Industry Without Borders:

Systematic Transfer Of Breakthrough Aviation Solutions From Other Disciplines

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Introduction

Question: What do the following problems have in common. 1) how to reduce tyre wear on aircraft during landings; 2) how to prevent toxins leaching from PVC into a patient's blood during kidney dialysis treatment; 3) how to increase the yield of a chemical process during the scale up from lab to production scale reactions; 4) how to maintain data integrity during the TCP/IP protocol of data in wireless transmissions; 5) how to improve knowledge retention in organizations when the rate of arrival of new information is so great?

What has this question got to do with the aerospace industry? Apart from the first problem, none of the others appears to have any relevance whatever. For most viewers, in fact, the five problems all look very different to one another. But in actual fact, according to the Systematic Innovation methodology (Reference 1), they are all not just similar but identical. Take that a step further and not only are the problems the same, but when the most significant breakthrough solutions developed for each are examined, the problem solver has consistently used exactly the same solution strategy.

If this is true then there are some potentially significant implications for designers and problem solvers working in the aviation business. Each of the problem solvers working to create their breakthrough solutions in these cases was unaware that someone in another industry was working on the same problem. This is because each industry has its own protocols, invents its own language and trains designers to think that their situations are unique. Well, of course, at a certain level their problems are unique, but at a more generic level things start to follow a well defined pattern. This pattern has now been observed in the 3 million plus case study examples that have thus far been analysed.

The author contends that the potential implications for the aviation industry of the discovery of these problem-mapping patterns are significant. One of the biggest issues in aerospace today is that it is so expensive to change anything. Qualification of even the simplest material change in a gas-turbine, for example, is going to cost the engine manufacturer at least a million dollars, and probably closer to five. As a consequence of these high costs, change tends to happen relatively slowly. In other industries on the other hand – like telecoms, IT and semi-conductor - the cost of change is considerably lower. Designers in these sectors therefore have the ability to evolve many more generations of breakthrough solutions at far less cost and in much shorter timescale. If we equate aircraft design to the slow, gradual evolution of humans, the IT, semi-conductor and other sectors are the evolutionary equivalent of the fruit-fly.

The paper proposes that because other industries are able to realise a greater rate of breakthrough solutions, and because there are means of mapping all problems onto a universal framework, whatever problem an aerospace designer may be tasked with working on, someone, somewhere outside aerospace is highly likely to have already generated a breakthrough solution. The paper seeks to demonstrate the potential that this may be true through a number of short, representative case study examples.

The common theme of each of these examples and of 'breakthrough' solutions in general is that step-change improvements in the design and evolution of systems happen when designers seek to challenge and eliminate trade-offs and compromises (Reference 1 again). In the terms of the tyre wear problem posed at the start of the introduction, for example, the usual design strategy involves the optimization of each of the parameters that create the problem; the designer tries to achieve the lowest possible landing speed with all that entails for the sizing of control surfaces and incorporation of features to cope with cross-wind effects; the rubber manufacturer tries to balance wear resistance with grip performance; the runway designer tries to balance dry and wet weather performance; and so on. The 'breakthrough' in each of these situations occurs when one or more of the contradictions present are eliminated. In the tyre problem, for example, a breakthrough would be the one where landing speed and tyre wear are completely de-coupled from one another such that no matter what the landing speed, there will be no tyre wear.

The paper examines three such contradiction-eliminating breakthrough opportunities:

1) looking at noise versus altitude versus image capture capability in reconnaissance UAVs
2) looking at engine exhaust temperature versus IR signature in jet engine exhausts
3) looking at energy consumption versus stability conflicts in helicopter tail-rotor design

In each case the paper demonstrates how the problems can be mapped onto a generic contradiction-elimination database in order to find already existing solutions already existing in other industries, and how these existing solutions can then be translated and transferred into the specific problem at hand. In each case the paper indicates the intellectual property generated as a result of the methods applied.

UAV Noise Versus Altitude

There is considerable interest these days in unmanned air vehicles (UAVs). These remote-controlled aircraft – like the small RQ-7 machine shown in Figure 1 – are very useful for reconnaissance over dangerous or difficult to access areas. They are basically controlled from a base-station and are required to transmit data – usually pictures – back to this base-station from the area over which they are directed to fly.

Figure 1: RQ-7 Remote Reconnaissance Unmanned Air Vehicle

The RQ-7 UAV is propeller driven via a small petrol-driven piston engine. If we ask ourselves 'what might we like to improve about this machine?' one of the first things we are likely to think about is noise. Anyone that has flown their own remote-controlled aircraft, or heard other people doing it, will know that these things can be very loud indeed, and this might not be such a good idea if we don't want to be detected. So, we have now identified something that we'd like to improve. In fact, the operators of the RQ-7 (and other equivalents) know very well about the noise problem. The solution they generally use to reduce the likelihood of the machine being detected is in fact to fly at a higher altitude. Unfortunately, what the operators also know is that this gives them a considerable trade-off since the higher the UAV is flying, the more difficult it is to get a good image of the area being photographed.

We can use a typical Systematic Innovation methodology scheme as shown in Figure 2 to make sense of this situation.

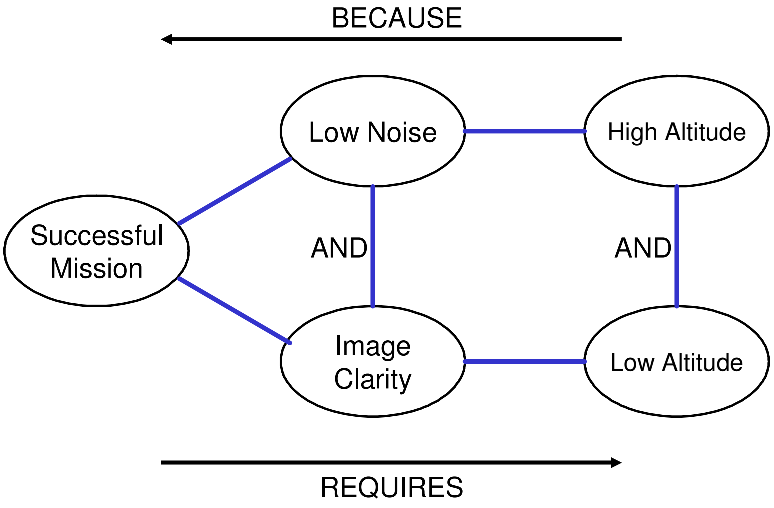


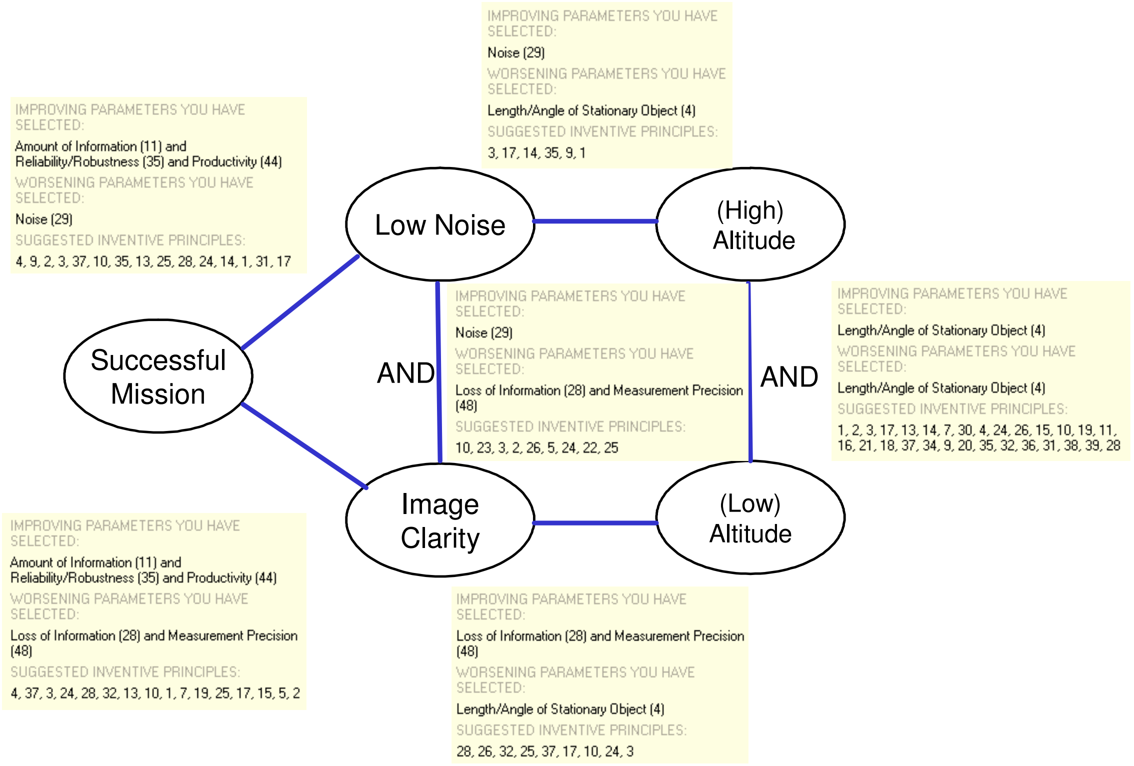
Figure 2: Example Contradiction Map – Unmanned Air Vehicle

Starting at the top middle of the picture, the top link is telling us 'low noise' requires 'high altitude'. Expressed the other way around we could describe the same link as 'we require high altitude because we require low noise'. We can describe each of the other links in similar terms; a successful mission requires low noise, or we want low altitude because low altitude gives good image clarity.

The two vertical links define other contradictions, including the one that sounds least like the sort of problem a designer will chose to tackle; that we want to fly at high altitude *and* low altitude. This is definitely not a typical problem definition. It is, however, a very typical Systematic Innovation problem definition. Very simply because, it is very likely that someone, somewhere has already been thinking about solutions to such problems.

Important to note here is that there is no suggestion that any of the six contradictions observed in the picture is any more important than the other. Indeed what the picture is actually trying to say is that each of the contradictions operate at the same level and are directly translatable between one and the other. They are, in other words, equivalent to one another.

We can take this a step further by realizing that creating a breakthrough solution or 'solving the problem' requires us to 'break' one of the six links. In our model this now means that we have six opportunities to do that job. The noise-versus-image contradiction and the 'high-versus-low' contradiction are two of the six. The other four can be described by examining the other four links. If we look at the topmost link again, we can formulate another contradiction; we want low noise, but (the need to fly at high) altitude stops us. Figure 3 describes all six of the contradiction solving opportunities.



IMPROVING PARAMETERS YOU HAVE SELECTED:
Noise (29)
WORSENING PARAMETERS YOU HAVE SELECTED:
Length/Angle of Stationary Object (4)
SUGGESTED INVENTIVE PRINCIPLES:
3, 17, 14, 35, 9, 1

IMPROVING PARAMETERS YOU HAVE SELECTED:
Amount of Information (11) and Reliability/Robustness (35) and Productivity (44)
WORSENING PARAMETERS YOU HAVE SELECTED:
Noise (29)
SUGGESTED INVENTIVE PRINCIPLES:
4, 9, 2, 3, 37, 10, 35, 13, 25, 28, 24, 14, 1, 31, 17

IMPROVING PARAMETERS YOU HAVE SELECTED:
Noise (29)
WORSENING PARAMETERS YOU HAVE SELECTED:
Loss of Information (28) and Measurement Precision (48)
SUGGESTED INVENTIVE PRINCIPLES:
10, 23, 3, 2, 26, 5, 24, 22, 25

IMPROVING PARAMETERS YOU HAVE SELECTED:
Length/Angle of Stationary Object (4)
WORSENING PARAMETERS YOU HAVE SELECTED:
Length/Angle of Stationary Object (4)
SUGGESTED INVENTIVE PRINCIPLES:
1, 2, 3, 17, 13, 14, 7, 30, 4, 24, 26, 15, 10, 19, 11, 16, 21, 18, 37, 34, 9, 20, 35, 32, 36, 31, 38, 39, 28

IMPROVING PARAMETERS YOU HAVE SELECTED:
Amount of Information (11) and Reliability/Robustness (35) and Productivity (44)
WORSENING PARAMETERS YOU HAVE SELECTED:
Loss of Information (28) and Measurement Precision (48)
SUGGESTED INVENTIVE PRINCIPLES:
4, 37, 3, 24, 28, 32, 13, 10, 1, 7, 19, 25, 17, 15, 5, 2

IMPROVING PARAMETERS YOU HAVE SELECTED:
Loss of Information (28) and Measurement Precision (48)
WORSENING PARAMETERS YOU HAVE SELECTED:
Length/Angle of Stationary Object (4)
SUGGESTED INVENTIVE PRINCIPLES:
28, 26, 32, 25, 37, 17, 10, 24, 3

Figure 3: Linking The Scheme To Contradiction Solving Opportunities

The figure, in fact, goes a step further in that it has interpreted the specific conflict pairs and interpreted them onto the (2003 – Reference 2) Contradiction Matrix – a tool specifically designed to provide a means of commonalising all technical trade-off type problems. So, for example, the specific UAV problem involves ‘altitude’; the generic connection is ‘length of stationary object’ – i.e. a linear dimension. This tool and this specific-to-generic mapping process is the thing that allows designers to see how others working in other fields have created breakthrough solutions and successfully challenged those trade-offs. The ‘Inventive Principles’ presented for each contradiction represent those strategies. To create a breakthrough to the UAV problem, we are most likely to find a solution by taking one or more of these strategies and interpreting in the UAV specific context.

What is well worth noting about the Inventive Principle suggestions produced by this analysis is that the list of recommendations for each of the six conflicts looked up on the Matrix is quite different. This is because each of the six links in the model represents a distinctly different problem. There is a tendency to try and merge all of these different problems into one in order to get a combined list of prioritized Principles. This can work, but in general – particularly when using Matrix 2003 – it is far more effective to focus the Principles suggested by the method on the specific conflict pair that was used to generate those Principles. Trying to solve a noise-versus-altitude problem, in other words, is not the same as trying to solve a mission-success (‘productivity’, ‘amount of information’ etc in the way we modeled the problem) versus image clarity conflict.

References

1) Mann, D.L., ‘Hands-On Systematic Innovation’, IFR Press, 2002.
2) Mann, D.L., Dewulf, S., Zlotin, B., Zusman, A., ‘Matrix 2003: Updating The TRIZ Contradiction Matrix’, CREAX Press, 2003.