Analogy-Based Ideation in Applied Innovations.

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Abstract:

This paper is part of a series on the creation of new techniques and knowledge for practical innovation. Applied Innovations also referred to here as Appinnove, is under development by the author and offers a practice-oriented approach towards ideative problem solving. It emphasises the gradual build-up of knowledge about the problem and required solution, which it calls "ideative-energy", and which can then be converted into practical solutions using three types of ideation: first principles-, abstraction-, and analogy-based. The process differs with TRIZ in that it does not rely primarily on an established system of heuristics, instead encourages the free accumulation of knowledge, its processing and intensification, and the use of stimuli to generate rapid results.

This paper presents a first look at the use of commonplace analogies as a source of ideation. Three examples are illustrated: the petrol engine as a conceptual basis for the process of ideation itself; an elephant hunt by Masai warriors as a conceptual basis for a breakthrough in the author's doctoral research in industrial engineering; and a dual trigger analogy from the author's childhood as the basis for an interesting engineering concept. Further aspects and details of Appinnove will be provided in future papers.

1 Role of heuristics in innovation:

An innovation is a missing piece of knowledge required to advance forward from the problem state towards a required solution state. For a unique perspective on innovation, please see "Innovation: Thinking Differently to Create Value." [Ref. 1, 2014]. The term "forward" is extremely important in that going forward is the difficult act of creating new knowledge. It is much easier to explain a known innovation going backwards and to retrospectively match it with a set of thinking patterns called heuristics. It should be evident that explaining an innovation, once known, is much easier than actually doing the innovation in the first place.

Genrikh Altshuller, the originator of TRIZ, studied a large number of patents, or patent abstracts, ***and resolved them backwards into certain heuristics or thinking patterns***, such as the 40 Principles. For this reason, TRIZ is usually demonstrated at its best in the explanatory role for known innovations. It is rare that a TRIZ expert publicly demonstrates its powers in the forward direction by creating new knowledge and thereby a new invention. For an example of forward ideation based on heuristics, please see "The Super Stream Augmented Approach for TRIZ and its Application to Aviation Safety." [Ref. 2, 2009].

This conceptual realisation is extremely important as it reveals to us that **the paradigm of forward innovation is sparsely populated and is open for new developments.**

Applied Innovations (Appinnove) develops our skills in forward innovation by treating it from an industrial engineering perspective. We can only cross the gap in knowledge if we have sufficient ideative energy to leap across. Before we begin the ideation process, it requires 1) accumulation of knowledge concerning the problem, 2) processing of the knowledge based on its core principles and intensification of ideative-energy, and 3) using the most suitable tools and resources for the task. In Appinnove, analogies are preferred over heuristics as tools and resources for ideation.

2 Ideation and its sources:

Ideation is the engine of innovation. Merriam-Webster Dictionary describes ideation as the ability to form mental images of things that either are not physically present or have never been conceived or created by others, while Wikipedia describes it as the creative process of generating, developing, and communicating new ideas, where an idea is understood as a basic element of thought that can be either visual, concrete, or abstract.

The following three types of ideation are used in Applied Innovations:

2.1 Ideation based on basic or first principles (intrinsic reasoning):

Intrinsic ideation is based on parameters that are basic and specific to, and an essential part of the composition of the problem. This is to say that the nature of the problem would change if these parameters were to be removed from our consideration. This is the oldest method of ideation, Aristotle (384-322BC) referred to these as the first principles, causes, elements or origins. He states: "It is clear, then, that in the science of nature as elsewhere, we should try first to determine questions about the first principles as known to us. (and move from there to things known to Nature)". Rene Descartes (1596-1650) emphasises first principles when he states ***cogito ergo sum*** (I think therefore I am).

A good example of intrinsic ideation based on first principles by the author will be provided in a follow-up paper: "First Principles-based Ideation in Applied Innovations"

2.2 Ideation based on abstractions (heuristic reasoning):

Heuristic ideation is the type of ideation originally used in most inventive problem solving methodologies such as TRIZ, and its derivatives such as USIT [Ref. 3, 1997] developed by Dr. Ed Sickafus, and its further development CrePS by Professor Toru Nakagawa. [Ref. 4, 2014] based on his Six-Box Model.

Heuristics are experience-based rules of thumb for problem solving. A good example is the systematic tracing of a breakdown in any machine: mechanical, electrical, or electronic, by the simple rule of isolating the fault. Here heuristic = "isolate".

TRIZ provides several forms of tools based on heuristics. A specialised problem may be abstracted to a form for which solutions are known. The known solution may then be re-applied and detailed back to the original domain.

The primary limitations or bottleneck with purely heuristic innovation such as in TRIZ lies at the interface of the detailed and abstract domains. For further discussion please see the author's article: "The Journey So Far and the Way Forward for TRIZ" [5, 2010].

2.3 Ideation based on analogies (analogous reasoning):

Analogous ideation relies on finding a similar example from a different domain and applying it to our domain of interest. As with the above two methods of ideation, this is a method familiar to most, and well mentioned in antiquity. Instead of a rule of thumb (terse heuristic), we borrow a more complete working example that can be studied in some detail and which provides much greater structure to the problem solving activity than a simple heuristic. Analogous ideation offers the following advantages over heuristic innovation:

1. It provides a partial exoskeleton as we attempt to bridge the chasm in knowledge (the ideation gap).
2. The study of the analogy may lead to unexpected stimuli for further ideation.
3. Loss of information is reduced in crossing the abstraction interface and subsequent recovery of information facilitated.
4. A continual two-way interchange of information may be possible between the problem space and the analogy.

On the negative side, there are no standard compilations or listings of analogies. The results will therefore vary greatly depending on the choice of analogies and how they are processed. Three examples of analogous reasoning are given in section 4.1 to 4.3 below.

3 Applied Innovations / Appinnove:

Applied Innovations / Appinnove is a process being developed by the author, which takes a somewhat different approach to systematic innovation than TRIZ, USIT, CrePS, etc. It moves away from a heuristic-centric approach. It values independent, free thinking above all. Knowledge about the problem and the solution state is taken as a composite concept called ideative energy (IE), and used to drive the ideation process. An example is provided in "Freeform Innovation and Ideative Energy" [6, 2014].

It treats any innovation as a missing piece of knowledge needed to transition across the ideation gap from the problem state towards a desired solution state and this is done by the enhancement and management of IE. The way of accumulation of ideation-energy (IE) is primarily by the use of first principle thinking or intrinsic reasoning. IE is enhanced by the use of analogies mostly, and by heuristics where applicable. Ideation occurs when concious or subconscious events trigger an ignition across the gap in knowledge, in a compressed, ideation-energy rich environment.

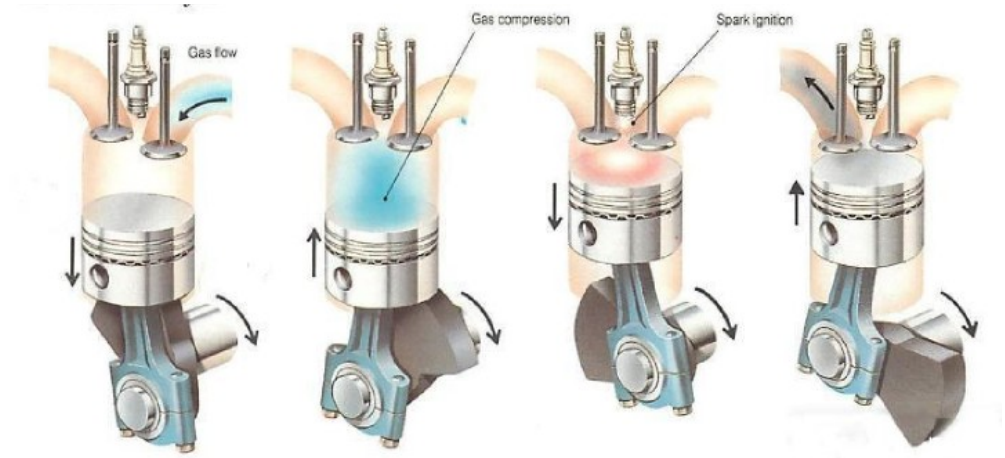
4 The use of conscious / subconscious triggers and analogies for ideation:

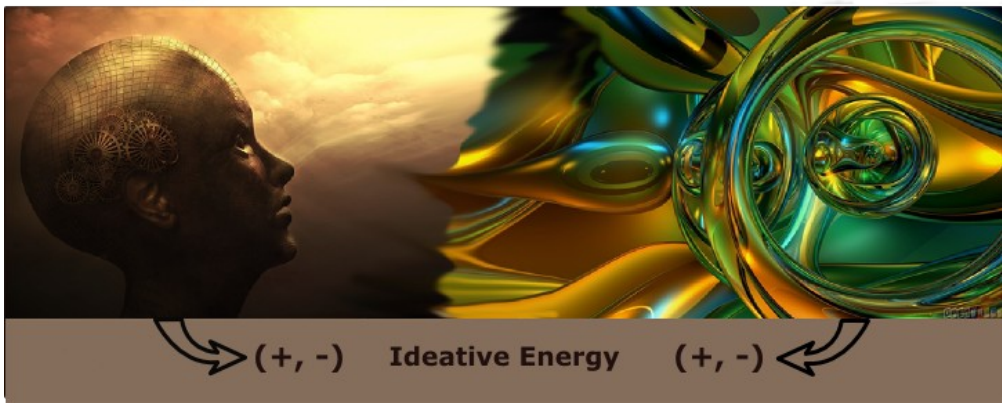
Applied Innovations / Appinnove recognises the essential role played by chance events which can act as triggers for ideation. Such triggers occur randomly and are usually not availed unless an ideation-energy rich environment exists in one's mind.

The following examples illustrate three of several different mechanisms leading to gains in ideative thinking. The first is a perfect analogy for Applied Innovations, in that it explains the process well. The second demonstrates the role of a chance trigger in a highly intensified thinking environment which led to a breakthrough in the author's doctoral research. The third example is interesting, in that the ideative energy enrichment came primarily from the spontaneity of childhood, two triggers occurring close together in time led to a whimsical notion which had been earlier proven in practice in WWII.

4.1 The "Compression, Fuel, Spark (CFS)" analogy for Applied Innovations:

Some of us have in the past tinkered with small petrol engines, such as in a motor bike. We quickly acquire some skills in self-maintenance. A good rule of thumb when the engine fails to tick over is the "Compression, Fuel, Spark" rule of thumb or heuristic. If any of the three are missing or deficient, the engine will not start. We may have poor compression due to mechanical causes, the carburettor may be clogged choking off the fuel, or the spark may be poor due to plug, ignition coil, or battery issues. This heuristic is a good place to begin, although the fault may lie elsewhere such as a short in the electric harness or fuel contamination or blockage.





When taken in its entirety, the CFS analogy provides useful parallels to drive the Applied Innovations process. Fuel is ideative-energy, compression is the amount of work done in the pre-ideation stages to cleanse and intensify the knowledge, spark is the conscious or subconscious trigger.

This rather simple mechanical analogy can provide a stream of ideation for the Applied Innovations processes, such as:

1. The combustion chamber must be rid of the exhaust products at every cycle to function efficiently.
2. Adulteration of the fuel or re-uptake of the exhaust will reduce efficiency
3. Multiple spark plugs will, to a degree, provide an improvement in efficiency.
4. The precise timing of the spark is most critical.
5. Metered additives added to the fuel or to the compression could improve start-up and output.

The reader may use their own imagination to work out other aspects of the analogy.

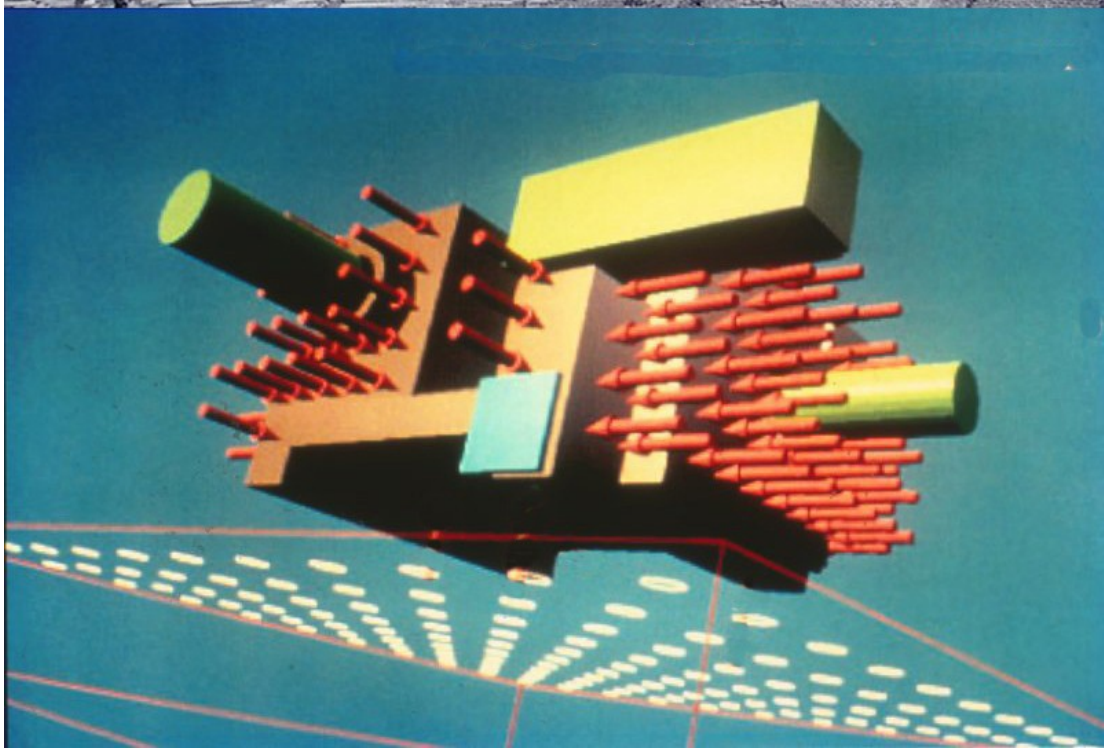
4.2 The “Masai Warriors” analogy:

Purdue University, W. Lafayette, IN, USA is an excellent engineering university, and for a long time its graduate program in Industrial Engineering was rated No. 1 in USA. The IE program has now dropped quite considerably in rankings. For my doctoral research, I had to devise original developments and a basis for integration of two very different and unrelated areas, the automated design of complex machining tooling using solid modelling /CAD, on the one hand and the automated robotic assembly of such tooling as in CAM. Normally doctoral research is narrowly focused in either one area or the other. Both areas had evolved independently of their own volition and were drifting further apart.

The difficulty of integrating the two areas along a common basis was considerable. No possibility of a solution had existed before and none appeared at this time. Every known technique of engineering design and problem solving was tried. Extensive literature survey of direct and related areas was carried out. Engineering prototypes in wood and metal constructed, assembly methods with various industrial robots tried out. The intensity of the problem occupied the mind constantly. During a meeting with a professor from a different department, he happened to use the phrase "it would be good if your system hunts for an optimal solution". This phrase lodged in my mind.

As I walked back across campus, I thought of the word hunts, hunted, then hunters, then thought of African Masai warriors who had felled an elephant, had surrounded it and were probing it from all sides with their spears. This led to the concept of 2D arrays surrounding the work-piece and bridged a gap in my thinking very efficiently. As an example of the important role of the subconscious, the first complex CAD work-piece I quickly made up for a test of the system looked like an elephant lying on its side with four stubby legs and a round head, a connection I did not realise at the time. The work-piece in the figure below is a different work-piece.

In my own ideation and problem solving activities, I have found that the needed insight occurs out of a mellow, trance-like state, often just when you wake up or when the mind has been working on a problem for quite some time, is fatigued, and a chance word or phrase used by someone in a conversation registers in the mind and then spawns an insight connected with the problem residing in the background.

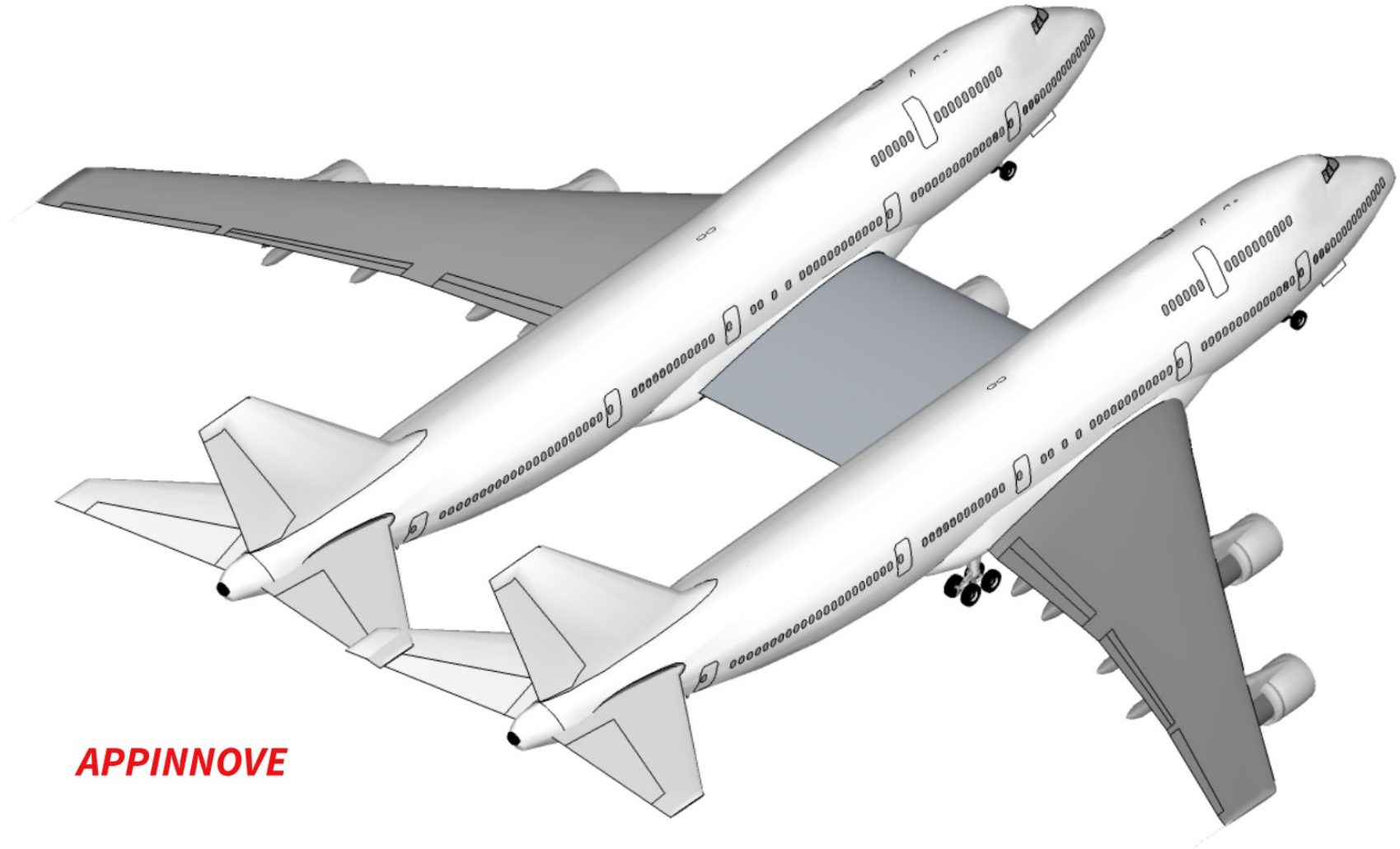


4.3 The "Three-legged Race" analogy:

I had an unusual childhood. I grew up in the residential part of a large industrial compound, and went to school at a huge air-force base nearby. Thus old components of machinery lying in the compound were my after hours interest, and my mind was preoccupied with aircraft. As a child I developed my own reasoning as to how an aircraft took off - as it began racing down the runway, the engines or the wings were rotated slightly upwards which caused it to leave the ground. Wrong, but feasible thinking. Google "tilt wing aircraft" and the Chance Vought F-8U Crusader.

On a Saturday in class V we had our annual sports day with the standard three legged race. The next day, as my father was at home going through his official mail, he handed me a brochure from KLM that featured whimsical cartoons of their airliners in flight – one had tulips growing and being watered on a large outside wooden deck under its tail. Childlike curiosity made me think of two airliners joined together with a common wing, so that two flights at different times of the morning could leave together as one. I pencilled a quick sketch and showed it to my father who was amused and impressed.

The point of this example is that childlike whimsy is quickly outgrown, but free-association of ideas, often through analogy, is a powerful ideation tool. In WWII the North American F-82 Twin Mustang, and the Heinkel He-111 Z *Zwilling* were two of many twin fuselage designs and the same concept is used for specialised conversions to this day and certainly will be in the future.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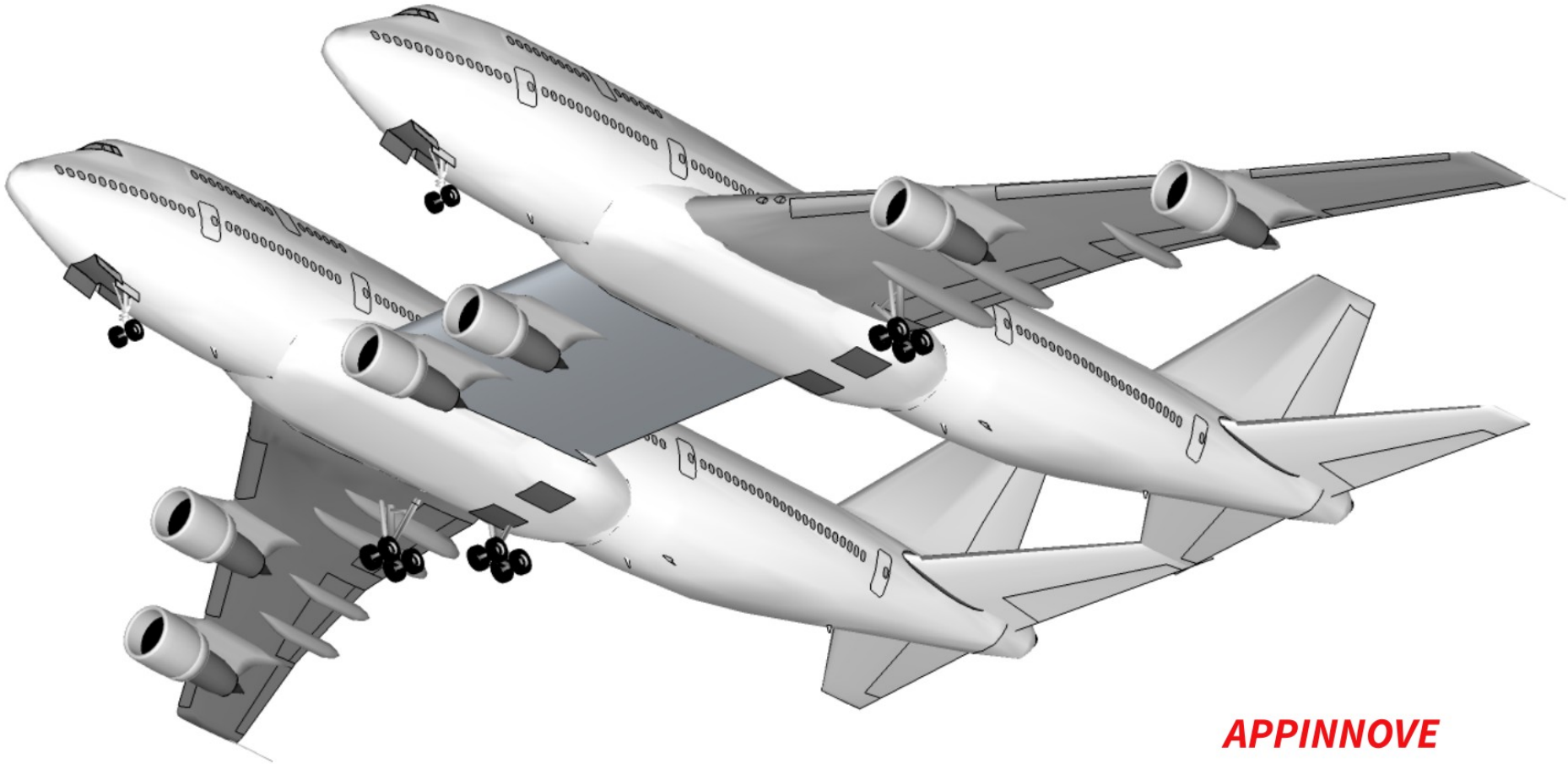

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5 Discussion:

This paper is part of a series on the creation of new knowledge and techniques for practical innovation and so its tone and content are not academic but accessible for a wider audience. The main question is that of improving our ideation processes, which are absolutely essential for practical innovation. Applied Innovations or Appinnove is one such effort which moves away from the heuristic centric approach as in TRIZ and instead uses the concept of ideative-energy to drive the innovation effort.

Innovation may be treated as a gap (ideation gap) in knowledge between the problem space and its required solution space. We can only cross the gap in knowledge if we have sufficient ideative energy to arc across. Ideation occurs when concious or subconscious events trigger an ignition across the gap in knowledge, in a compressed, ideation-energy rich environment. Compression, fuel and spark are all essential. The accumulation of pertinent knowledge, its processing, cleansing and intensification, as well as the use of appropriate tools and stimuli are the building blocks of Applied Innovations.

The reader may appreciate the fact that to replicate the ideation process shown in the three examples by using heuristics instead of analogies would not be an easy task. It should be appreciated that the primary purpose of an ideation process is to break the static inertia and change it to a dynamic or rolling inertia – it represents the beginning of the process, not its conclusion.

While this paper dealt with analogy-based ideation, a companion paper on first principles ideation or intrinsic reasoning, without the use of heuristics or analogies, will be presented next.

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