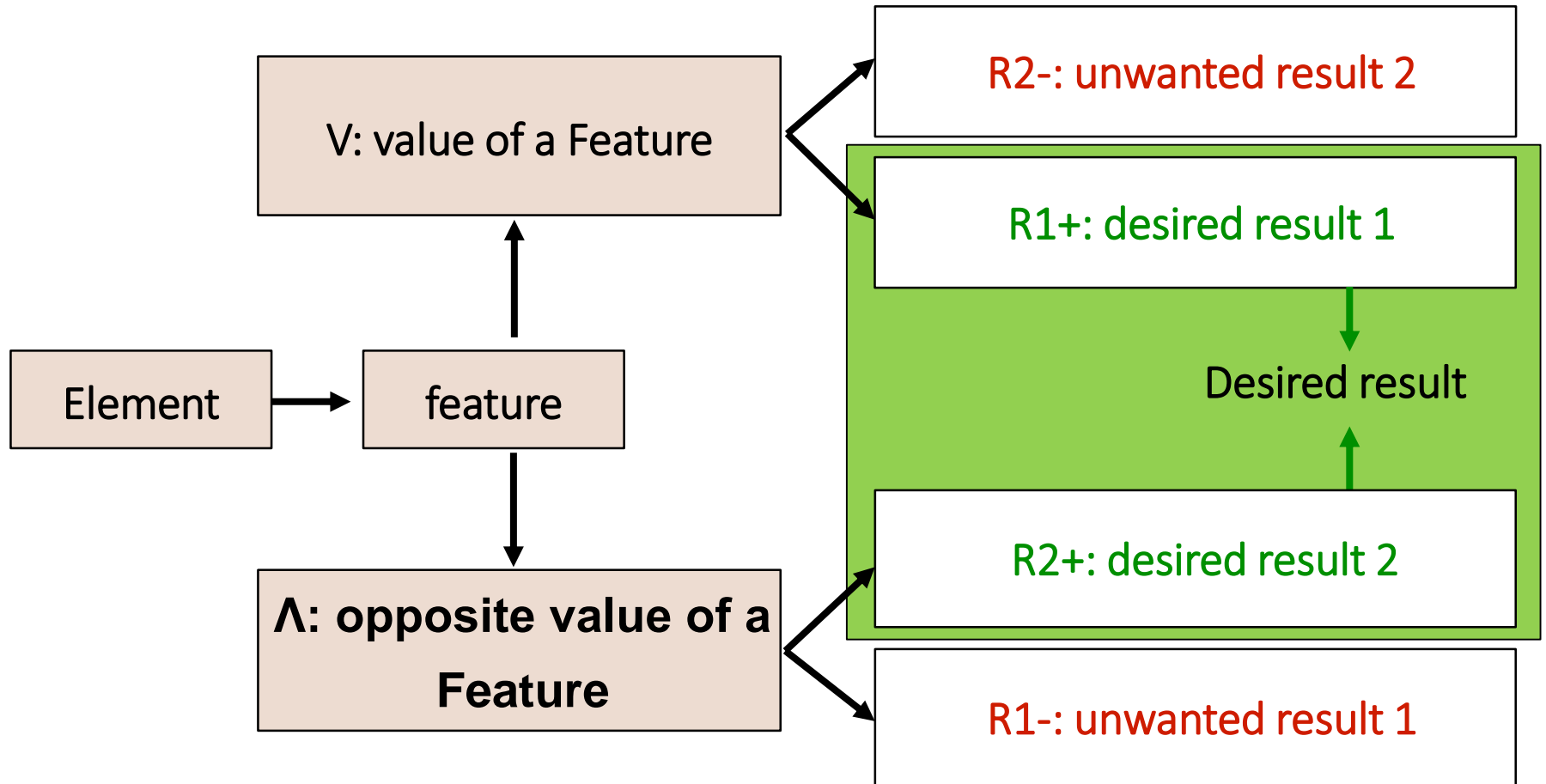
Back to the Example

Identifying Contradictions from the **Network of Problems**:

Pb: 1

The device should last long without recharging with tracking features on (at least 1 week)

➡️ R1-: Short operation without charging

PS: 2

Add extra battery for extended duration

➡️ Battery → Size

V: Double size

Pb: 30

The device should be lightweight (30g or less)

➡️ R2-: Heavy device

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Back to the Example

Battery → Size

Size ↕ V: Double

Size ↕ Λ: **Regular**

V: Double →
- R2-: Heavy device
- R1+: Long operation without charging

Λ: **Regular** →
- R2+: Lightweight device
- R1-: Short operation without charging

R1+: Long operation without charging ↓ Desired result ↑ R2+: Lightweight device

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Back to the Example

Separation
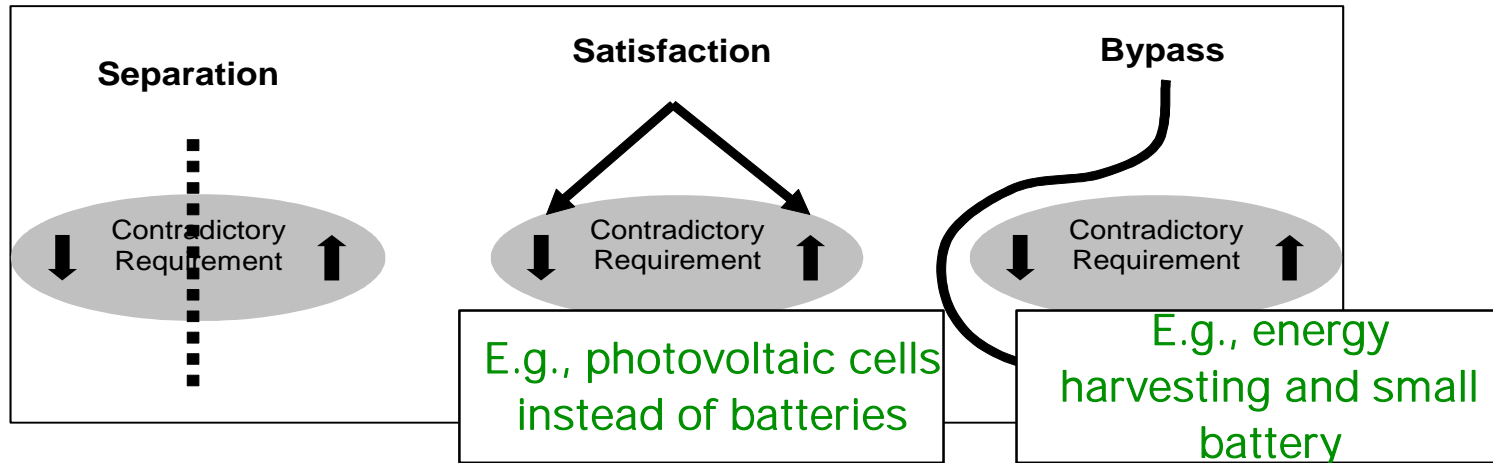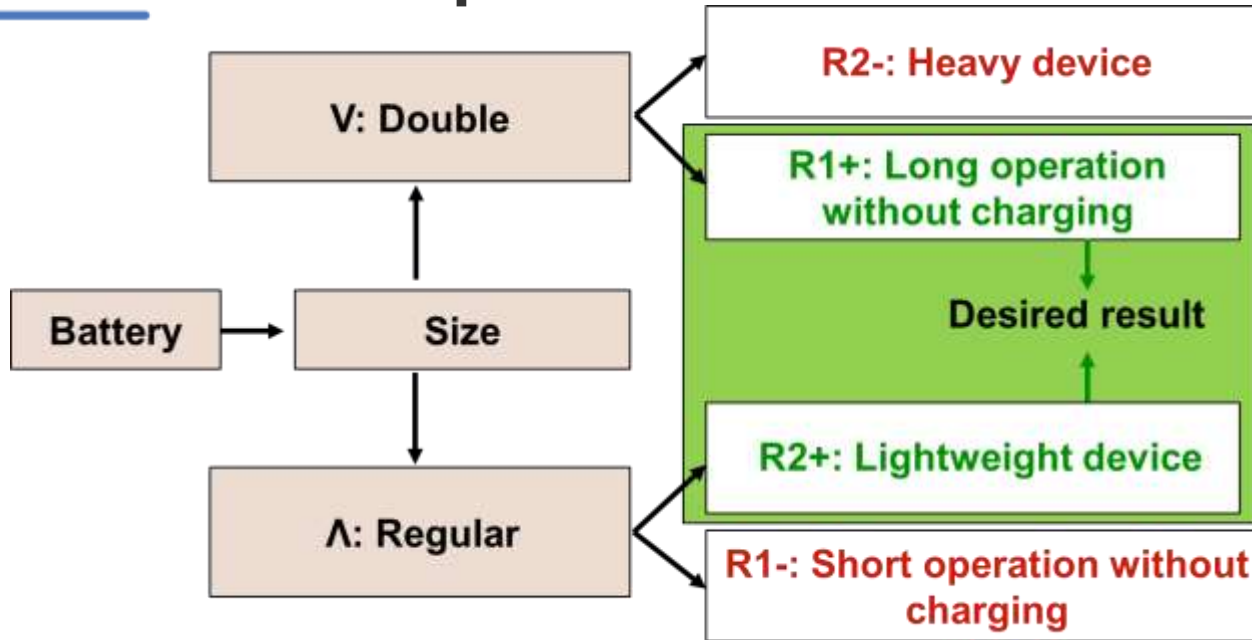
Contradictory Requirement
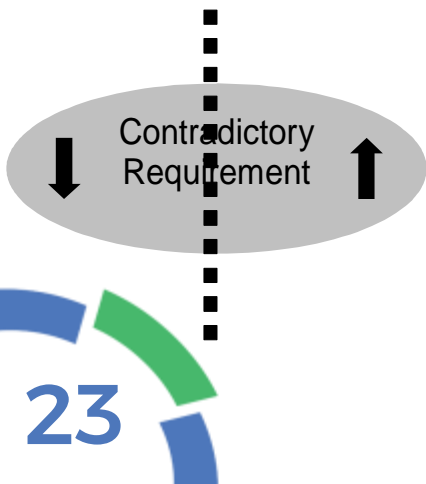
In space: Extra batteries around the waist / on the shoulder

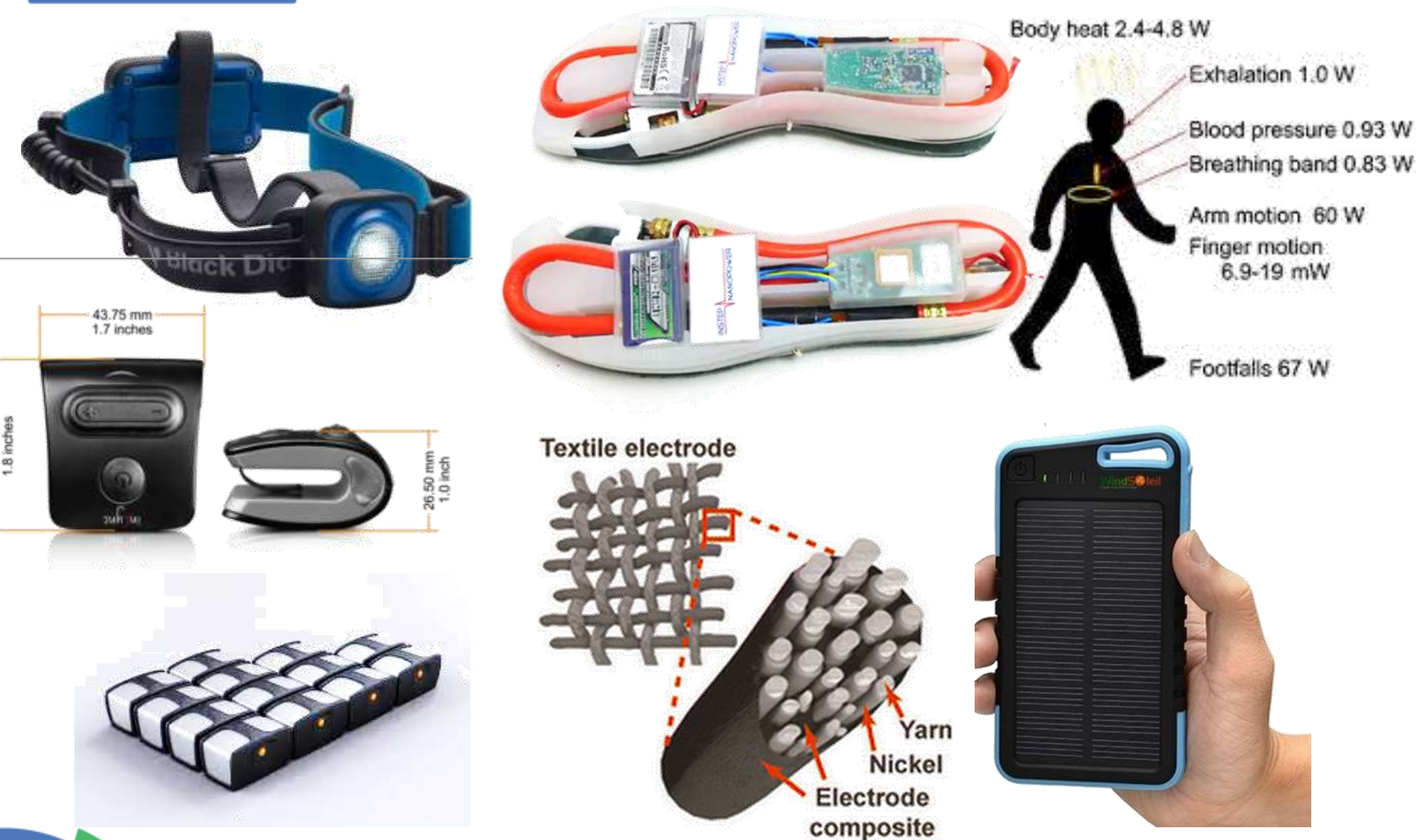In time: Modular batteries super-easy/fast to change

Upon condition: Customizable size of batteries according to...

Macro/Micro: Supersmall batteries distributed on the body surface

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Back to the Example

Back to the Example

Body heat 2.4-4.8 W

Exhalation 1.0 W

Blood pressure 0.93 W

Breathing band 0.83 W

Arm motion 60 W

Finger motion 6.9-19 mW

Footfalls 67 W

43.75 mm
1.7 inches

1.8 inches

26.50 mm
1.0 inch

Textile electrode

Yarn

Nickel

Electrode composite

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Summing Up

Problem Framing

- When dealing with **complex problems** it is important to keep an **overall view** on the design task, still having the possibility to analyse the **details**

- Network of Problems and Partial Solutions can help, also to share tasks in a (large) team

Dealing with conflicting requirements

- Modelling a design problem in the form of **contradiction** is a way to identify the roots of the problem, as well as opportunity for generate solutions (and **variants**)

- **Separating conflicting requirements** is a universal strategy for solving contradictions

- When separation is (really) not applicable a major change is necessary (**technology shift** or **bypass**).

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Task for Today Afternoon Session

1. Revise your network of Pb and PS (and complete it if necessary)
2. Identify contradictions that most prevent your system to behave as an ideal system
   - Build a model of the contradiction;
   - Identify where and when the contradiction occurs;
   - Apply separation principles to overcome the contradiction;
   - Check for technological substitution suitable to fulfill the two sides of the contradiction;
   - Check for by-pass options at super-system level that make the contradiction disappear
3. Update the network of Pb and PS
   - Represent all the variants (alternative solutions) you identified for each problem and further emerging problems if any
4. Prepare the presentation of your partial results
   - Deliver a PPT to gaetano.cascini@polimi.it by 16:15
   - At least 2 (different) team members speaking
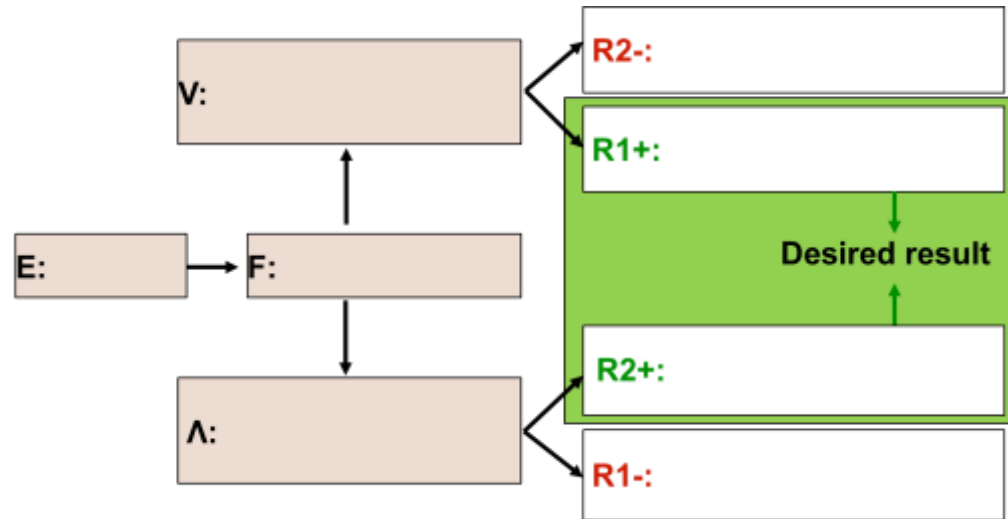   - The presentation should last 7 minutes (or less)

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Template for Contradiction Analysis

| PB: | ⟹ | R1-: |

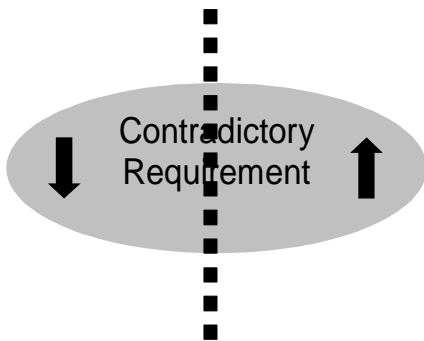| PS: | ⟹ | E: | F: |
| | | V: |

| PB: | ⟹ | R2-: |

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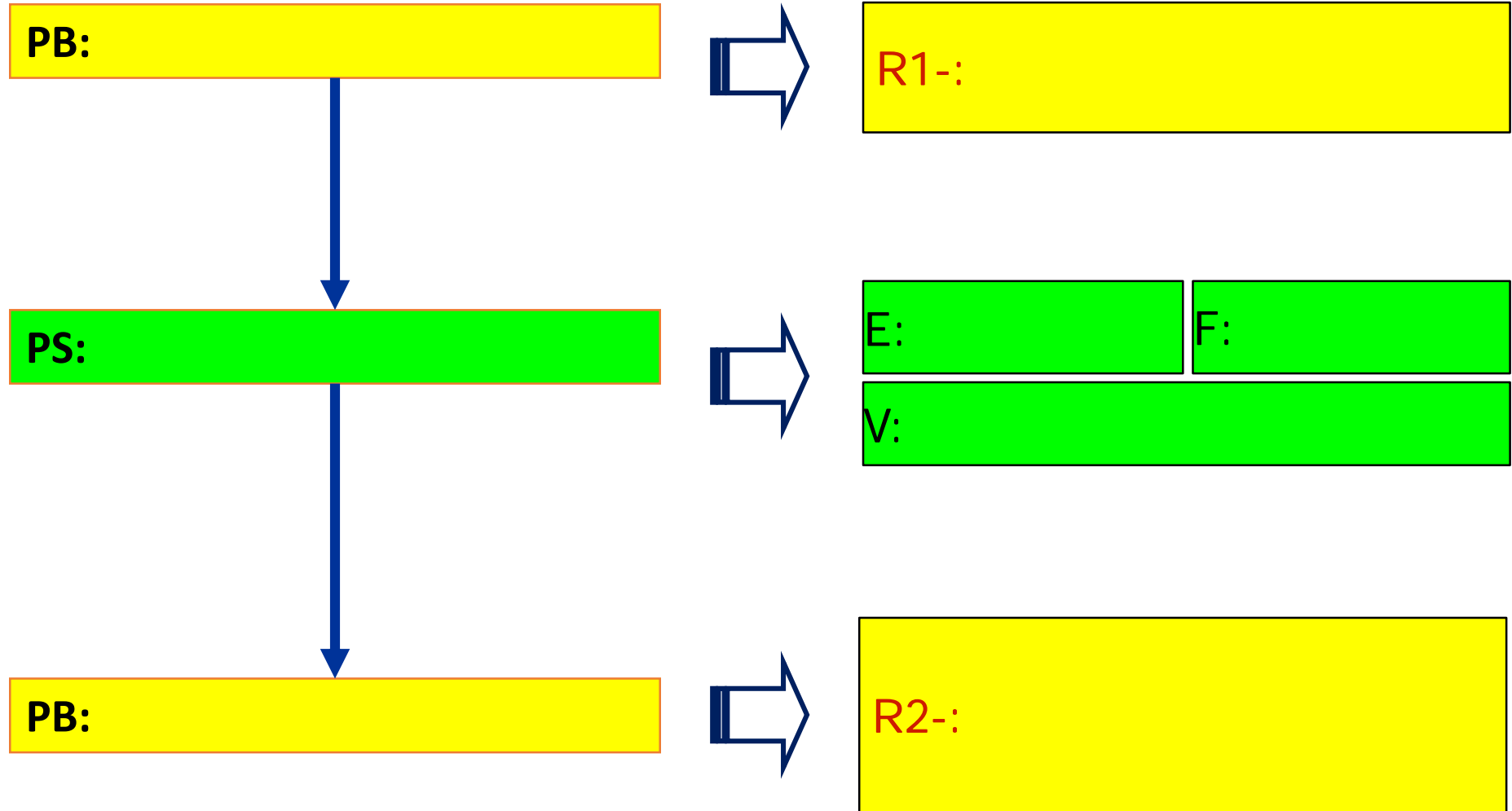
Template for Contradiction Analysis
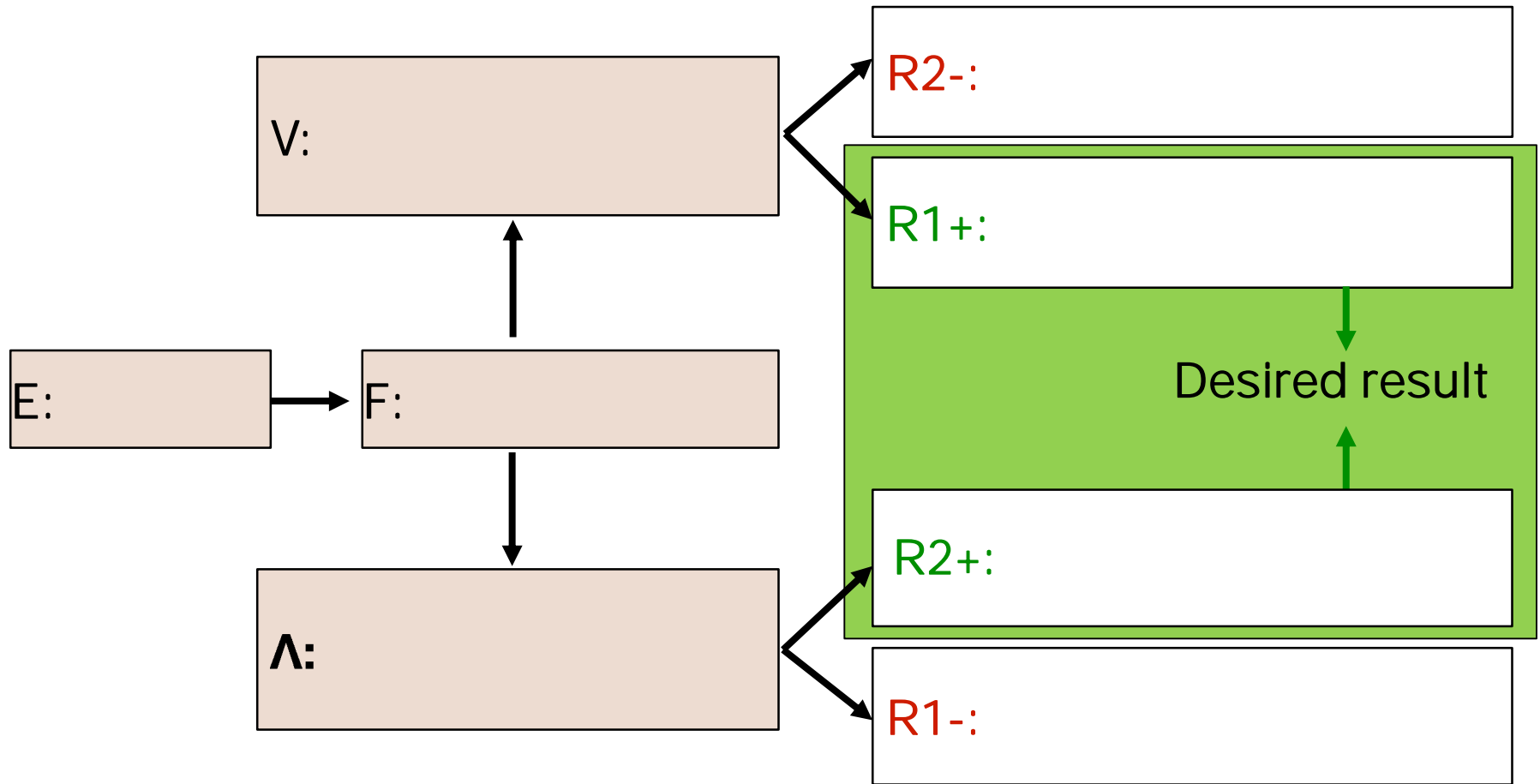
Template for Contradiction Analysis

Separation

In space:_____

In time:_____

Upon condition:_____

Macro/Micro:_____

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Thank you