The Seventy-six Standard Solutions, with Examples
Section One

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This is the first of 5 monthly appendices for the Standard Solutions.
Yes, this is all public domain in the spirit of Altshuller.

The "76 Standard Solutions" of TRIZ were compiled by G.S. Altshuller and his associates between 1975 and1985. They are grouped into 5 large categories as follows:

1.	Improving the system with no or little change	13 standard solutions
2.	Improving the system by changing the system	23 standard solutions
3.	System transitions	6 standard solutions
4.	Detection and measurement	17 standard solutions
5.	Strategies for simplification and improvement	17 standard solutions
	Total:	76 standard solutions

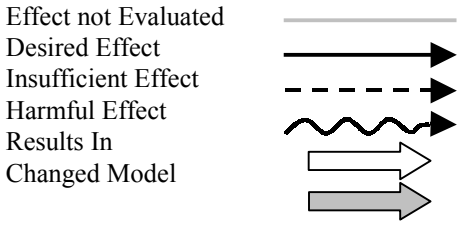
(References 1-5)

This list was developed from those works, and published in a comparison with the 40 principles (Ref. 6) to show that those who are familiar with the 40 principles will be able to expand their problem solving capability by learning Su-field analysis and the 76 standard solutions.

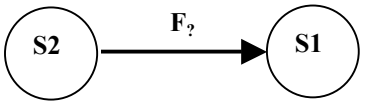
The 76 standard solutions are useful for level three inventive problems (Ref. 3.) Level 3 inventions significantly improve existing systems, and represent 18% of the patents. An inventive contradiction is resolved within the existing system, often through the introduction of some entirely new element. This type of solution may require several hundred ideas, tested by trial and error. Examples include replacing the standard transmission of a car with an automatic transmission, or placing a clutch drive on an electric drill. These inventions usually involve technology integral to other industries but not widely known within the industry of the inventive problem. The resulting solution causes a paradigm shift within the industry. A Level 3 innovation lies outside an industry's range of accepted ideas and principles.

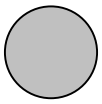
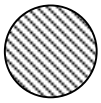
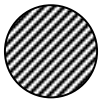
Typically, the 76 standard solutions are used as a step in ARIZ, after the Su-field model has been developed and any constraints on the solution have been identified. The model and the constraints are used to identify the class and the specific solution. It is useful to view the Su-field model as the zone of interest as used in ARIZ. As in other TRIZ instructional material, examples are used to show the application of the standard solution to a wide variety of problems from many fields.

The following symbols will be used for the Su-field models.

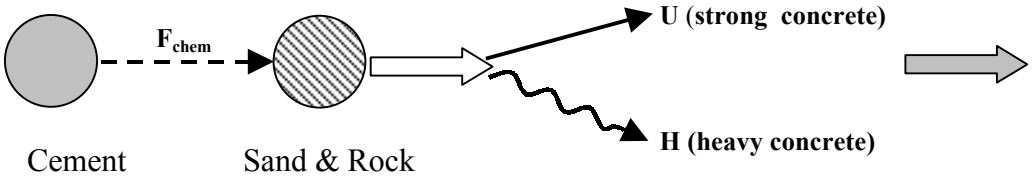


Field types	F_{type}
Useful Effect	**U**
Harmful Effect	**H**



S2 =  **S1 =**  **S3 =** 

Environment (E) = **Environmental Resource (ER) =** 



Cement Sand & Rock

Cement Sand, rock & fly-ash

The Seventy-six Standard Solutions

Class 1. Modifying a system in order to have a desired outcome or to eliminate an undesired outcome. There are no changes or small changes to the system. This group includes the necessary solutions for completing an incomplete model (In Su-field terms, an incomplete model is one that does not have S_1, S_2, and F, or the force F is inadequate.)

Remember that the fields include mechanical, thermal, chemical, acoustic, electrical, magnetic, gravitational, weak nuclear and strong nuclear.

1.1. Improving the performance of an inadequate system

1.1.1. Complete an incomplete model . If there is only an object S_1, add a second object S_2 and an interaction (field) F. *Example*:

If the system is just a hammer, nothing happens. If the system is a hammer and a nail, nothing happens. There must be a complete system—hammer, nail, and mechanical energy for the hammer to act on the nail.

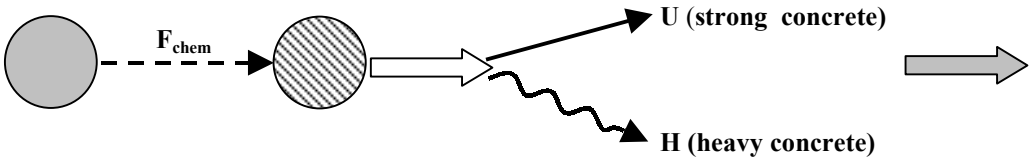
If a truck has no fuel, it won't move. The complete system is the truck , the fuel, and the conversion from the chemical energy of the fuel to mechanical energy of the truck.

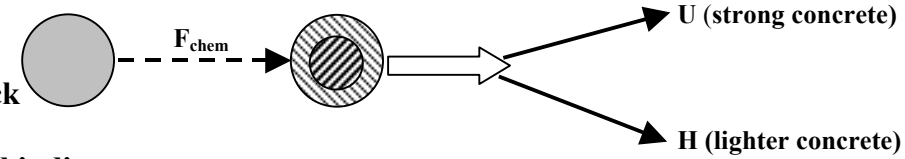
In many organizations, a single individual cannot get anything done. The system must be complete with the original individual (S_2) acting on others (S_1) by means of persuasive arguments (F)

1.1.2. The system cannot be changed but a permanent or temporary additive is acceptable. Incorporate an internal additive in either S_1or S_2. *Examples:*

Adding aerated slag particles can reduce the density of concrete

1.1.2





S1= cement
S2= sand & rock
S3 = flyash
F_{Ch} = chemical binding

Doping of silicon wafers changes properties.

Carrying agent in spray paint.

Baking (improve leavening system)

Add ammonia bicarbonate to increase the loft of bread (larger cells)

Add baking powder to enhance the effect of yeast

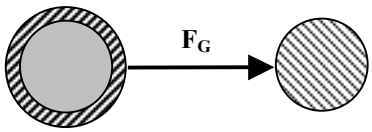
Add vitamin C (to a person) to strengthen the immune system

In a heart lung machine blood clotting is a problem which is reduced by the addition of heparin. Later, the heparin metabolizes.

1.1.3. As in 1.1.2, but use a permanent or temporary external additive S_3 to change either S_1 or S_2. *Examples:*

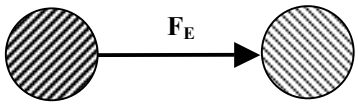
A system with snow (S1) and skis (S2) can be improved by adding wax (S3) to the skis.

1.1.3
S1= ski
S2= snow
S3= wax
F_G = gravity



Converting photographs for this book into digital format is costly and inconvenient. Replacing the traditional camera with a digital is effective.

1.1.3
S1= scene
S2= camera
S3= digital camera
F_E = digital



Teflon tape is added to seal threaded joints in an air compressor system.

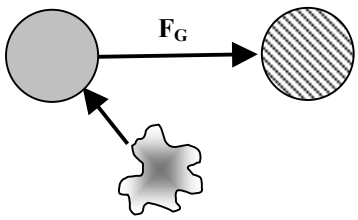
Medical products are humidified to increase the susceptibility of the microorganisms (have spores open up) to a sterilizing agent.

If the cargo is damaged by the motion of the truck, add a buffer such as foam packaging around the cargo.

1.1.4. As in 1.1.2, but use a resource from the environment as the additive, either internally or externally. *Examples:*

A channel marker buoy rocks too much in the traveling seas. Sea water can be used as ballast.

1.1.4
S1= buoy
S2= warning
ER= sea water
F_G = gravity



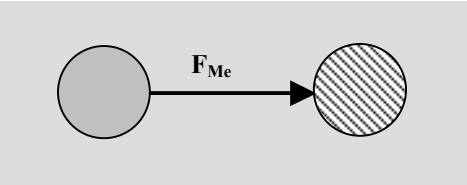
A leather oil seal leaks because the leather is dry and does not fit tightly against the shaft-- use the oil to expand the leather. S_2 is the leather seal, and S_1 is the shaft, and F is the mechanical force between the seal and the shaft, which is inadequate. The oil is S_3, which is present in the environment. When the oil soaks the seal, the seal swells up, thereby improving F.

1.1.5. As in 1.1.2, but modify or change the environment of the system. *Examples:*

In an office with desktop computers, the computers increase the room temperature, compromising their performance. Change the environment by air conditioning the office.

A person suffering from a cold breathes through her mouth, instead of her nose. Because the path of the air is shorter, the air is not humid enough, and the person suffers from a dry throat in addition to the cold! Change the environment by humidifying the air in the room.

1.1.5
S1= mouth
S2= throat
E= moisture
F_{Me} =



1.1.6. Precise control of small amounts is difficult to achieve. Control small quantities by applying and removing a surplus. *Examples:*

Exceed the requirements and remove the excess. This is commonly done with coatings by applying a surplus and removing by centrifugal force.

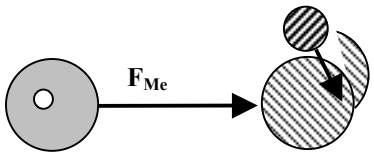
Dipping a handle in paint and allowing gravity to remove the excess paint.

To get a flat surface when pouring concrete into a form, overfill, then remove the excess to get fine control of the height and level.

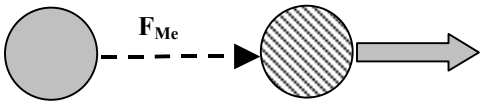
Engraved printing plates are flooded with ink and a squeegee (doctor blade) removes the excess before the paper is placed upon the plate. The same technique is used in silk screen printing.

Some features in a cavity are difficult to fill in injection molding. One approach is to place a small vent hole to allow out-gassing and to allow material to flow out. The excess material (called "sprue") is removed later.

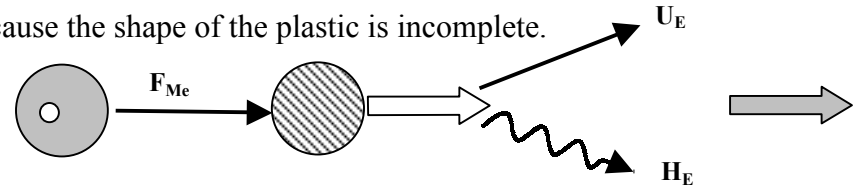
1.1.6
S1= mold
S2= plastic
S3=knife
F_{Me} =



This whole process of examples is really complex when we only give the final action. In this example the original problem was



We add a hole in the mold because the shape of the plastic is incomplete.



Which really becomes a new incomplete model of a product with excess material and we need a way to correct it, as seen above.

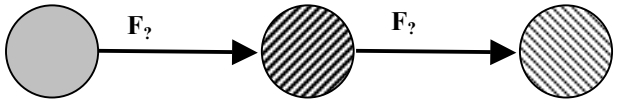
1.1.7. If a moderate field can be applied which is insufficient for the desired effect, and a greater field will damage the system, the larger magnitude field can be applied to another element which can be linked to the original. Likewise, a substance that cannot take the full action directly but can achieve the desired effect through linkage to another substance can be used.

Examples:

The common double boiler in the kitchen is one example. The material to be cooked can not withstand direct flame. The flame heats the water which is in contact with the interior container. The temperature of the inner container never exceeds the boiling temperature of the water.

One way to stretch the iron rods for pre-stressed concrete is to heat the rods until they lengthen to the desired length. Then the rods are held in position and allowed to cool before the concrete is poured. In some applications cable is used. Cable can not withstand the temperatures required for the expansion. Rods are connected to the cables and heated. The rods/cables system is made secure. When the rod shrinks the cable is under the proper tension.

1.1.7
S1=
S2=
S3=
$F_?$ =



1.1.8. A pattern of large/strong and small/weak effects is required. The locations requiring the smaller effects can be protected by a substance S_3. *Examples:*

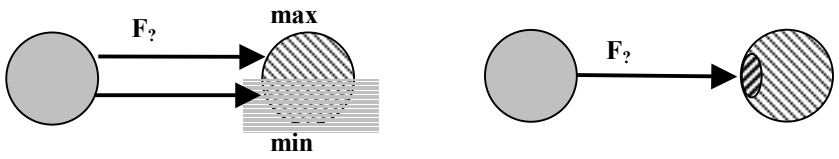
Small glass ampoules of medicine are sealed by flame, but the heat from the flame can degrade the medicine. Immerse the ampoules in water to keep the medicine at a safe temperature.

Using heat sinks during soldering to protect elements which could be damaged by high heat.

Use masks during the fabrication of silicon wafers to allow dopants to penetrate certain regions and to prevent them from penetrating other regions. Likewise, masking tape or stencils can be used to keep paint in the region where it is desired.

We have the same challenge here because the introduction of a mediator is just the creation of a chain of two Su-field models.

1.1.8
S1=
S2=
S3=
$F_?$ =



The locations requiring the large effects can be enhanced by a substance S_3. *Example*:

Place explosives only where needed to demolish a building. Precise timing of the explosions increases the effectiveness of minimizing the pile of debris.

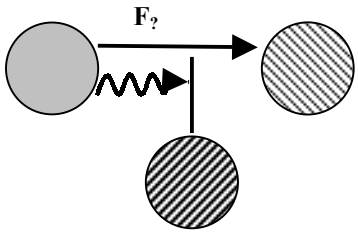
1.2. Eliminating or neutralizing harmful effects.

1.2.1. Useful and harmful effects exist in the current design. It is not necessary for S_1 and S_2 to be in direct contact. Remove the harmful effect by introducing S_3. *Examples:*

The hands of the doctor S_2 are used to perform surgery on a patient S_1. Wearing sterile gloves (S_3) eliminates germs.

A house jack (S_2) will damage the main carrying timber (S_1) but a steel plate (S_3) between the jack and the timber will distribute the load.

1.2.1
S1=
S2=
S3=
$F_?$ =



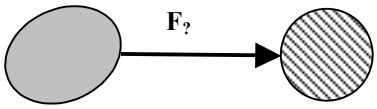
1.2.2. Similar to 1.2.1., but new substances cannot be added. Remove the harmful effect by modifying S_1 or S_2. This solution includes adding "nothing"—voids, hollows, vacuum, air, bubbles, foam, etc., or adding a field that acts like an additional substance. *Examples:*

Gust-proof umbrella—vents and flaps in the fabric reduce the aerodynamic forces, protecting the umbrella.

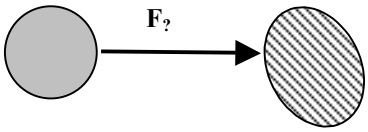
A classic TRIZ teaching problem involves steel balls wearing conveyed through a pipe, that wear a hole through the material of the pipe at an elbow. A magnetic field cause a layer of balls to form at the elbow, protecting the material.

To fit one part inside another, cool the inner one, reducing its diameter, put them together, then let it expand. Thermal contraction is used instead of a lubricant to make it easy to fit the 2 pieces together.

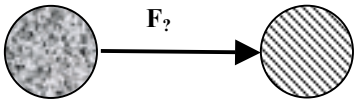
1.2.2
S1=
S2=
S3=
F? =



modify **S1**



introduce voids

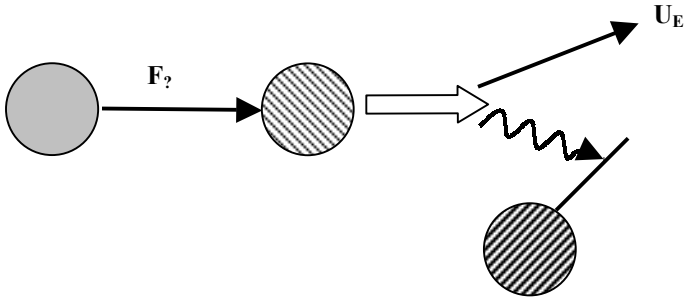


1.2.3. The harmful action is caused by a field. Introduce an element S_3 to absorb the harmful effects. *Examples:*

Medical x-rays are only needed in the exact area where the image is being formed, but the tubes that generate them create a broad beam. A lead apron is used to protect the other parts of the patient's body from the x-rays, and a lead shielded wall is used to protect the technicians.

Heat generated by an electronic component can cause warping of the board on which it is mounted. Place a heat sink under the component to dissipate the heat into the air.

1.2.3
S1=
S2=
S3=
F? =

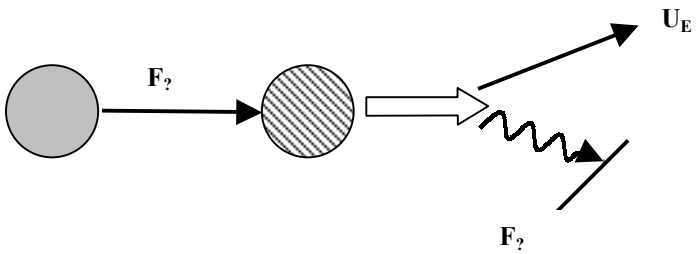


1.2.4. Useful and harmful effects exist in a system in which the elements S_1 and S_2 must be in contact. Counteract the harmful effect of F_1 by having F_2 neutralize the harmful effect or gain an additional useful effect. *Examples:*

A water pumping system causes noise. Water is S_1, pump is S_2 and the field is mechanical F_{1mech}. An acoustical field F_2 is used to mask the sound or cancel the sound by generating a field 180 degrees out of phase with the noise.

After surgery to repair a torn tendon, the leg must be immobilized. The brace S_2 acts on the leg, S_1, by means of a mechanical field F_{1mech}. But, the muscle atrophies very quickly if it is not used. A pulsed electrical field F_{2elec} is applied to the muscle during physical therapy sessions to stimulate the muscle and prevent atrophy.

1.2.4
S1=
S2=
S3=
$F_?$ =



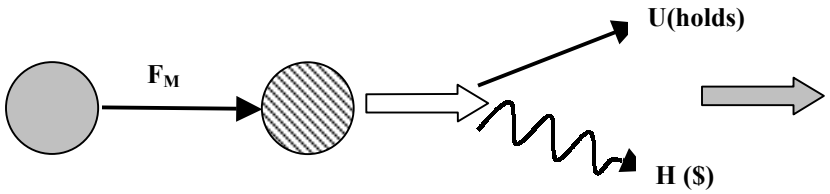
1.2.5. A harmful effect may exist because of magnetic properties of an element in a system. The effect can be removed by heating the magnetic substance above its Curie point, or by introducing an opposite magnetic field.

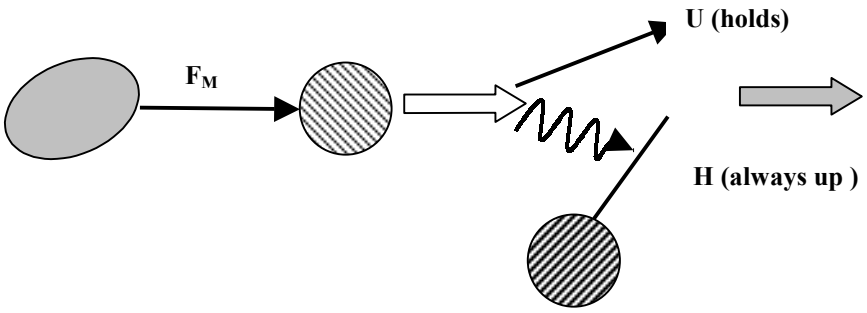
The energy required to operate a magnetic crane for moving materials is directly related to the time material is being carried. The energy can be reduced by having a permanent magnet hold the load. The power is needed only to release the load by activating a counter electromagnet. An free added safety benefit is that the load is supported even during a power failure. (Ref. 7)

Car and airplane owners frequently mount a compass in the vehicle as a navigation aid. The magnetic fields within the vehicle interfere with a true reading. Compensation by means of small permanent magnets is a feature built into the compass.

Magnetic recording media (tape or disk) can develop a memory that persists through ordinary attempts to erase and re-record data due to alignment of domains in the material. The medium can be heated above the Curie temperature to disorder all the domains and refresh it for future use.

1.2.5
S1' = permanent magnet
S2 = scrap
S3 = counter electrical magnet
F_M =





We are committed to have one of each of the remaining sections each month. However, we are having difficulties finding examples for section four. We may leave it as a request for help.

References.

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