Substance Field Modeling: Measurement and Detection

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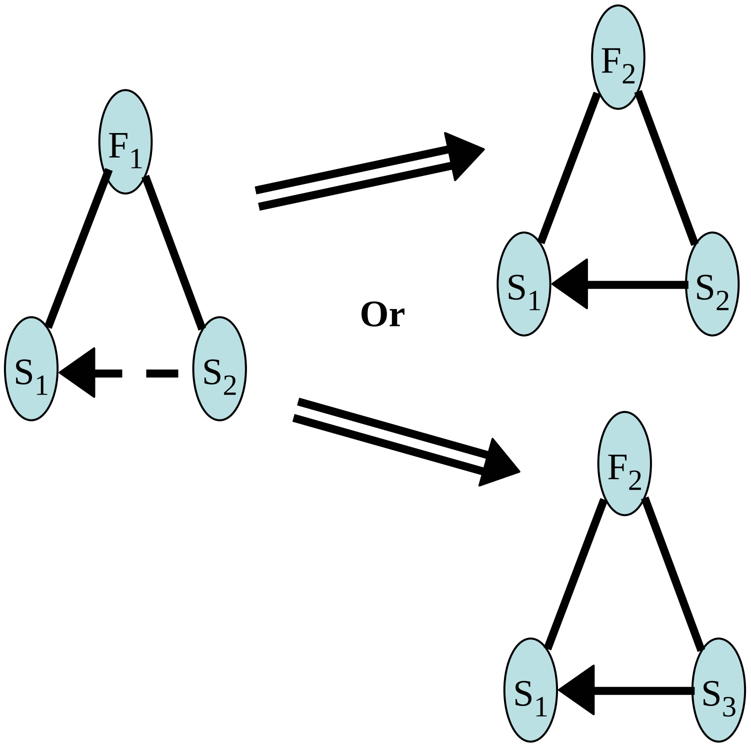
Substance-Field Modeling (SFM)



Why A Model ?

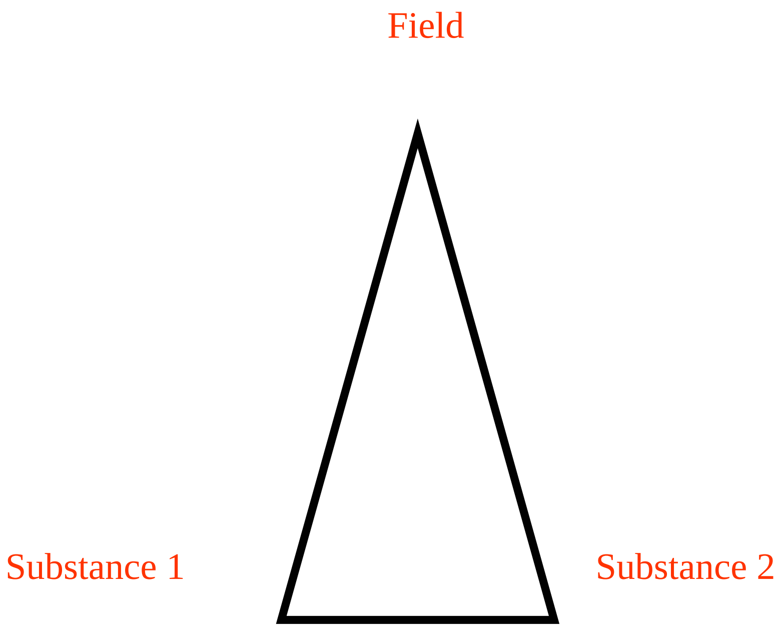
- Some systems need modeled in order to understand the inequalities and inconsistencies that manifest as problems or insufficiencies
- Complex systems may be better understood with the use of a model
- A SFM identifies specific problem types and then offers solution standards

SFM Defined

- Su-Field models are pictorial representations of the elements in the system and the field through which the elements interact.
- These are formed into triangular diagrams
- The diagrams are analyzed for defects
- The particular defect type yields solution standards

Minimum Model of a Functioning Technical System (SFM)

- Object 1, Substance 1
- Object 2, Substance 2
- Field or force (energy)
- Object 1 interacts with Object 2 through the field or force, Field
- Model system using triangle



A complete SFM with no defects

The Model

- Substance 1 is known as the *workpiece*
- Substance 2 is known as the *tool*
- The *tool* is applied to the *workpiece*
  - this is the flow of energy through the model
- The *field* is the connecting component

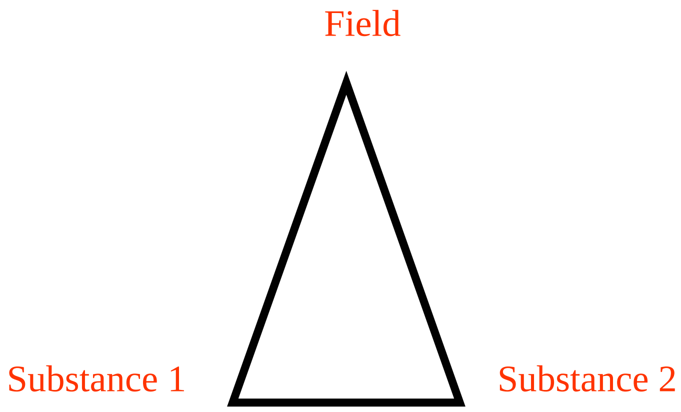
The *Field*

- The *Field* is divided into sub-groups:
  - Me: mechanical
  - Th: thermal
  - Ch: chemical
  - E: electrical
  - M: magnetic
  - EM: electromagnetic
- The subgroup is used as a subscript to the F in the Su-Field Model (i.e., F_{Me}, F_{Ch})

Example

A person is painting a wall:

- S1: wall (workpiece)
- S2: person (tool)
- F: painting (mechanical field)



Different Levels of Modeling

- S1: wall
- S2: person
- F: painting

- S1: wall
- S2: paint
- F: adhesion

- S1: wall
- S2: brush
- F: application

- S1: paint
- S2: brush
- F: application

- S1: brush
- S2: person
- F: moving application

76 Standard Solutions

- The 76 Standard Solutions were developed from patterns of solutions of technological / transactional problems

76 Standards of Solutions

- The Solutions are broken into 5 Classes
  - Class 1 – Composition and Decomposition of SFMs
  - Class 2 – Evolution of SFMs
  - Class 3 – Transition to Super-system and Micro-level
  - **Class 4 – Measurement and Detection Standards**
  - Class 5 – Helpers

The 5 Classes

CLASS 1. COMPOSITION AND DECOMPOSITION OF SFMS

GROUP 1-1: SYNTHESIS OF A SFM
GROUP 1-2: DECOMPOSITION OF SFMS

CLASS 2. EVOLUTION OF SFMS

GROUP 2-1: TRANSITION TO COMPLEX SFMS
GROUP 2-2: EVOLUTION OF SFM
GROUP 2-3: EVOLUTION BY COORINATING RHYTHMS
GROUP 2-4: FERROMAGNETIC SFMS (FESFMS)

CLASS 3. TRANSITIONS TO SUPERSYSTEM AND MICROLEVEL

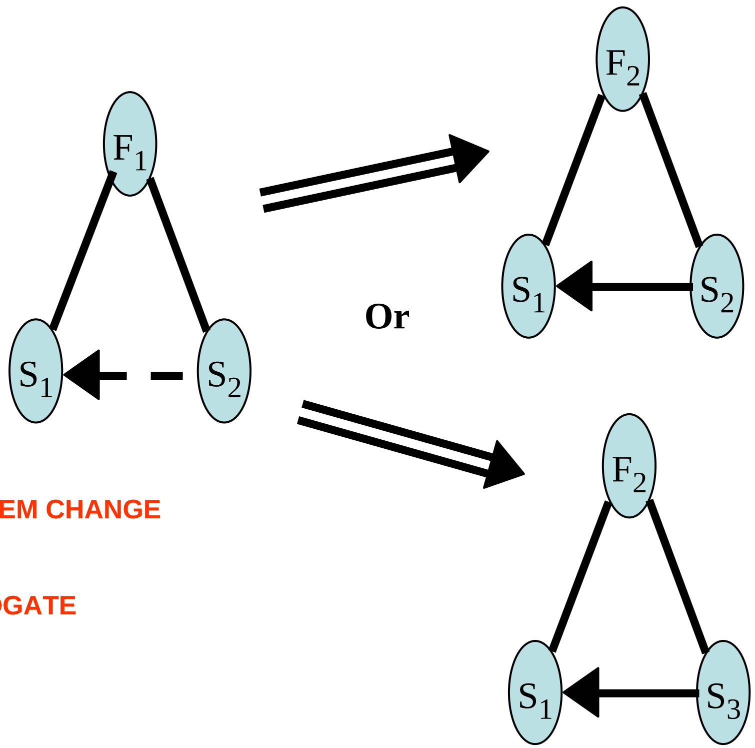
GROUP 3-1: TRANSITIONS TO BISYSTEM AND POLYSYSTEM
GROUP 3-2: TRANSITION TO MICROLEVEL

CLASS 4. MEASUREMENT AND DETECTION STANDARDS

GROUP 4-1: INSTEAD OF MEASUREMENT AND DETECTION - SYSTEM CHANGE
GROUP 4-2: SYNTHESIS OF A MEASUREMENT SYSTEM
GROUP 4-3: ENHANCEMENT OF MEASUREMENT SYSTEMS
GROUP 4-4: TRANSITION TO FERROMAGNETIC OR OTHER SURROGATE MEASUREMENT SYSTEMS
GROUP 4-5: EVOLUTION OF MEASUREMENT SYSTEMS

CLASS 5. SPECIAL RULES OF APPLICATION

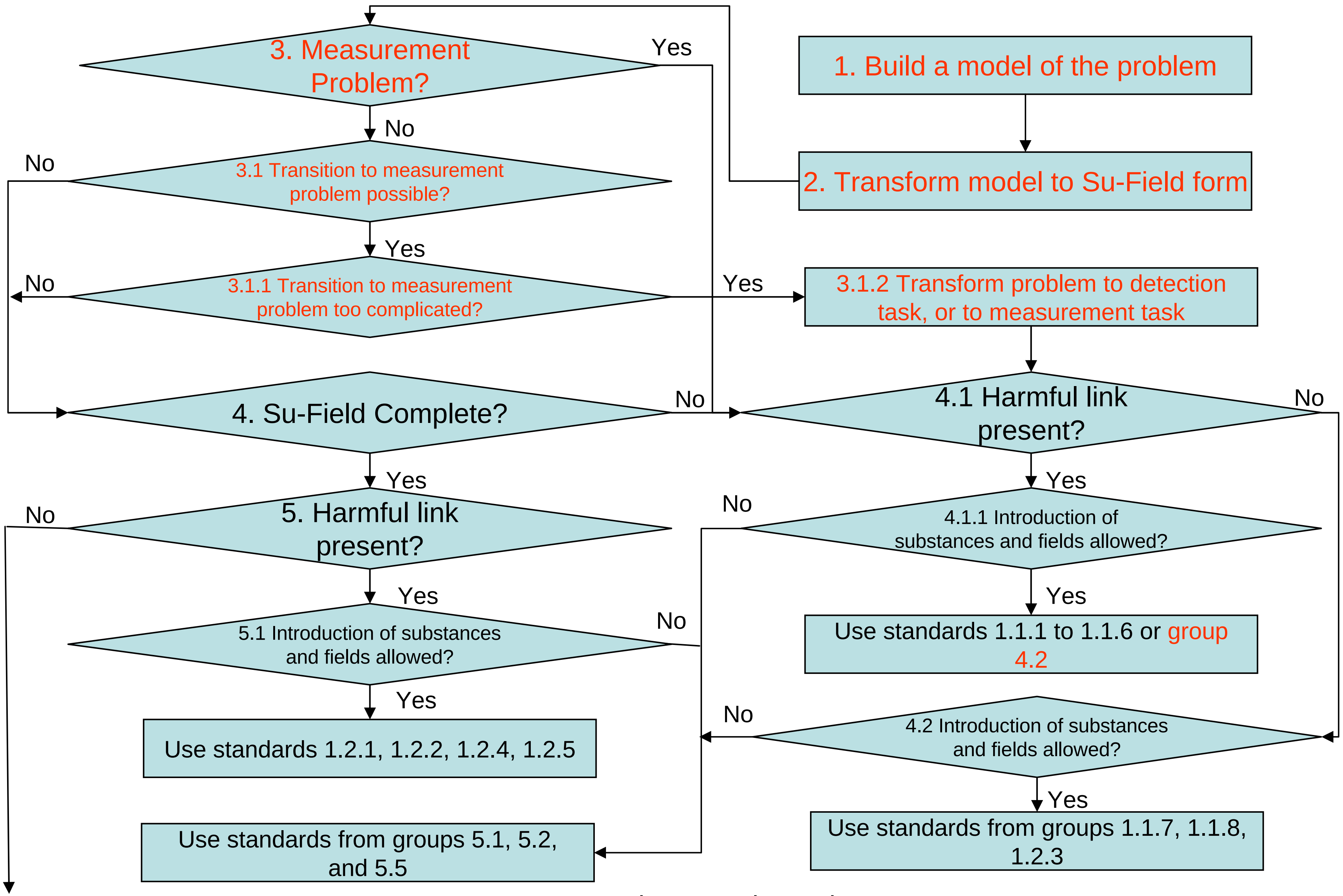
GROUP 5-1: SUBSTANCE INTRODUCTION
GROUP 5-2: INTRODUCTION OF FIELDS
GROUP 5-3: USE OF PHASE TRANSITIONS
GROUP 5-4: PHYSICAL EFFECTS USE
GROUP 5-5: SUBSTANCE PARTICLES OBTAINING

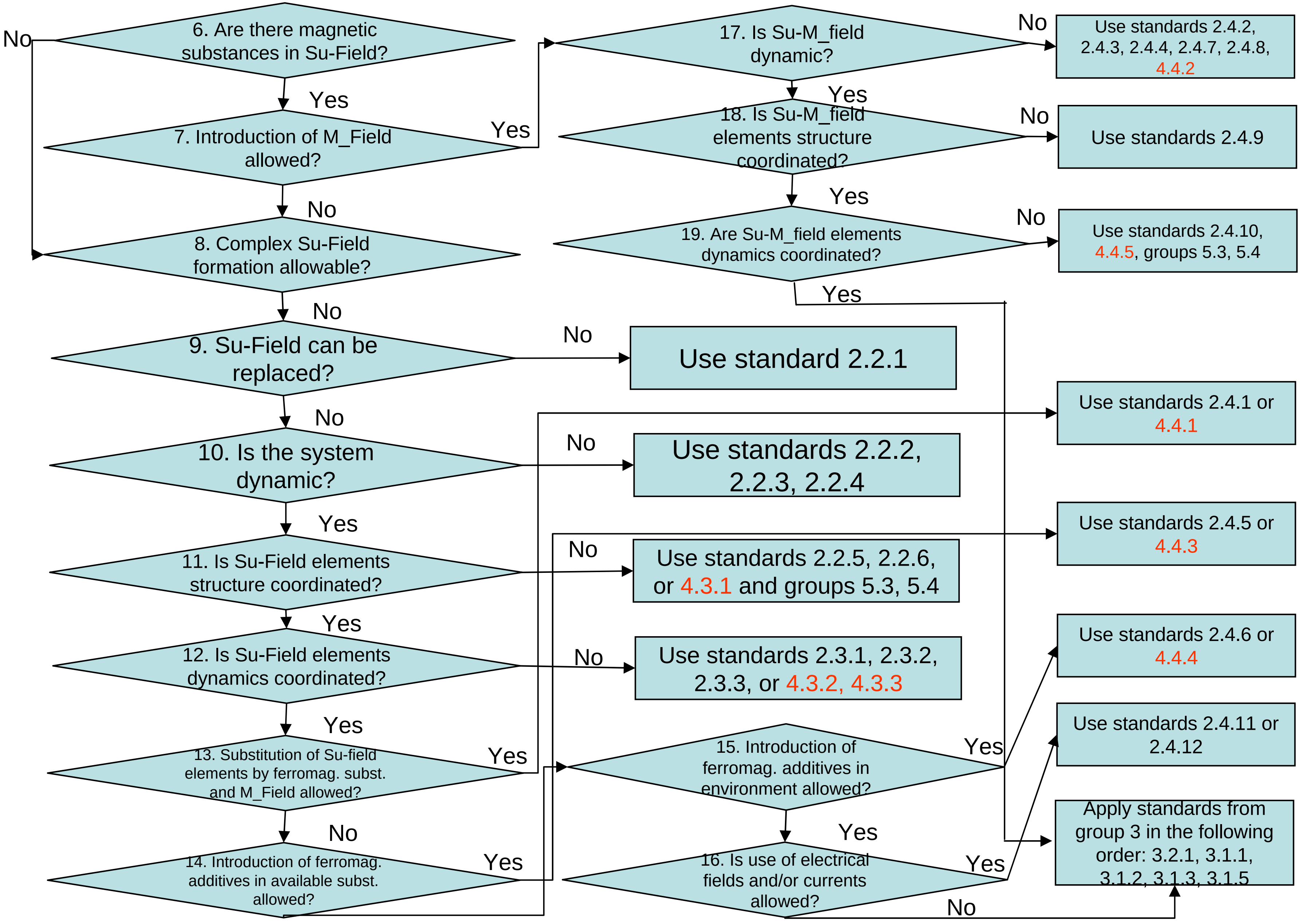


Example: Standard 4-3-1

- If we are given the problem of measurement and the problem cannot be changed to remove the need for measurement, and it is impossible to use copies or pictures, it is proposed to transform this problem into the a problem of successive detection of changes.
- *Example: To measure temperature, it is possible to use a material that changes its color depending on the current value of the temperature. Alternatively, several materials can be used to indicate different temperatures.*
  - *Uses color as a surrogate measurement.*

SFM Algorithm

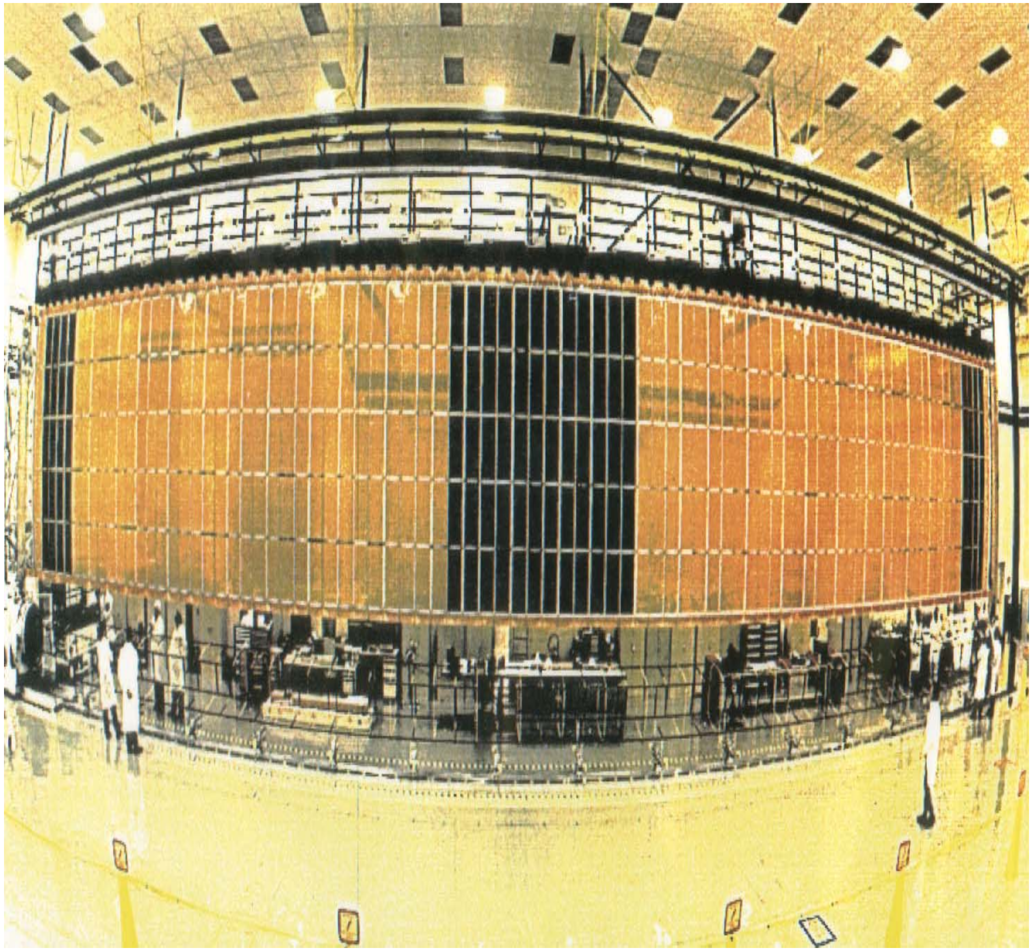




6. Are there magnetic substances in Su-Field?
No
Yes
7. Introduction of M_Field allowed?
Yes
No
8. Complex Su-Field formation allowable?
No
9. Su-Field can be replaced?
No
Use standard 2.2.1
No
10. Is the system dynamic?
No
Use standards 2.2.2, 2.2.3, 2.2.4
Yes
11. Is Su-Field elements structure coordinated?
No
Use standards 2.2.5, 2.2.6, or 4.3.1 and groups 5.3, 5.4
Yes
12. Is Su-Field elements dynamics coordinated?
No
Use standards 2.3.1, 2.3.2, 2.3.3, or 4.3.2, 4.3.3
Yes
13. Substitution of Su-field elements by ferromag. subst. and M_Field allowed?
Yes
No
14. Introduction of ferromag. additives in available subst. allowed?
Yes
17. Is Su-M_field dynamic?
No
Use standards 2.4.2, 2.4.3, 2.4.4, 2.4.7, 2.4.8, 4.4.2
Yes
18. Is Su-M_field elements structure coordinated?
No
Use standards 2.4.9
Yes
19. Are Su-M_field elements dynamics coordinated?
No
Use standards 2.4.10, 4.4.5, groups 5.3, 5.4
Yes
Use standards 2.4.1 or 4.4.1
Use standards 2.4.5 or 4.4.3
Use standards 2.4.6 or 4.4.4
Use standards 2.4.11 or 2.4.12
15. Introduction of ferromag. additives in environment allowed?
Yes
Yes
16. Is use of electrical fields and/or currents allowed?
Yes
No
Apply standards from group 3 in the following order: 3.2.1, 3.1.1, 3.1.2, 3.1.3, 3.1.5

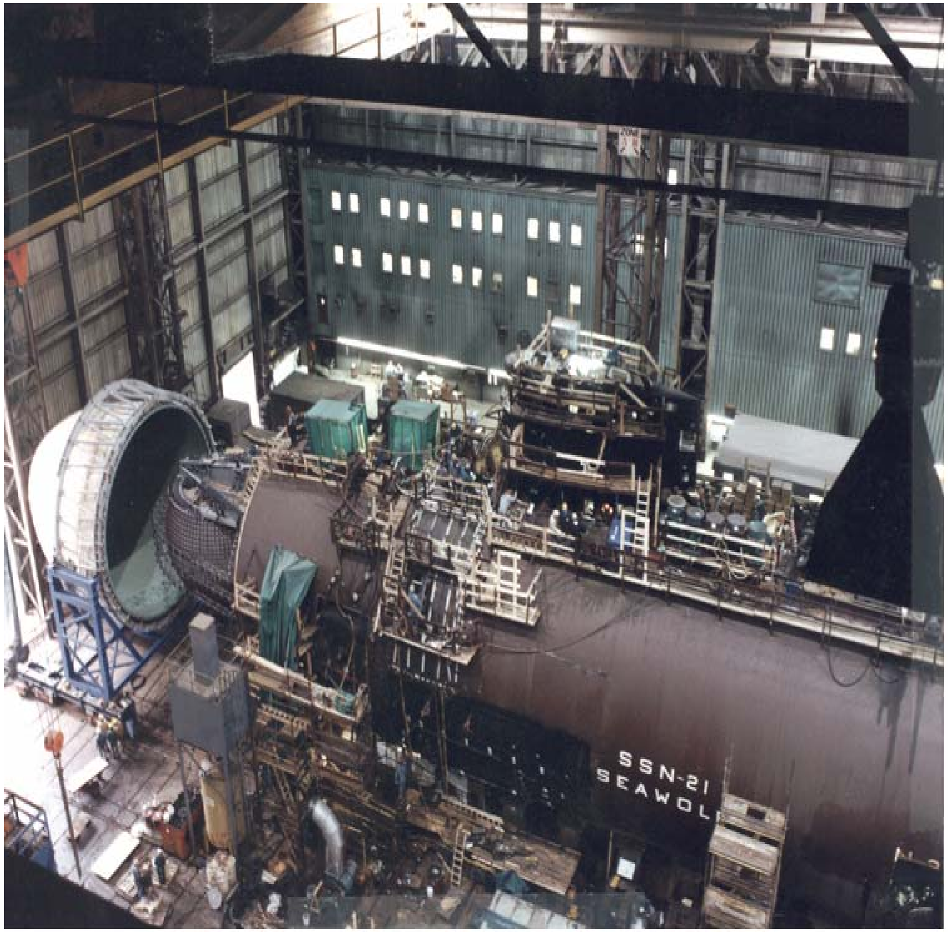
No

ISS Solar Panel Array



SFM was used to create solutions for surface imperfection problems in the ISS Solar Panel Array

SeaWolf Submarine



SFM was used extensively throughout the development of the fore and aft passive sonar arrays

Cassini-Huygens Satellite

SFM was used in many cases to help understand complex system interactions and create isolation systems for the Huygens Probe

Conclusions

- SFM is a powerful method of understanding a system and all interactions
- SFMs that contain defects may be solved using the 76 Standards
- The SFM Algorithm simplifies standard selection
- SFM Theory may be learned as part of an Advanced TRIZ curriculum

You can learn more at:

www.realinnovation.com

www.triz-journal.com

www.inventioneeringco.com and www.airacad.com

Class 4 – Measurement and Detection Standards

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-1: CHANGE INSTEAD OF MEASUREMENT AND DETECTION

STANDARD 4-1-1

If a problem involves detection or measurement, it is proposed to change the problem in such a way, so that there should be no need to perform detection of measurement at all.

Example: To prevent a permanent electric motor from overheating, its temperature is measured by a temperature sensor. If to make the poles of the motor of an alloy with a Curie point equal to the critical value of the temperature, the motor will stop itself.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-1: CHANGE INSTEAD OF MEASUREMENT AND DETECTION

STANDARD 4-1-2

If a problem involves detection of measurement, and it is impossible to change the problem to eliminate the need for detection or measurement, it is proposed to change/detect properties of a copy of the object (e.g. picture).

Example: It might be dangerous to measure the length of a snake. It is safe to measure its length on a photographic image of the snake, and then recalculate the obtained result.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-1: CHANGE INSTEAD OF MEASUREMENT AND DETECTION

STANDARD 4-1-3

If a problem involves detection or measurement, and the problem cannot be changed to eliminate the need for measurement, and it is impossible to use copies or pictures, it is proposed to transform this problem into a problem of successive detection of changes.

Notes: Any measurement is conducted with a certain degree of accuracy. Therefore, even if the problem deals with continuous measurement, one can always single out a simple act of measurement that involves two successive detections. This makes the problem much simpler.

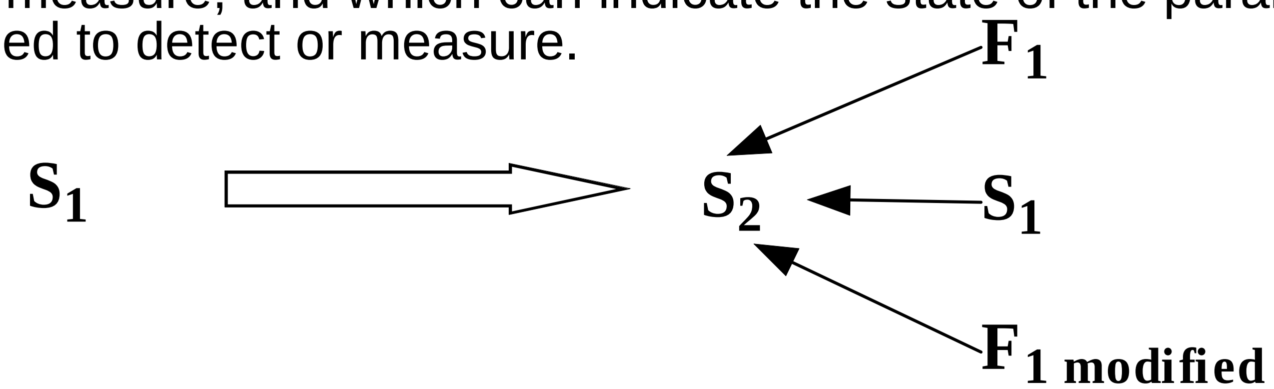
Example: To measure a temperature, it is possible to use a material that changes its color depending on the current value of the temperature. Alternatively, several materials can be used to indicate different temperatures.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-2: Synthesis of Measurement System

STANDARD 4-2-1

If a non-SFM is not easy to detect or measure, the problem is solved by synthesizing a simple or dual SFM with a field at the output. Instead of direct measurement or detection of a parameter, another parameter identified with the field is measured or detected. The field to be introduced should have a parameter that we can easily detect or measure, and which can indicate the state of the parameter we need to detect or measure.



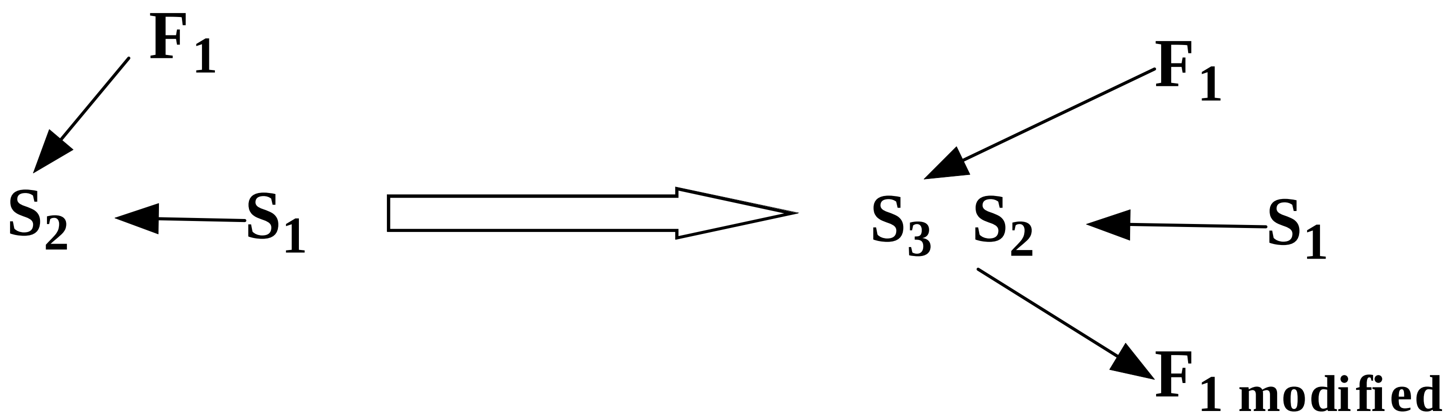
Example: To detect a moment when liquid starts to boil, an electrical current is passed through the liquid. During boiling, air bubbles are formed - they dramatically reduce electrical resistance of the liquid.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-2: Synthesis of Measurement System

STANDARD 4-2-2

If a system (or its part) does not provide detection or measurement, the problem is solved by transition to an internal or external complex measuring SFM, introducing easily detectable additives.



Example: To detect leakage in a refrigerator, a cooling agent is mixed with a luminescent powder.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-2: Synthesis of Measurement System

STANDARD 4-2-3

If a system is difficult to detect or to measure at a given moment of time, and it is not allowed or not possible to introduce additives into the object, then additives that create an easily detectable and measurable field should be introduced in the external environment. Changing the state of the environment will indicate the state of the object.

Example: To detect wearing of a rotating metal disc contacting with another disc, it is proposed to introduce luminescent powder into the oil lubricant, which already exists in the system. Metal particles collecting in the oil will reduce luminosity of the oil.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-2: Synthesis of Measurement System

STANDARD 4-2-4

If it is impossible to introduce easily detectable additives in the external environment, these can be obtained in the environment itself, for instance, by decomposing the environment or by changing the aggregate state of the environment.

Notes: In particular, gas or vapor bubbles produced by electrolysis, cavitation or by any other method may often be used as additives obtained by decomposing the external environment.

Example: The speed of a water flow in a pipe might be measured by amount of air bubbles resulting from cavitation.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-3: Improvement of Measurement Systems

STANDARD 4-3-1

Efficiency of measuring SFM can be improved by the use of physical effects.

Example: Temperature of liquid media can be measured by measuring a change of a coefficient of retraction, which depends on the value of the temperature.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-3: Improvement of Measurement Systems

STANDARD 4-3-2

If it is impossible to detect or measure directly the changes in the system, and no field can be passed through the system, the problem can be solved by exciting resonance oscillations (of the entire system or of its part), whose frequency change is an indication of the changes taking place.

Example: To measure the mass of a substance in a container, the container is subjected to mechanically forced resonance oscillations. The frequency of the oscillations depends on the mass of the system.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-3: Improvement of Measurement Systems

STANDARD 4-3-3

If resonance oscillations may not be excited in a system, its state can be determined by a change in the natural frequency of the object (external environment) connected with the system.

Example: The mass of boiling liquid can be measured by measuring the natural frequency of gas resulting form evaporation.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-4: Transition to Ferromagnetic Measurement Systems

STANDARD 4-4-1

Efficiency of a measuring SFM can be improved by using a ferromagnetic substance and a magnetic field.

Notes: The standard indicates the use of a non-fragmented ferromagnetic object.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-4: Transition to Ferromagnetic Measurement Systems

STANDARD 4-4-2

Efficiency of detection or measurement can be improved by transition to ferromagnetic SFMs, replacing one of the substances with ferromagnetic particles (or adding ferromagnetic particles) and by detecting or measuring the magnetic field.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-4: Transition to Ferromagnetic Measurement Systems

STANDARD 4-4-3

If it is required to improve the efficiency of detection or measurement by transition to a ferromagnetic SFM, and replacement of the substance with ferromagnetic particles is not allowed, the transition to the F-SFM is performed by synthesizing a complex ferromagnetic SFM, introducing (or attaching) ferromagnetic additives in the substance.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-4: Transition to Ferromagnetic Measurement Systems

STANDARD 4-4-4

If it is required to improve efficiency of detection or measurement by transition to F-SFM, and introduction of ferromagnetic particles is not allowed, ferromagnetic particles are introduced in the external environment.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-4: Transition to Ferromagnetic Measurement Systems

STANDARD 4-4-5

Efficiency of a F-SFM measuring system can be improved by using physical effects, for instance, Curie point, Hopkins and Barkhausen effects, magnetoelastic effect, etc.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-5: Evolution of Measurement Systems

STANDARD 4-5-1

Efficiency of a measuring system at any stage of its evolution can be improved by forming bi- and poly-system.

Notes: To form bi- and poly-systems, tow or more components are combined. The components to be combined may be substances, fields, substance-field pairs and SFMs.

Example: It is difficult to accurately measure the temperature of a small beetle. However, if there are many beetles put together, the temperature can be measured easily.

CLASS 4: MEASUREMENT AND DETECTION STANDARDS

GROUP 4-5: Evolution of Measurement Systems

STANDARD 4-5-2

Measuring systems evolve towards measuring the derivatives of the function under control. The transition is performed along the following line:

Measurement of a function → measurement of the first derivative of the function → measurement of the second derivative of the function.

Example: Change of stress in the rock is defined by the speed of changing the electrical resistance of the rock.