



Computer-Aided Problem-solving Assistant for Su-Field Analysis (CASFA)

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Outline

- Motivation
- Research Method
- Case Study
- Conclusion
- Briefing on the Society of Systematic Innovation (time permitting)



Motivation

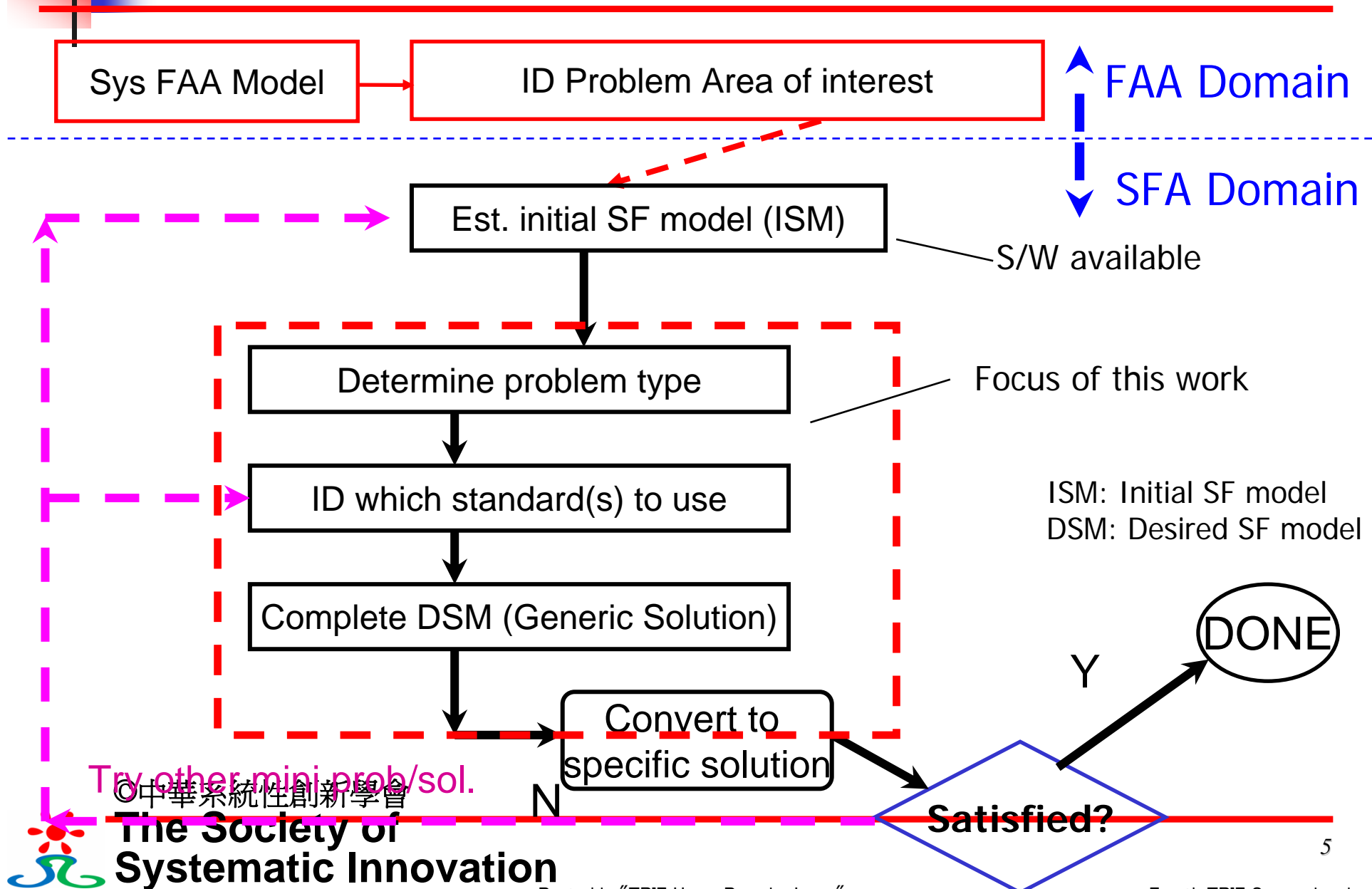
- There have been many software to aid the process of using CM & IP.
- Some software available for producing the diagrams of su-field models.
- No software is available to help ID relevant standards for any given su-field problem and provide solution trigger for problem solving.





Contributions of this research

- Providing a way to model the core of engineering problems so that the process of identifying relevant inventive standards for problem solving can be automated.
- Establishing a piece of S/W to assist human ID of standards and providing related examples for idea generation relevant to the problem.


Common approach 4 using SFA in problem solving



Key issues & Contributions

Issues	Current computerized Approach => our contributions
1) Modeling the current problem into SF models and form <u>Problem Su-field Model (PSM/ISM)</u> – especially when the system is quite complex 	Provide graphing capability only. Rely only human brain to manually interpret it. => a) Provide sense of Component/Function/Field in computer knowledge; b) Drill down to elemental mini-problem
2) ID corresponding standard for the current PSM and form the Solution Su-field Model/Desired Su-field Model (SSM/DSM)	No computerized approach. Rely only human brain to manually locate SSM/Solution Standards (SS). => Provide automatic ID of SSM/SS by computer for the elemental problem.
3) Connecting the Identified solution/standard (SSM) to specific solution for the problem. ©中華系統性創新學會	No computerized approach. Manually reference examples to trigger solutions. => Rendering relevant examples automatically for easier reference. 

Issue 1: Model the current problem

- Focus on the problem w/ 1/2 substances + 0/1 field & 0/1 relational functions.
- Form a Su-field array to model the mini-problem:
 - S1 (Object): 1
 - S2 (Tool): 0/1
 - Func: 0/H/I/E/P
 - Field: **MeThChemONAB** 

0: None existence; 1: exist; H: Harmful; I: Insufficient; E: excessive; P: Proper (C)

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Issue 1: Model the current problem

- Form a Constraint Array to constrain the solution space relevant to the resource/constraint indicated by the Standards.
 - Can S be added? Y/N
 - Can F be added? Y/N
 - Detection/Measurement problem? Y/N
 - Ferro-magnetic material available? Y/N
 - Magnetic field allowable? Y/N
 - ...



Issue 1: Problem model

- The combination of the **Su-field Array** and (solution) **Constraint Array** then fully qualify the problem to be solved. The set of values in the fields within these 2 arrays fully defines (models) the problem. (Problem Array)
- **Su-field Array + Constraint Array**
= **Problem Array**



Classification of Fields: MeThChemONAB

- Me: Mechanical (0/1)
- Th: Thermal (0/1)
- Chem: Chemical (0/1)
- O: Optics (0/1)
- N: Nuclear (0/1)
- A: Acoustics (0/1)
- B: Biological (0/1)

- 0: absence
- 1: presence



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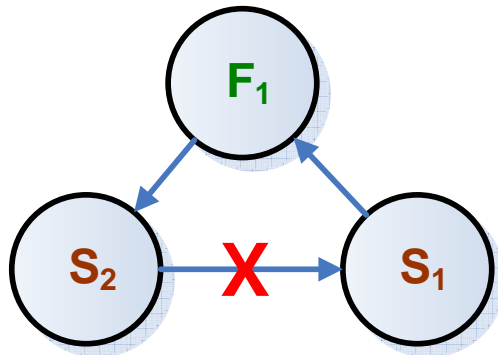


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Example Problem Array

Initial Su-field Model

	Code
S ₁	0、1
S ₂	0、1
Field	Me Th Ch EM ONAB (0~9, 0 Not exist)
Interaction	0、 P 、 I 、 H 、 E (0~4)



Problem Array: [1 1 4 3] [0 1 1 1 1 0 1 1 0]


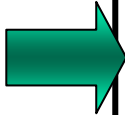
Interaction: 0: missing; P: Proper; I: Insufficient; H: Harmful; E: Excessive.

Solution Constraints





Restrictions	State
D/M problem?	0(No) 、 1(Yes)
Dynamic system?	0(No) 、 1(Yes)
Sub(S2) added allowed?	0(No) 、 1(Yes)
Sub(S3) added allowed?	0(No) 、 1(Yes)
Field added allowed?	0(No) 、 1(Yes)
Added into Env. allowed?	0(No) 、 1(Yes)
Added into (S2) allowed?	0(No) 、 1(Yes)
Added Magnetic Field allowed?	0(No) 、 1(Yes)
Included Fe. Material in system?	0(No) 、 1(Yes)



Key Issues & Contributions

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Issue 2: ID corresponding standard for the problem

- With the fully defined Problem Array, 4 methods are used to ID corresponding Solution Standards:
 - Commonly used standards 
 - Savransky flow chart process 
 - Victor Fey's flow chart process 
 - Darrell Mann's list of solutions. 
- Rank the ID solutions based on the frequency picked by above 4 methods.

Issue 2: ID corresponding standard for the problem

- Solution Array:
 - Bit stream representation of whether each standard is used. [0/1]
- Draw the Identified SSM/DSM for the solutions.
- User can select any combination of these search methods to locate relevant standards. Default is to use all of them.





Method 1: Common Problem Patterns

- Common Su-Field patterns → Common Solutions
 - In-Complete → Standard: 1.1.1 ~ 1.1.8
 - Insufficient(function) → Standard: 2.1.1 、 2.2.1 、 5.1.1.2
 - Harmful(function) → Standard: 1.2.1



Method 4: Mann's Classification of S-Field Problems

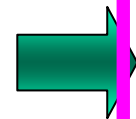
- Mann's classification of problems (Hands-on Systematic Innovation) into 78 Standard solutions:

	Standard solution classes						
<u>Incomplete</u>	Add subs and/or field to complete system						
<u>Measurement / detection</u>	Eliminate need; Measure copy/image etc.; Meas changes indir.; Mod / add field 4 better param; Use detectable additive to sys; Use detectable additive to Env; Use physical/chemical/biological eff.; Use resonance; Intro Ferromagnetics; Use physical effect asso w/ ferromagnetics						
<u>Harmful</u>	Mod. subs	Mod Field	Add Subs	Add Field	Add Sub & Field	Trans 2 Super-sy	Trans 2 Sub-sys
<u>Insuff or Excessive</u>	Mod. subs	Mod Field	Add Subs	Add Field	Add Sub & Field	Trans 2 Super-sy	Trans 2 Sub-sys

Key Issues & Contributions

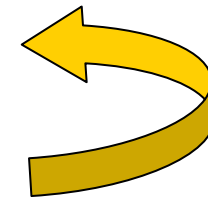
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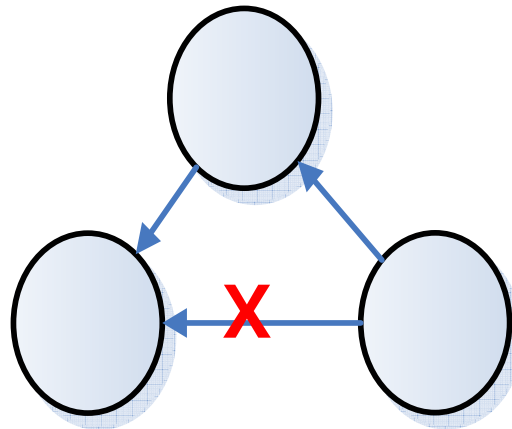


Issue 3: From Solution Standard to Specific Solution

- Connecting the identified Standard (DSM) to specific solution for the problem.
 - Still need to use human brain to locate the specific solution.
 - List all examples under each standard in an easy-to-look-up manner for user to reference.

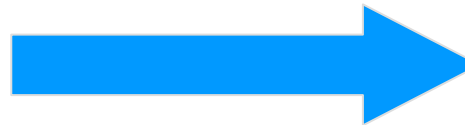


Summary of the work



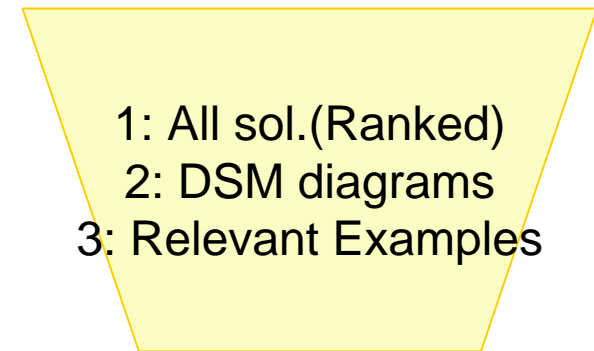
Common Pattern

Savransky -
Vector Fey



Darrell Mann

Ranked Solution(s)



$\left[\begin{matrix} S_1 & S_2 & \text{Field} & \text{Action} \end{matrix} \right] + [\text{Constraints}]$

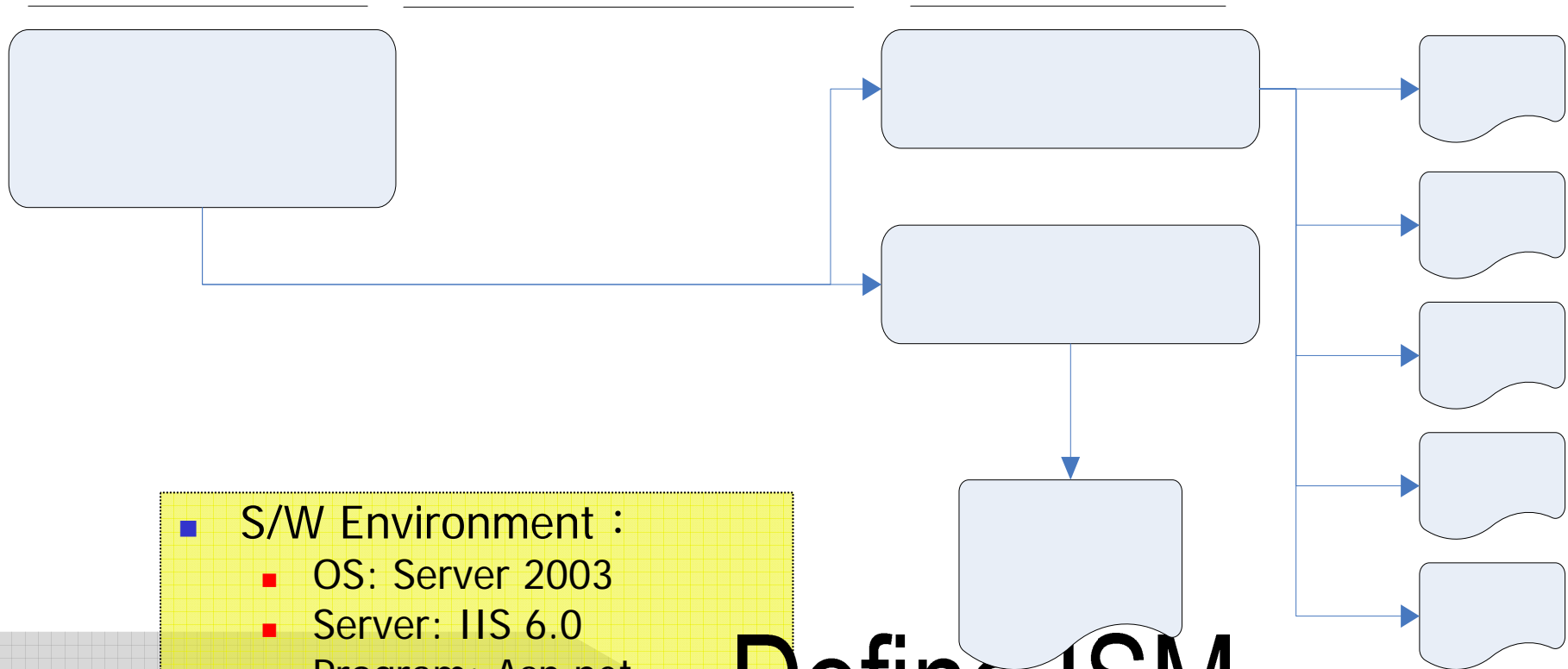
$\left[\begin{matrix} 1 & 1 & \text{Me} & \text{H} \end{matrix} \right] [0 \ 1 \ 0 \ 1 \dots]$

Problem Array

Solution Array

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Program Structure

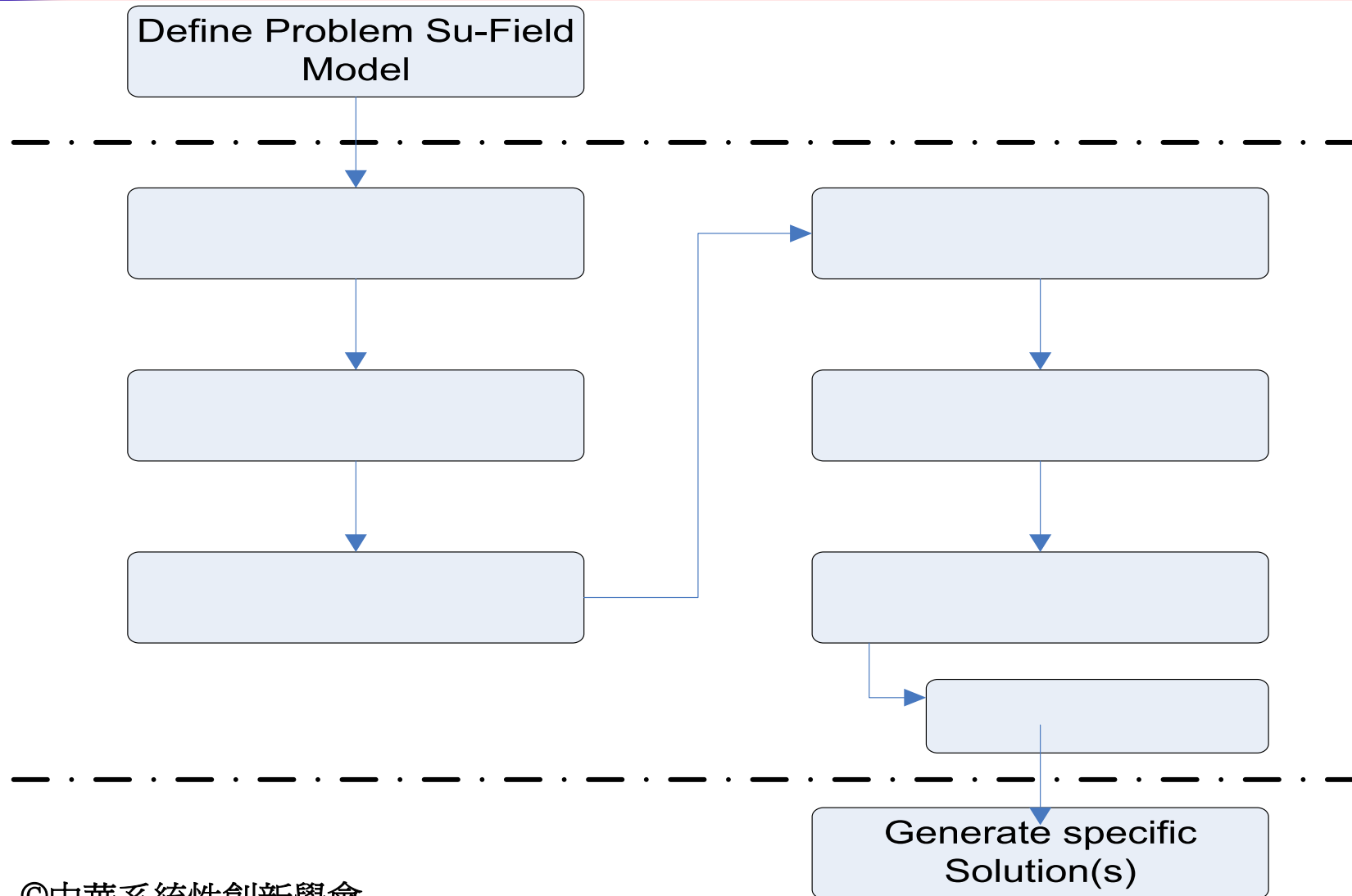


- S/W Environment :
 - OS: Server 2003
 - Server: IIS 6.0
 - Program: Asp.net
 - DB: Access 2003

Define ISM

Fin

Problem solving process



Program Display (1/2)

1: Define ISM

Define the Substances:

The interaction between the two substances: Complete Direction: Sure

Constraints for Problem-Solving

- Detection/Measurement Problem
- Dynamic System
- Add Substance 2 allowed
- Add Substance 3 allowed
- Ferromagnetic material within Su-Field
- Add Field allowed
- Add to Environment allowed
- Add to Substance 2 allowed
- Add Magnetic Field allowed

All Solutions Fey Savransky Mann Common Pattern Solution GO

2: Select Constraints



Program Display(2/2)

3: Display **PSM**



4: Display **DSM**

Source Standard No

FSM	5.2.1	Use one field
MC	1.1.1	Complete an object S2 ar
FS	5.1.1	Indirect wayt
FS	5.1.1.1	Use "nothing clearances,
FS	5.1.1.2	Use a field i
FS	5.1.1.3	Use an exte
FS	5.1.1.4	Use a small
FS	5.1.1.5	Concentrate
FS	5.1.1.6	Introduce the
FS	5.1.1.7	Use a copy i
FS	5.1.1.8	Use the original

完成

Standard : 1.2.2

Similar to 1.2.1., but new substances cannot be added. Remove the harmful effect by modifying S1 or S2. This solution includes adding "nothing"—voids, hollows, vacuum, air, bubbles, foam, etc., or adding a field that acts like an additional substance.

- Stress-thickening fluid inside bicycle saddle stiffens and conforms to the shape of the cyclist to remove discomfort
- Introduction of bevelled edge on a retaining ring reduces harmful movement between ring and part to be retained or housing
- Wing-flaps and/or vortex generators prevent stall on wings
- Add vents to an umbrella to equalise pressures and prevent gusts from causing damage
- Add bevelled edges to components – e.g. pistons, retaining rings, to eliminate wear problems

All Solutions Fey Savransky Mann Common Pattern Solution

Return DSM GO View All Standards

Source Standard No Statement

FMC	1.2.1	Useful and harmful effects exist in the current design. It is not necessary for S1 and S2 to be in direct contact. Remove the harmful effect by introducing S3.
SMC	5.1.1.2	Use a field instead of a substance.

完成

5: List ID Solutions in order.

Method used to ID solution

6: Description of standards & examples



Verification Cases

■ Cases:

- 1~3、CMP Patents
(Chemical Mechanical Polishing)
- 4、Wind Turbine Patent (Skip)

■ In the cases:

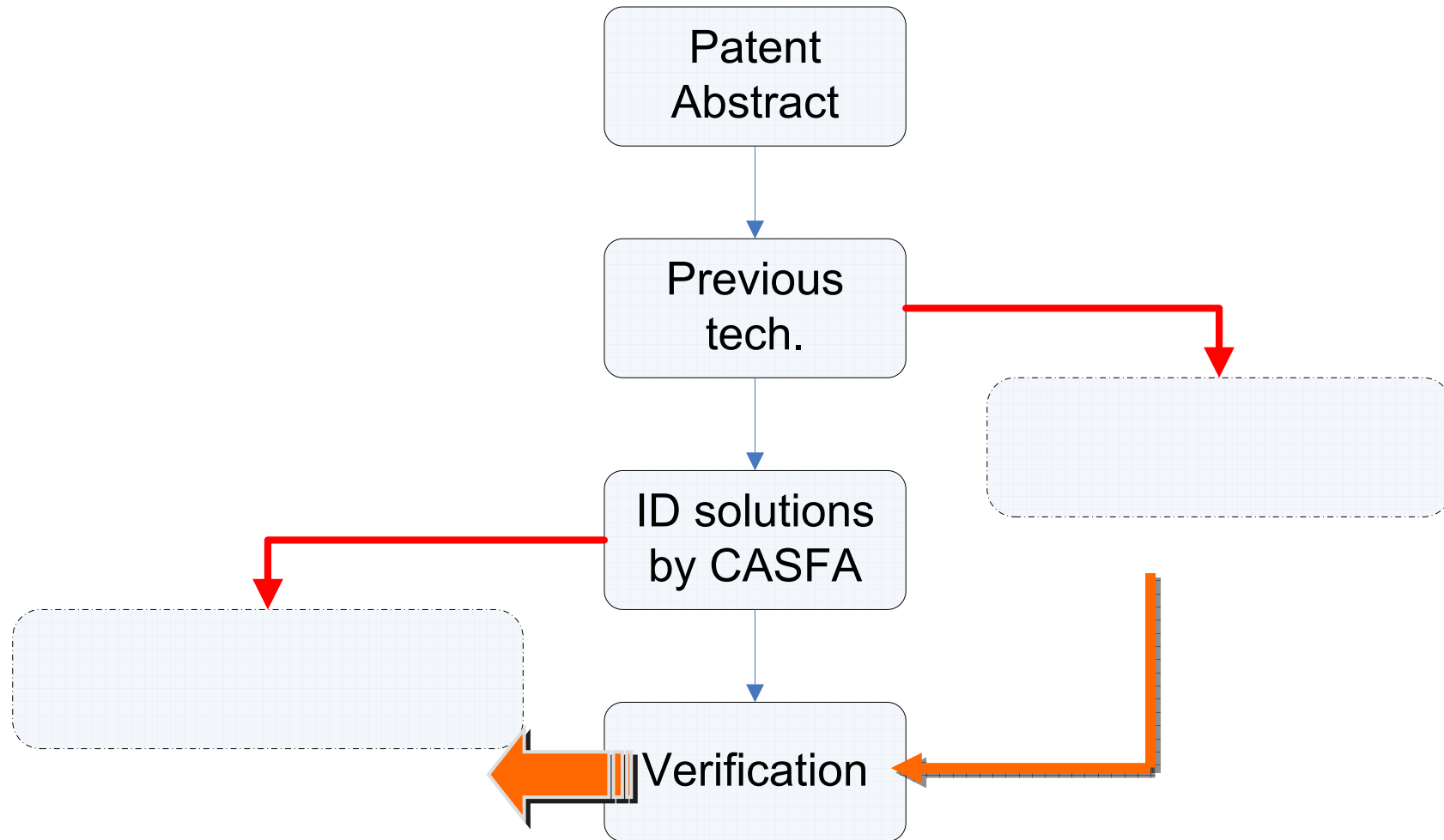
- current situation in the patents were converted to the ISMs
- Software was used to locate solution standards
- One of the solutions suggested by the software coincides with the solution used by the patent.

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Patent Analysis Process





Case 1: Wafer Cleaning method (提高元件性能之方法)

Source: R.O.C. Patent #I242234

Inventors: 李國輝、李興隆、顏清郎

Year: 2005

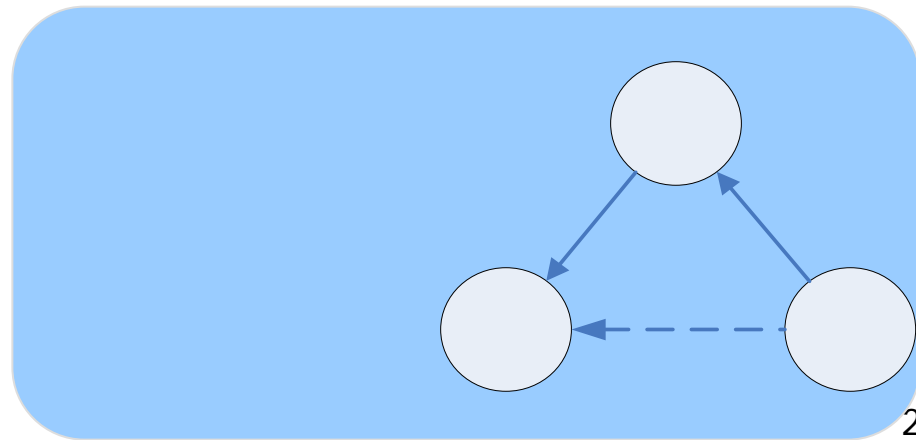
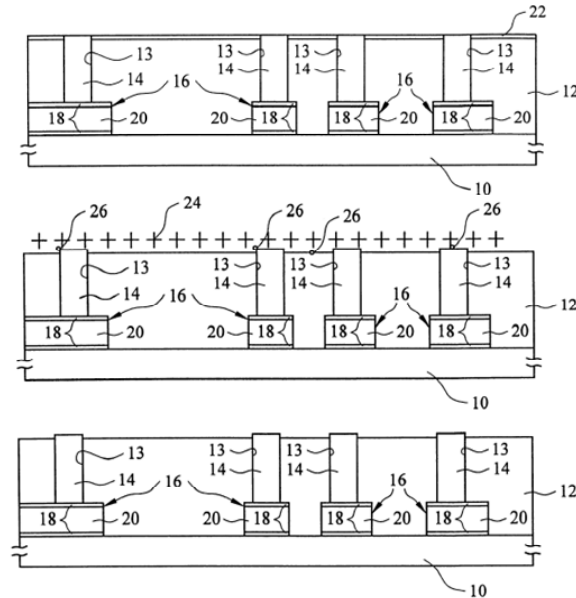
Wafer clean after CMP(1/3)

Goal :

- Enhance the effect of removing the static electricity and particles after CMP process.

Previous solution :

- Use pressurized DI water to clean wafer surface 利用高壓去離子水進行表面清潔
- Insufficient cleaning between surface holes.



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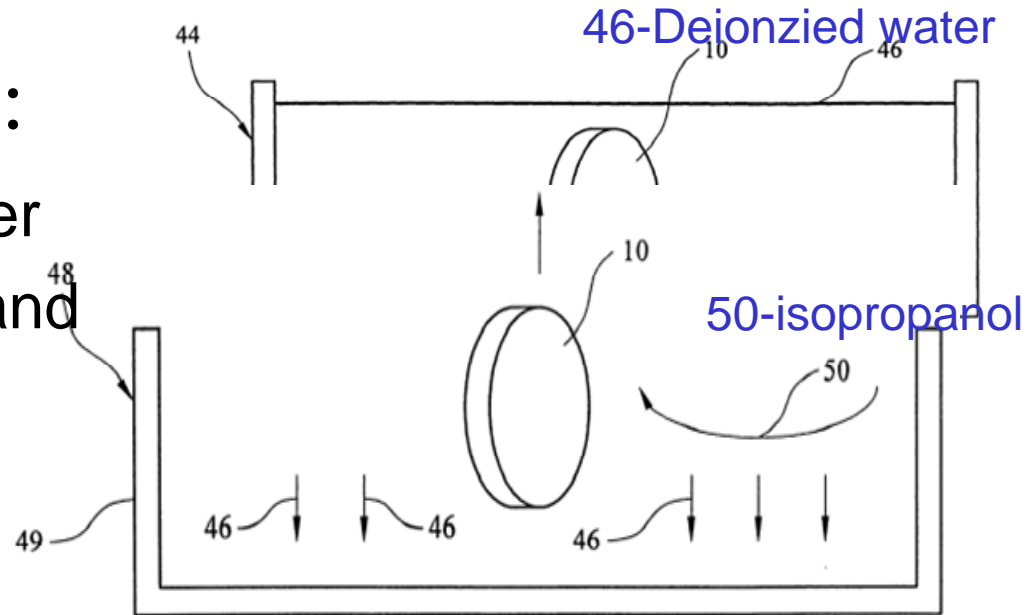


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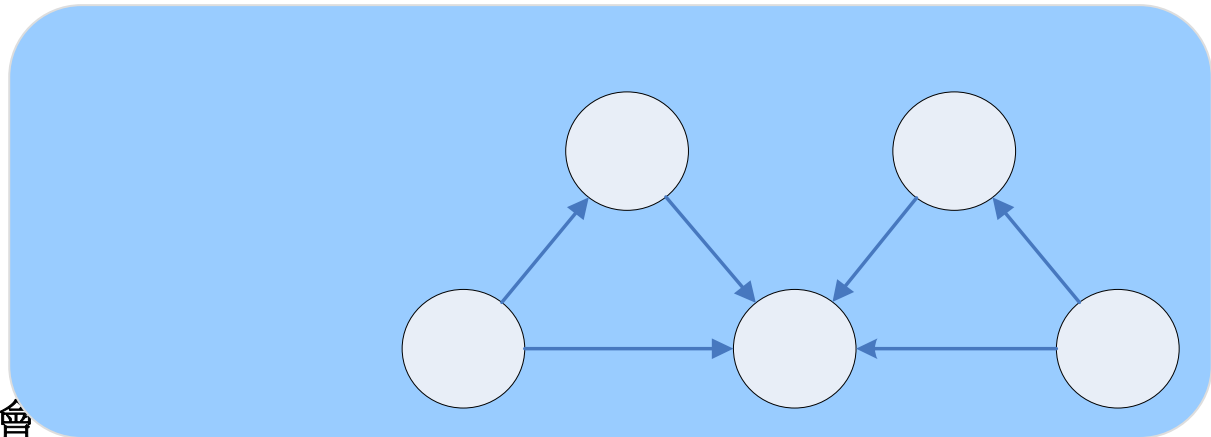
Wafer clean after clean(2/3)

Patented solution :

- Soak wafer in DI water
- Dry wafer in a room and spray IPA to remove static elec.)



Corresponding to
Standard 5.1.1.8

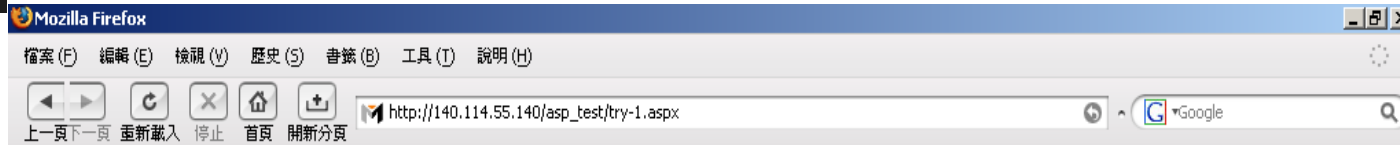


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Case 1

Use CASFA to locate solutions



Define the Substances:

1、Subs all existed



The interaction between the two substances Insufficient Direction: ←←←← →→→→

2、Insufficient interaction

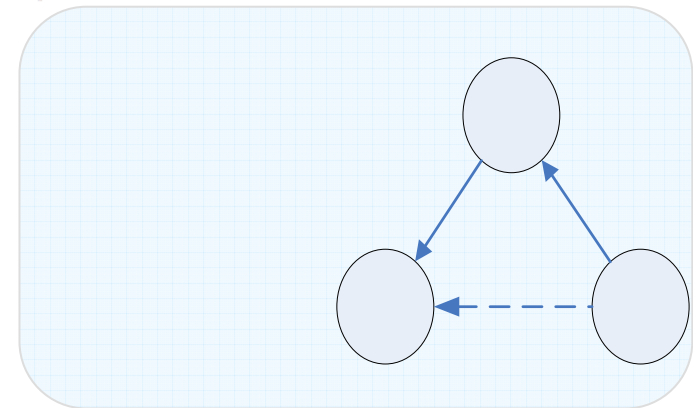


3、Mechanical Field

Constraints for Problem-Solving

<input type="checkbox"/> Detection/Measurement Problem	<input type="checkbox"/> Add Field allowed
<input type="checkbox"/> Dynamic System	<input type="checkbox"/> Add to Environment allowed
<input type="checkbox"/> Add Substance 2 allowed	<input type="checkbox"/> Add to Substance 2 allowed
<input type="checkbox"/> Add Substance 3 allowed	<input type="checkbox"/> Add Magnetic Field allowed
<input type="checkbox"/> Ferromagnetic material within Su-Field	

All Solutions Fey Savransky Mann Common Pattern Solution



完成

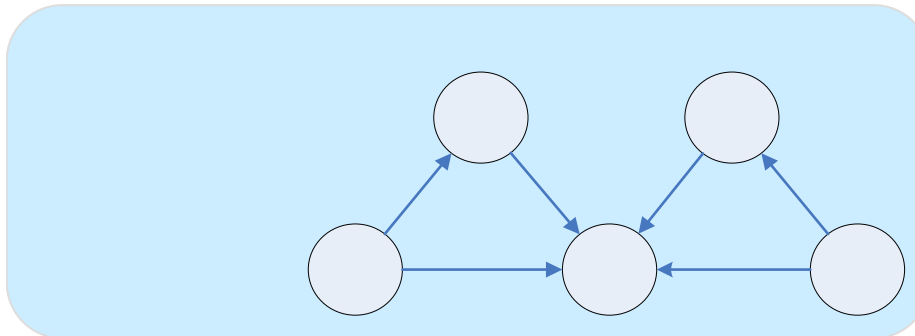
Wafer clean after clean(3/3)

Locate SSM (DSM)

Standard 5.1.1.8

- Introduce a chemical compound which reacts, yielding the desired elements or compounds.

- M 3.1.2 Improving Links in the Bi- and Poly-Systems.
- M 3.1.3 System Transition 1b: Increasing the Differences Between Elements.
- M 3.1.4 Simplification of the Bi- and Poly-Systems.
- M 3.1.5 System Transition 1c: Opposite Features of the Whole and Parts.
- M 3.2.1 System Transition 2: Transition to the Micro-Level.
- M 5.1.1.1 Use "nothing" – add aire, vacuum, bubbles, foam, voids, howllows,



Standard : 5.1.1.8

Introduce a chemical compound which reacts, yielding the desired elements or compounds, where introducing the desired material would be harmful.

- People need sodium for metabolism, but metallic sodium is harmful. Ordinary salt is ingested, then converted to sodium and chlorine for use by the body.
- Race cars use nitrous oxide instead of air for combustion to get higher power
- Non-persistent, bio-degrading pesticides
- Bio-degrade trigger materials – additives which promote decomposition of parent structure
- Add sludge and oxygen in hydrocarbon coking operations to prevent harmful reaction temperature variations
- Bio-degradable additives speed break-down of oils upon disposal
- People need sodium for metabolism, but metallic sodium is harmful. Ordinary salt is ingested, then converted to sodium and chlorine for use by the body.
- Race cars use nitrous oxide instead of air for combustion to get higher power
- Cavitation erosion – air bubbles released to atmosphere after erosion effect
- Plant-pots made of hardened fertiliser



Conclusion

- Establish the computer-aided problem solving assistant using SFA, contributions include:
 - Establishing a modeling approach to fully represent mini-problems via Problem Array.
 - Providing automatic identification of solution standards using various searching methods based on Problem Array.
 - Providing automatic conversion from ISM into DSM and ample examples for solution triggers.



Future work

- Integrate other TRIZ tool for more solutions:
 - Automatic Identification of relevant K/E DB from problem array
 - Automatic Identification of relevant trends from Problem Array.