Foundations of Systems Architecture Design

On Design Synthesis

A Mysterious Synthesis or how a Miracle Occurs Here

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Abstract: This paper attacks the core problem with Design: What is a synthesis and how is it possible. We begin by asking why this Transdisciplinary approach to the problem of design synthesis is necessary and significant.

The normal approach to Systems Software Architectural Design Synthesis is problematic because it is not explained how Synthesis is possible. If we do not know how it is possible to make a synthesis then it is clear we do not know what we are doing. A sign of this is that the Stanford Philosophy Encyclopedia on the Internet has no entry for synthesis but only for analysis. When I asked the editor why he said that there was not enough material on it. When I searched for books on Synthesis explaining it from a philosophical point of view, I could only find one book[2] which the history of the concept of synthesis through various philosophers and mathematicians. In other words, there is no theory of Synthesis. But in Systems Engineering architectural design synthesis has always in the standards been represented as a phase of development. What this suggests is that at a practical level people seem to know about synthesis, how to create them, but in fact there is

[1] http://independent.academia.edu/KentPalmer See also http://kentpalmer.name

[2] Otte, Michael, and Marco Panza. *Analysis and Synthesis in Mathematics: History and Philosophy*. Dordrecht: Kluwer Academic Publishers, 2001.

no general theory of synthesis in our tradition. Is this not strange? It is like the most important thing has been skipped over completely. And this is true of all fields. Not just Systems Engineering or Software Engineering. But our focus is on Software Systems Engineering because we need a case example, and this is an important one because software is transforming our world in unexpected ways becoming more and more ubiquitous. So, if we are going to start anywhere we should start with the gap over which is written "Miracle occurs here" where a theory of synthesis should be that supports the creative work of producing large scale systems that a Systems Engineer might be concerned with, or software systems that a Software Engineer might build.

It is clear that we know how to create such syntheses, there is existential proof of that because there are actually existing systems that have been built that work. But what we have to go through to make them work can at times be horrendous, a matter of trial and error, and mostly error, that needs to be tested out of the system. It is not a straight forward task to design something and have it work properly. Defects can occur anywhere along the way from requirements to design, to implementation, to testing and even installation. This is to say throughout the lifecycle defects can arise and the later they are found and the earlier that they were instituted in the system the more expensive they are to fix. But the basic problem is that we have no model for synthesis in the first place that can allow us to understand what is going on in the process of Design theoretically. And thus, development as a whole is a messy process, and design within development is a mysterious process normally made the responsibility of one person overall to attempt to assure the coherence of the design.

There are books about architectural design and real systems get designed eventually and the pragmatic realities are that the systems for the most part work eventually even if that ability to function correctly is difficult to achieve in many cases. Just because we have no theory does not mean we cannot design systems syntheses. It is just that without a theory of it we are more or less flying in the dark. It is a craft that is passed down from designer to designer. Now what helps is the fact that by experience different Software Engineers or other types of Engineers invented methods for getting abstract views of the system under design. We call these minimal methods and they have for the most part been combined into UML/SysML. And these abstract views that give a representation of the essence of the system that can be understood and manipulated separately from the whole of the system under production and that can guide development are very useful. But what we note about these minimal methods is that they are fragmented and separate from each other. This means that we have discrete views of the essence of the synthesis that we have to fit together in our mind to get an approximation of the essence of the whole system under construction. But at least these minimal methods seem to work to give us working representations that can be used to picture the design of portions of the system, and then by visiting these one at a time and iterating on the series of views it does seem possible to produce a design representation that relates the essential characteristics of the system as a whole. But, of course, there is quite a bit of difference between the high level abstractions of the architectural design of the whole system in relation to the detailed design of its components, and still quite a bit of distance between the component design and the actually implementing code. Many times we backfill the design because coding comes first and then by a process of trial and error the design is actualized, and then abstracted from the code. Sometimes the tests come first and then the code is written and the design itself evolves as the system is built up incrementally. But then it is a question of the design of the tests. Basically practitioners try every approach they can think of to produce systems. And even if

they write code directly (called hacking) without any intermediate representations at higher levels of abstraction still somehow within the process a design evolves that gives organization to the overall application that allows it to work. The code has to be differentiated into various functions that cooperate to produce the desired effect. That overall organization is called the design. That design may be represented externally from the code or not as the case may be. If the code has an organization, then it has a design. But the key to the design is that it is the way we understand the whole system and the way it works. Otherwise most systems are too complex to have a handle on how they work without the ability to grasp their essence through the design. Even if we do not separate out the minimal method representations in separate documents for the most part they are still used to represent the design of the system for ourselves in our minds in order to grasp the essential organization of the system under design in production. So, we don't want to limit designs to external representations. If there is no overall organization of the code, then it is not going to work and we are not going to be able to work with it. The design is what allows us to have access to the code detail in a way that makes sense of it, making it understandable how it works. Either the design is an abstraction of the workings of the code derived from it, or the design is the way that the designer thinks about organizing the code before writing it. Designs are shared among the team engaged in the development even if only implicitly, or as diagrams drawn on whiteboards. Designs are also shared with future maintainers of the system who have to understand it to fix problems and to upgrade the design with new functionality. So even in Agile which is against documentation and plans for the most part there must be at least implicit designs otherwise they would not understand what they were building in each iteration as a team.

So, what we need is a theory of design which will address the possibility of synthesis, and that explains synthesis. If we go back to Kant who said that we need the hypothesis of the system to undertake science as a project, and which plays an important role in engineering as well, in as much as what we are synthesizing is a whole system, then we will note that in his metaphysics there are both a priori synthesis and a posteriori synthesis, but according to him only a priori analysis and no a posteriori analysis. Thus a priori synthesis are the passive syntheses presented to us in experience, and a posteriori synthesis are those we build based on our experience. The kind of synthesis we are talking about with respect to system design is a posteriori synthesis. But the design uses the a priori implicit synthesis as a way to grasp the essence of the system being designed and built. Once it is designed or built we can use a priori analysis to decompose it analytically. The ability to do analysis is dependent on the wholeness of the phenomena and its systematicity. There is some controversy whether a posteiori analysis exists. Kripke[3] has suggested how it might exist. One way we can understand it is that Kant's theory is based wholly on possibility. It does not take into account actuality. Once we produce an a posterori synthesis as the design of a system then we could analyze that actuality which we have created artificially and we can analyze that in a way that is a posteriori. So, it seems that this fourth possibility does occur. Kant is focused on passive synthesis of wholes of experience given to us, and has not taken into account the actuality of designed syntheses after the fact which are artificial. If we consider that it is possible for us to create designed syntheses as a posteriori syntheses then it is possible to do analysis of these syntheses after the fact and that is precisely what we need to do if we are going to understand designs. A posteriori analysis give us new information beyond what is possible by a priori logical analysis. Our knowledge of minimal methods come to us from doing this sort of a

[3] Kripke, Saul A. *Naming and Necessity*. Cambridge, Mass: Harvard University Press, 2001.

posteriori analysis of what worked and what did not work of systems. Engineers create perspectival abstractions of different sorts to represent the structures that they find in the systems or that they want to instill in the systems by a sort of Aposterori analysis of actual systems. But the aposterori analysis occurs just the first time that the abstraction of the minimal system is distilled, after that it is a synthesis too. But as we build a system we are moving back and forth between synthesis and analysis as we try to figure out how it should work and why it is not working the way it should. The minimal methods themselves are patterned on the template of the Kantian Categories and thus depend on a priori structures such as causality or unity and totality in order to posit certain characteristics of the system or to discover those characteristics in the system. For instance, from the Kantian point of view spacetime is posited by the Transcendental Ego of apperception and that is a prerequisite for understanding the synthetic software system as designed or as built. Then there are the categories of understanding that are a priori synthetic structures that allow the characterization of the artificial synthesis of the system from different perspectives though different minimal methods, like state machines, or petri-nets, or dataflow diagrams or interacting objects etc. One of the assumptions in Kantian Metaphysics is that Analysis and Synthesis are duals of each other and intertransformable. And if that inter-trasformability is true then the System which is treated by both analysis and synthesis either in terms of a proris or in an a posteriori manner should be transparent to us. If it is true we can put it together and take it apart at will then that would lend a certain transparency to the system under construction. In a sense this is the real problem, that synthesis and analysis are not directly transformable into each other and perfectly interchangeable. Connect that with the fact that in our tradition Synthesis is not well understood compared with analysis, i.e. we seem to have a blindspot with regard to synthesis in our tradition. Thus, we leave synthesis to pragmatic practical means without having a theoretical basis for it. So, the point is not only that the transformation between analysis and synthesis is not transparent, we actually don't really know clearly what synthesis is, i.e. we don't know what we would be transforming out analysis into. And it is key to understand that analysis always comes second, there must be a synthesis given passively at least to analyze. So, if we don't know what synthesis is then we cannot really know what analysis is whether a priori or a posteriori. And it is problems like this that force us into philosophical reflection. When we realize that we are doing things that have no real basis in our understanding, i.e. that we cannot understand their possibility, and thus their actuality remains under a cloud of unknowing. If we do not know what syntheses are then how can we know what we are doing, are we just operating blindly producing things we cannot understand and for which there is no basis? We feel as if we understand what we are doing, and we do with difficulty produce things that appear to work. So practically and pragmatically we are accomplishing synthesis in actuality, but if we reflect on it with in our tradition we really don't know how that is possible. And that is disturbing to say the least. But that is the situation we find ourselves in. We are like the cartoon character that goes over a cliff and does Ok until they look down, then they fall. Once they realize that there is nothing underneath their action holding it up. It is like a sweater that unravels if you just pull on a single strand. There is a single strand of the possibility of synthesis unmentioned in all the books on Architectural Design of systems. We don't know how it is possible, despite the fact we sometimes do it successfully with great effort. And, of course, this means that many times we fail. But we are failing at something we do not understand completely, so that makes sense that we would fail at it if it is just a matter of trial and error. But design itself suggests that there is a plan that we document (anathema to agile which finds virtue in operating blindly) to instill design into products we build, i.e. we attempt to write down the basis of our understanding of their organization either before or after development. The point is that

even if we do not have a plan either with foresight or hindsight, we need the design in order to talk about the system in terms of generalities that can be grasped at a higher level of abstraction than the totality of the code. This is called conceptual design. It is the design concepts we invoke to explain or describe the code to others, or to ourselves. If no external description or explanation exists then at the very least there is the conceptual design that describes the essence of the software system as built and abstracted from the code. But the fact that we can explain or describe the conceptual design does not mean we know how we create it, or how we understand it theoretically.

So, this is our starting point. Not knowing what synthesis is and because of that not really knowing what analysis is either. And so, this opens up a problematic. And the problematic revolves around the grounding of architectural design that describes or explains the essence of a software system considered for development, in development or as produced. It turns out that in order to approach this problematic nature of synthesis in a way that yields understanding we must go fairly deeply into uncharted territory which is philosophical. We leave all the books that tell you how to do software design intact and we move off in another dimension which attempts to explain the necessary conditions for the possibility as well as the contingent sufficient reasons for the actuality of Software Systems Architectural Design of software products, or from the Systems Engineering point of view the Systems design of combinations of hardware and software.

The first thing we need to understand is why Analysis and Synthesis when we transform between them they are not transparent vis a vis each other. This occurs because there is a problem in Kant's episteme which only has two sets of dichotomies – Analysis/Synthesis and A priori/A posteriori. Taking Analysis/Synthesis dichotomy we can subject them to scrutiny and one way to do that is to give examples and then convert the examples into Category Theory representations and then reverse the arrows. Kant contrasts arithmetic and geometry which he relates to time and space as absolutes, i.e. unrelated to each other. He more or less assumes that arithmetic is perfectly analytic and geometry is synthetic. Arithmetic is a way to produce numbers and then manipulate them to get answers to counting problems. But as we know from number theory we continually find new numbers due to the inadequacy of arithmetic, and this eventually leads us to substitute algebra for arithmetic. Arithmetic can evaluate numbers of different kinds that range over fields in relation to algebraic equations. So, in a more modern version of Kant's argument we can substitute algebra for arithmetic as the basis for our understanding of time. But when we represent algebras in Category Theory it is possible to always reverse the arrows. And when we do that we get the co-algebra instead of geometry as the opposite of algebra. And this implies that there is something that Kant did not recognize which was the co-geometry which is the dual of geometry. And this is believable because we already have something that fits that characteristic of a co-geometry and that is topology. So, as we move from the Kantian Episteme to a meta-episteme we see that the simple dichotomy between analysis and synthesis does not really hold up. Co-analysis of algebras does not transform into Geometry but instead into Analysis of Co-algebras. Synthesis of Geometries gives rise to the Co-synthesis of Co-geometries which are topologies. And surprisingly co-algebras relate to computing. So, no wonder there is a problem with the transparency of the of the transformation between analysis and synthesis, there is actually no direct relation between them. There are instead six different kinds of math that correspond to the combinations of these four fundamental mathematical structures by which we attempt to comprehend the difference between space and time and our powers of comprehension that we tout under the rubric of analysis and synthesis. Category theory tells us why these are not intertransformable transparently and that

is because they are in fact unrelated to each other directly, but rather their relation is mediated by other faculties which we did not really know we had except in as much as they are mirrored in different kinds of mathematics. It is algebra that is related co-analysis and not analysis. Analysis in Co-algebra is related to the *Direct Product* and Synthesis in Geometry is related to the *Direct Sum*. And although this is nonstandard terminology we can say that Co-Analysis in Algebra is related to *Indirect Product* while Co-synthesis in Co-geometry is related to the *Indirect Sum*. We do this just so our terminology remains consistent. Mathematics as it stands does not represent either Indirect Products or Indirect Sums. In algebra two numbers with an operation produces one product. Indirect here means the product is produced mediated by another input. On the other hand, in Topology we are concerned indirectly with the properties of surfaces and solids and not the specific form and thus we are describing indirectly the constraints on the geometrical form rather than directly. So, we can see that these terms do have meaning. Anyway, we now know that the dichotomy between Analysis and Synthesis actually hides a whole field of possible kinds of mathematics and is not a straight forward duality whose elements can be interchanged at will but rather they lead us into a complex mathematical field. We call this field revealed by Category Theory analysis the Kantian Meta-episteme. Part of the importance of this field is that the Co-algebra gives us a basis for Computer Science in that field. It has already been posited that Computational Systems are really Co-algebras[4] by Rutten. And so suddenly we have an extremely counterintuitive result. Systems lend themselves to Analysis through Direct Products because they are mathematically based on Co-algebras. Co-Algebras produce two things out of one rather than like algebras producing one thing out of two melded together with an operation. In Co-algebras things are splitting apart, and that is the essence of Analysis to split things apart. So, this theory would identify systems with Analytic Systems. And since Analysis is something we think we understand this seems like a good way to define Computational Systems. But in order to split things apart there must be wholes given in passive synthesis first to be split. So Rutten's definition of the Computational System cannot be the whole story. Particularly it does not explain how the synthesis that was split was produced. However, it is a big advance because up until recently this aspect of the system as splitting in Analysis was not even known. Rather all four of the different viewpoints in the Kantian Meta-episteme need to be used to understand the nature of a system. But Rutten's understanding it as a co-algebra related to analysis needs to be prominent because previously it's role was unknown. We would just like to state that it is these four kinds of mathematics and their combinations that are the fundamental basis for understanding the system and all other schemas. These are mathematically formalized possible views of the system or any schema. And what it shows us is that Analysis is not transformable into Synthesis except through the mediation of this field. And the nature of Analysis and Synthesis are embedded in this whole field. They are not individually distinguishable as separate from the field as concepts.

Now let's think about the other dichotomy in the Kantian Episteme which is A priori and A posterori. This dichotomy also does not stand up to scrutiny. A priori means before and A posterori means after. Before and after what? Before and after the present in which sensation is occurring. A priori means that something is used to create the sensual synthesis as passively received, like the categories or the positing of spacetime, while a posteriori means something done or added after the fact, after the privileged now. So, the present as a third moment of time on a line between the two others is implied in this dichotomy. Kant says that knowledge can only come to us by

[4] Rutten, J J. M. M. *Universal Coalgebra: A Theory of Systems*. Amsterdam, the Netherlands: Centrum voor Wiskunde en Informatica, 1996

experience, i.e. through sensation, and that sensation has its now moment in which it appears. But there is another implicit moment that is not so easy to recognize. That is the reference point beside the stream that allows one to know how quickly time is flowing. That reference point has to be outside the stream, i.e. outside the line which in the Metaphysical Era contains the other three canonical points through which time is flowing. We will call this fourth point parallel with the Now but off the line of metaphysical time the co-Now. Kant implies the now in his use of a priori and a posteriori but does not recognize the co-now that appears if we treat these temporal categories Categorically, i.e. through Category Theory. Each concept must have its dual, and if a priori and a posteriori are dual concepts then Now must also have a dual, i.e. the co-Now. So there is something hidden on the temporal side as well as the side of mathematical order. Relativity Theory of Einstein established and this theory has been experimentally confirmed, showing that Space and Time are not absolute (independent) but rather they are one thing called Spacetime. There is a phase space that relates space to time from different inertial frames, and this means that there is no absolute synchronicity in the universe, but rather synchronicity can be different based on the relative movement of the observers. And thus, Relativity theory establishes that all Nows are relative and that there are indeed co-Nows for any given Now of a specific observer in a particular inertial frame.

Topology was left out of Kant's Epistime and so were the co-Now and these missing elements are what distinguishes the Kantian Meta-episteme from the original epistemic stance of Kant. Hidden implicate categories appear when these dichotomies are treated through Category Theory ideas of duality. This implies that time is actually a surface rather than a line. The co-now pushes us outside of the metaphysical line of time to recognize the necessity of that surface. Part of the surface relates to past and future. But the other extent of that surface relates to now and co-now. This implies the possibility of parallel timelines. But it also implies the radical possibility of orthogonal time such as that discovered in F-theory[5] which breaks the episteme of the Metaphysical Era. F-theory has two orthogonal timelines. This is a radical implication that we will not explore here. But the key point is that there must at least be parallel timelines and not just a single timeline and we know that when there is no global clock that relativity theory applies to real-time systems. And so, this is a fundamental fact that we need to take into account that times are relative and that we need independent reference points in space, time or population as Klir says to understand what is going on in a system, these are called background variables by Klir. In such a system there may be clocks out of sync with each other and time may be relative. This is in fact what makes real-time systems interesting. Synthesis and Analysis as well as their Co-faculties (Co-synthesis and Co-analysis) have to take place in time. And we find out that time itself is more complex than we thought within the Kantian Meta-episteme.

Part and parcel with these other forgotten members of the four faculties there is also the A posteriori Analysis[6] that Kant believed did not exist. We have explained this as the analysis of A posteriori Syntheses. But of course, this is not fully satisfactory because that explanation would make A posteriori Analysis fall after A posteriori Synthesis rather than be equivalent to it. Some have instead argued that this is where the Unconscious[7] enters Kant's framework. It could be that

[5] https://www.wikiwand.com/en/F-theory

[6] http://philosophy.stackexchange.com/questions/474/what-are-examples-of-analytic-a-posteriori-knowledge

[7] Cutrofello, Andrew. *Imagining Otherwise: Metapsychology and the Analytic a Posteriori*. Evanston, Ill: Northwestern University Press, 1997.

it only appears when one distinguishes something in an Emergent Event which once distinguished becomes part of a synthesis. There are many possibilities for explaining it, but what this shows is that even in the combination of terms there is a fourth element that is inexplicable from the Kantian perspective. All of these hidden fourth elements take us from the Kantian Episteme to his Meta-episteme, i.e. the complete field of all possibilities in the terms of which there are actually sixteen terms instead of four including:

Analytic A priori
Analytic A posteriori = ?
Synthetic A priori
Synthetic A posteriori

As well as
CoAnalytic A priori = ?
CoAnalytic A posteriori = ?
CoSynthetic A priori = ?
CoSynthetic A posteriori = ?

And we might as well mention:

Analytic Now = Quality (?)
Analytic CoNow = CoQuality (??)
Synthetic Now = ?
Synthetic CoNow = ?

As well as
CoAnalytic Now = ?
CoAnalytic CoNow = ?
CoSynthetic Now = ?
CoSynthetic CoNow = ?

In other words, when we consider all permutations the Kantian Meta-epistemic field becomes quite complex, at least theoretically. Not all of these possibilities are necessarily meaningful. We merely mention this in order to make clear that all the possibilities generated by the Kantian Meta-episteme have not been considered and the possibilities of interaction of Analysis/Synthesis and A priori/A posteriori are much greater than we might have expected given their treatment in the tradition. And the point of all this is to say that the reason Synthesis is not well understood in the tradition is that it has merely been seen as the flipside of Analysis, and the transformation between the two has been thought of as transparent. But clearly it is not transparent because the fourfolds of Analysis/CoAnalysis//Synthesis/CoSynthesis and Apriori/Aposteriori//Now/CoNow and their interactions have not been fully explored and the transformation between Analysis and Synthesis implicates the entire field.

But even though our lives have been made more difficult by the expansion of the Meta-episteme of Kant, it has been helped by the fact that it is mathematics that has become the subject of the field separating Analysis and Synthesis in relation to time and space. So, it has introduced a level

of precision into the formulation of the difference between analysis and synthesis that we might not have expected otherwise. This gives us mathematical analogies to work with in our attempt to understand the relation between Analysis and Synthesis. In effect Geometry and Topology together represent synthesis and Algebra and Co-Algebra together represent analysis. But these are modulated by their relation to the four moments of time. Essentially Analysis becomes possible when things are discrete, and Synthesis becomes possible when things become continuous in some sense. And thus, the relations between Set and Mass enter the picture. Syntheses tend toward being wholes which exemplify pervasion of properties within a single individual. Analysis tends toward being about separable substrates of discrete individuals. The entry of the Continuity/Discontinuity distinction as a way of characterizing the difference between Geometry/Topology and Algebra/CoAlgebra helps to bring clarity and focus us on a higher level of abstraction in which we distinguish Set and Mass as categories along with their logics: Syllogistic Logic and Pervasion Logic. In other words, we can distinguish an essential difference within the field by focusing on Set Theory but that is discrete, and leaves out the continuous that we have in Geometry and Topology so the dual of the Set that preserves that continuity is Mass Theory. And it is at that point that we enter the field of Fundamental Mathematical Categories which function at a higher level of abstraction from the various forms of mathematics that appear in this Kantian Meta-epistemic field. By entering a new higher level of abstraction we focus the issue of the difference between Analysis (as Discrete) and Synthesis (as Continuous) and enter the realm of contemporary Formal Logic instead of mathematics.

What we have seen so far is that the term Synthesis if we go back to Kant has a meaning that is tied to Analysis but which cannot be transparently transformed into and out of Analysis without encountering a complex mathematical field that we did not expect to find which gives us four different views on synthesis and analysis. But the theme running though this field is the relation of continuity to discontinuity, and this brings us to a higher level of abstraction where we can deal with Syllogistic Logic and Set theory instead of the entire mathematical field. But to do so we must add Mass theory and its Pervasion Logic as the complement of the syllogistic traditional logic. Therefore, we substitute a duality between Categories Set and Mass for the complexity of the mathematical field generated by the Kantian Meta-episteme. And thus, we enter into what is called the Foundational Mathematical Categories (FMCs). These appear at a very different level of abstraction than the mathematical field that underlies the Kantian Meta-episteme. And it is this move to a higher level of abstraction that helps us to understand the images of the stages of the development of the synthesis better. It is here also that we first encounter what I call Dagger Theory[8]. Dagger Theory is an arbitrary name because I did not know what to call it[9]. It refers to the dagger icons that are sometimes used as footnotes because the theory seemed to have a similar structure to these icons. But Dagger Theory[10] refers to four series: Philosophical Principles (PP), Foundational Mathematical Categories (FMCs), Schemas Theory, and View/Order Hierarchies. These appear as the interfaces between the various 'worlds', or regions of experience, that Ken Lloyd[11] posits based on those of Penrose and Popper, to which we add the Intersubjective 'world'. But the connection to world theory and thus the connection to specific pairs of schemas came much

[8] https://www.academia.edu/9868340/Exploring_the_Dagger_or_

[9] But we would like to think perhaps it relates to the Dagger Category.

[10] https://www.academia.edu/36065265/Essential_Schemas_Theory_The_Supra-rational_Dagger

[11] http://wattsystems.com/

later seemingly by happenstance. What we want to do here is to explain the roles of each of these series and their relations to each other and how they help us understand Synthesis in Architectural Design of Systems.

The System schema is just one out of ten. We develop Schemas Theory in order to give a context to Systems. We go up to the next level of abstraction and ask what other schemas may exist other than the 'system' and what relations do they have to the System schema. We develop a specific hypothesis about that which is that there are ten schemas: facet, monad, pattern, form, system, meta-system (openscape), domain, world, kosmos, pluriverse. Then we posit a rule that there are two schemas per dimension and two dimensions per schema. We call this the S-Prime hypothesis. Then we describe each schema in relation to the others and posit that there are no gaps between them and that this is all there are, a finite series of a specific length rather than an infinite series. Each schema is like a holon because it actually encompasses two dimensions. The schemas are templates of understanding that are ontological and thus projected onto things that we find inhabiting our experience as already schematized. Many of them are mentioned in the tradition by various thinkers, but a good source for many of them is Philosophical Grammar[12] by Wittgenstein, a precursor to Philosophical Investigations[13]. The description of the Schemas as we mean the term is given by Umberto Eco in Kant and the Platypus[14] where he calls them "Mathematical and Geometrical" Schemas. We posit that the spacetime is not homogeneous experientally, i.e. as encountered phenomenologically, as is believed by most of the tradition, but is instead broken up by these various schemas that are projected a priori in experience by the apperception of the Transcendental Ego and all phenomena are encountered as already schematized by the Cogito or Mundane Ego. Thus, each type of schema is a different generic type of synthesis. They nest to produce complex syntheses. They answer the question as to what a Synthesis is made of in its passive form. But also, these schemas are the basis for all designs, whether architectural or detailed, and in fact for all the elements of whatever artifacts we produce. They are the building blocks out of which we produce designs of things we build, and serve as the templates of understanding by which we comprehend systems we did not build ourselves, but are trying to learn how they work. All the minimal methods rely on the schemas to give them their content which then they use to understand how designed artifacts should work or do work. Schemas organize natural language and all artificial languages (Domain Specific Languages) as well as the things we experience through perception, or imagination, or memory, etc. i.e. through our faculties. They are the ubiquitous frameworks for understanding phenomena that are built into our cognitive faculties. So if the question is what is a synthesis composed of our answer would be "they are composed of schemas". They are the material cause of all Syntheses and the wholeness that makes possible all Analysis of schematized things.

Philosophical Principles = Final Cause
Foundational Mathematical Categories = Formal Cause
Schemas = Material Cause
View/Order Hierarchy = Efficient Cause

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[12] Wittgenstein, Ludwig, and Rush Rhees. *Philosophical Grammar*. Oxford England: Blackwell, 1974.

[13] Wittgenstein, Ludwig, and G E. M. Anscombe. *Philosophical Investigations*. Oxford: Blackwell, 1967.

[14] Eco, Umberto, and Alastair McEwen. *Kant and the Platypus: Essays on Language and Cognition*. London : Vintage Digital, 2014.

If we have a formal cause for synthesis when we apply the principle of sufficient reason to the concept of a synthesis then we can think of the other Dagger series as representing the other *aition*, or Aristotelian causes. Schemas have no structure in and of themselves but instead are transparent and they borrow their order from the Foundational Mathematical Categories (FMCs). The organization of things within a schema borrow their order from the various FMCs. When we say what the various schemas are we mean by that whatever you have in mind when you hear the term Form, or Pattern, or System, etc. In other words, we do not define them but see them as whatever you have in mind when you use these words. But this does not mean they are amorphous because they borrow their inner formation from Mathematics and especially the FMCs. The same mathematics or sometimes different unique parts of mathematics can be used in different ways to define the inner formation of the various schemas. Schemas do not have within themselves a Set structure, or pattern, or form because this is the provenance of the schemas themselves. Instead we have to think of them as different ways in which something can be seen as whole. The Synthesis goes beyond this abstract variation of types of wholeness, to an actual embodiment of a given schema with its content both in terms of adjacent lower schemas and the hyle that make up the material basis of the entity that is schematized. We reserve the term whole for the nature of the schema itself as an ontological abstraction that is projected onto entities within the world at the ontic level. We reserve the concept of synthesis for the actual embodiment of that wholeness in a thing that has been schematized and realizes that schematization in its organization.

Here we should distinguish between what Spinoza calls 'Adequate Ideas' and what Leibniz calls 'Complete Ideas'. Schemas are Adequate Ideas that is to say they being with them everything that is necessary for us to understand them, i.e. the other Dagger series that are concomitant with them. But syntheses are Complete Ideas in as much as in the synthesis the schema and its content must be reconciled in a specific embodiment. Hegel talks about this necessity for reconciliation of Form and Content in the *Preface* to Phenomenology of Spirit. It is this reconciliation at a concrete embodied level that Leibniz calls a Complete Idea. There must be an embodied example that shows how the reconciliation takes place for the Idea to be brought to completion. For Adequate Ideas we need only the necessary supporting concepts that would allow complete understanding. So for instance besides the idea of the circle we need the generative image of a line segment whirling around to form the circle by its attachment to the center point, and its constraint to a single plane for its rotation. But for the idea of the Circle to be complete we need actually drawn circles as examples. Unless we actually draw circles then we cannot tell whether we have satisfied the hypothetical imperative, can it actually be done, even if only imperfectly in actuality. Syntheses have to be complete ideas in order to know if they work. Mere possibility of wholeness is not enough. Syntheses bring together the ontological and the ontic as a proof by existence.

But the FMCs themselves are derived from the various possible foundations for mathematics that have been proposed beyond Set Theory, but these have been ordered based on the Philosophical Principles of C.S. Peirce and B. Fuller. Thus, we can see the PP as the Final Cause because it gives the fundamental telos of the series of the FMCs. And finally, the View/Order Hierarchies are the answer to What, When, Where, Why, How, Which-one, and Who which are epistemological questions and it is only at this level that the process of systems development is defined which is the efficient cause of the creation of the system. So, although I never thought about it this way before, it appears that the various series from Dagger Theory can be seen as the embodiment of the different types of causes or aition that we find in Aristotle. And thus, we have defined the

principle of sufficient reason with regard to the production of synthesis by poiesis[15]. If this is the case it explains why these four form a set that go together. I hate to appeal to a concept like this because in a sense it does not explain anything. But within the Western tradition following Aristotle a complete explanation of the cause of something takes in the Four Aition (causes). We can appeal to Robert Rosen who also uses the Four Causes as an explanatory device but who admits its limitations. Western Science has reduced itself to only dealing with efficient causes. But if we want a deeper causal explanation the Four Aition are always appealed to as sufficient within the tradition.

The Philosophical Principles give the inner structure of the phenomena based on Pascal's Triangle and its interpretation from a geometrical point of view. But it formulates principles based on that which are the basis for understanding all phenomena. But the PP do not give us any insight into order. For that we need the FMCs in an sequence dictated by the PP. Then we say that the Schemas draw on the FMCs in order to make accessible the phenomena through the templates of understanding. And finally, we transition to an epistemological layer which is at the surface that is related to what Klir calls the lattice of Methodological Distinctions and it is within that context that the Architectural Design of Artifacts take place mostly understood as Formal Structural Systems through the work of George Klir in his Architecture of Systems Problem Solving[16]. And we appeal to Puntel[17] in Structure and Being for an Analytic grounding for Structural Systems in relation to Being. This surface level where the Architectural Design Synthesis occurs as a result of efficient causes is a series of trees in the lattice of methodological distinctions which give us traceability lines between the trees as an external representation of the essence the formal structural system under design. The actual tree of the components representing the How appears in the middle of the lattice where the architecture takes form. These structures are all built up by composition. And wholeness is achieved by the circular trace lines that loop among the trees and close to give complete circuits. This external representation of the essence[18] answers to epistemological questions is a simulacra of the internal essence of the software (or systems) product. But if we do not have this external superstructure then the design essence is invisible and implicit within the code of the system which is very difficult to apprehend without the externalized superstructure that mimics it.

Once we know how these various elements of the Dagger series relate to each other via the *aitons* then we can see that we have produced a model of the sufficient reason for Design Syntheses by producing an elaborate model of the context within which the design occurs, and the various causal (aition) elements that underwrite it. And we can see that key among these are the FMCs Series which focuses on the relation between Set and Mass, but also includes Multiple with Groupoid on the one hand and Wholes with mereotopology on the other hand. And here we approach the key point. Among these FMCs there is the Groupoids related to the Multiple which is the precursor to

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https://www.academia.edu/6525152/The_Concept_of_Poiesis_and_Its_Application_in_a_Heideggerian_Critique_of_Computationally_Emergent_Artificiality

16 Klir, George J. *Architecture of Systems Problem Solving*. New York: Plenum Press, 1985.

17 Puntel, Lorenz B, and Alan White. *Structure and Being: A Theoretical Framework for a Systematic Philosophy*. University Park, Pa: Pennsylvania State University Press, 2008

18 The Essential Nature of Product Traceability and its Relation to Agile Approaches by Kent Palmer https://doi.org/10.1016/j.procs.2014.03.007 https://www.sciencedirect.com/science/article/pii/S1877050914000702

the Set. We notice that Hegel in his *Introduction* to Phenomenology of Spirit uses Groupoids[19] to organize the structure of the argument. Groupoids have a special property that may be unique in mathematics which is that they directly produce syntheses. And thus, they are the basis of the active production of synthesis that we have been looking for. And they answer the question about the nature of synthesis and how they are produced. Categories, Directed Graphs and Groupoids are all inter-transformable. Thus, this is where Category Theory enters our discussions. Sets are a particular kind of Category, and so are Topoi which we can use to describe the Site/Event locale FMC. Basically, we start with the singularity (related to the holoidal) and from that we go to the site/event locale that may be described by a topoi, and then to the groupoid with the Multiple, and from there to Set Theory and then Mass Theory which are duals. Then we add a mereology to the Mass to get a Whole. Then we have wholes and parts that are the same in Holons, and then Holoidal structures that interpenetrate and have intra-inclusion, and finally we end up with the Singular. At the other end of the V of the series, the wide end there is the singular, but at the narrow pointed in we have the Anti-type, Type, Co-type and NonType which specifies the types of things within these various formations. These various images of mathematical order and arranged in relation to the PP. Schemas can draw on any of them to specify the internal order necessary to describe a particular schemas organization.

Once we introduce the Groupoid then our problems with syntheses are much better because we have a model of how a synthesis should work. All the other Categories within the FMC series can be represented as groupoids or directed graphs. And through the FMCs we get access to the whole of mathematics including the field that appears with the Kantian Meta-episteme. The series of worlds and the schemas each of them include become a self-referential context for the Dagger elements. The Dagger elements are the interface between the worlds, and the worlds contain specific schemas as well. This means that the schemas are both outside the worlds and inside the worlds being dispersed amongst them.

So, it turns out that there is a bit of mathematics, groupoids, that can explain how syntheses work and thus how Architectural Designs are built up. And with Dagger Theory we give a framework in which to understand this buildup of syntheses. We recognize that there are various levels which are involved in the design process that are associated here with the Dagger series. The prime motive is to instill the various Philosophical Principles into the artifact being designed. But we do that by introducing order and the kinds of order are determined by the FMCs but as they stand in the broader mathematical field of the Kantian Meta-episteme. The FMCs of Set and Mass are abstractions of discontinuity and continuity which characterize the two major sides of the Kantian Meta-epistemic field, Algebras, Co-algebras, Geometries, and Topologies are all different ways of looking at the relation between Analysis and Synthesis along with Co-Analysis and Co-synthesis. But the order that is drawn upon from the FMCs is used by the schemas which are transparent but draw upon those sources of order as needed to represent the various templates of understanding of things in spacetime that the schemas allow us to comprehend intelligibly. And then the schemas are used to build components within the ViewOrder hierarchies which is the surface level where Designs are pieced together. All of this underlies the building up of syntheses in the Design process. But this explains the sufficient reason for the causal constitution of design synthesis which covers all the Aristotelian Causes (aition). Synthesis needs all these different causes to coordinate

[19] https://www.academia.edu/35992276/Hegels_Groupoids

to constitute the design of the artifact that is being developed. Groupoids play an important role in producing these syntheses. They tie together the elements into a whole, and the whole is seen then as a combination of the boundary of the mass and the internal articulation of a mereology. The whole is needed for internal relations to be specified. They are further articulated in terms of Holons and Holoid networks within a Singular. Set Theory and Mass Theory mediate between the Groupoid with the Multiple and the Whole which is Dialectical, i.e. in which the content cannot be separated from Form.

When we think about the Dagger Theory series as related to the *aition* or Aristotelian Causes, which were just the meanings of *aition* in Greek, and thus have no ultimate necessity other than that given by the Greek language. But our tradition has been so invested in these causes that within the tradition if we have those four causes then we find those to be sufficient reason that satisfies out understanding. But this does explain why these four Dagger Elements go together to give us a basis for understanding Design Synthesis which was unclear previously.

We started with the difference between Analysis and Synthesis in Kant's Episteme, and then we analyzed the Episteme in Category Theoretical Terms and found missing terms like Co-Geometry of Topology or the CoNow or the Analytic Aposteriori and then this caused us to posit the Kantian Meta-epsitemic field and understand that much of mathematics is formed from the combination of these different types of mathematics that appear in the Kantian Meta-episteme. We noted as Kant did that Geometry as Direct Product serves as the key analogy of all syntheses of manifolds. But then to this we added the forgotten term of Co-Geometry which appears in our tradition as Topology which Leibniz tried to inaugurate as Analysis Situs, but which was not accepted by the Mathematicians of his time. We also pointed out the fact that the idea of CoNow is a necessary complement of the Now in the fourfold of time, that breaks the traditional concept of time as a threefold synthesis. And we also brought up the various interpretations of a posteriori analysis and attempted to show that it could be seen as important for analyzing artifacts that are produced by a posteriori synthesis following the argument of Kripke that this element of the of the Kantian Episteme exists and possibility points toward emergence or the unconscious. Within this context of the Kantian Meta-episteme we see that there is no transparent transformation between analysis and synthesis but that it is mediated by the Meta-epistemic field and that is why Synthesis is difficult to understand because there are different kinds of synthesis and that synthesis can be seen as related to Algebra, Co-algebra (computation and state machines), Geometry and the lost pole of the field which is Topology. Once we know why Synthesis is difficult to understand and thus why we do not find explicit treatments of it in the Western tradition which focuses on Analysis then we can comprehend the difficulty of our task in comprehending Design Synthesis of Systems.

But all is not lost because it is possible to construct the Dagger Theory which is composed of various series (PP, FMC, Schemas, View/Order epistemological hierarchies) that we see interconnect the various worlds posited by Ken Lloyd (Popper/Penrose) with the addition of the intersubjective world. But these worlds are more of less affirmed by Husserl in Ideas I as various levels of Phenomenological reduction. Husserl would call these so called 'worlds' ontological *regions* instead. And these various Dagger Series are not just the interfaces between these worlds but provide the sufficient reason for synthesis based on the Four Aition of Aristotle which is the traditional set of causal reasons that are sufficient. But beyond that we can abstract from the Kantian Meta-episteme based on the key distinction of discrete/continuous and thus get the

primary dichotomy between Set and Mass with their associated logics within the FMCs. We find prior to the Set/Mass distinction the necessity of positing Type as the point at which the FMC series folds which we understand in terms of Anti-type, Type, Co-Type and NonType. But then after the Set/Mass distinction we find the next pair of FMCs are Multiple/Groupoid and Dialectical Whole. And here is where it is possible to see the kernel of the synthesis to arise from the Groupoid which is one of the few mathematical sources of active synthesis. Hegel makes use of the groupoid in the *Introduction* to Phenomenology of Spirit as his way of framing the problem of understanding. Groupoids can build syntheses and in fact it is the source of the syntheses that appear in the Pascal Triangle, and the Pascal Tetrahedron. Just like in Hegel the Groupoid is the prerequisite for building Dialectical Wholes. And it is dialectical wholes that we need to see *internal relations* which Hegel emphasizes. Dialectical wholes are genetic syntheses which develop over time. These dialectical wholes come from the addition of a mereology to the boundary of the mass to get a mereotopology. The other FMCs allow us to understand in detail how the wholes arise and become more and more coherent. The wholes arise first from a singularity, then there is the site/event locale (Dasein) which is understood in terms of Topoi. Topoi are the templates of all Logics with their sub-object classifiers. From that we graduate to the Groupoid/Multiple in which equivalence relations between heterogeneous and even incommensurable elements are produced. And with groupoids we get the relation to Category Theory and Directed Graphs. From here we graduate to the Set Theory that Badiou discusses in Being and Event[20]. Badiou adds to Set Theory the Multiple and the Event of the arising of the Ultra-One in order to create a viable ontology. Sets can be empty projections, but from the Multiple arises the individuals that appear as particulars in Sets. Then as the dual of the Set is the Mass based on continuity and identity, while Set is based on discreteness and discontinuity between particulars. Mass theory has its own logic which is pervasion logic. Particulars and Mass boundaries are emergent while Sets and instances of Masses are de-emergent. Between the Set and Mass we have to recognize the ipsity (from ipseity) in the Aggregate which is what arises out of the Multiple and which has a form of conjunction and synchronicity that becomes reified in the set and mass nihilistic opposites. We apply types to the ipsities in the aggregate and thus get the various modes that Deleuze identifies in Bergsonism which are real, possible, actual and virtual which are the modes of the Emergent Meta-system that is the image of how ipsities in aggregate transform into each other to produce a transforming manifold in which the elements change type. This loose manifold of fish in schools, birds in flocks, insects in swarms, herbivores in herds that appear everywhere in nature as a social phenomena is a fundamental type of manifold in the Kantian Sense. But when we lend this manifold continuity via the mass and then add a mereology to isolate individuals then we get the dialectical Whole. And it is only this dialectical Whole that can have internal relations. And this is what Hegel wants to emphasize which is the fact that purely Formal Systems must give way to dialectical systems. Purely Formal systems are static, while dialectical systems are dynamic. Purely Formal Systems ignore their own content, while real understanding takes into account the relation between form and content and is in fact structural. Hegel is the precursor to structuralism with his call for us to understand the content within the forms we project. And thus, in dialectical wholes we cannot divorce the content from the forms in which they appear and we see this played out in Phenomenology of Spirit and also Hegel's Logic, although the logic is much more reified in its progression through the dialectical unfolding of the logical categories. Thus, we need to take into account Hegel's critique of Kant. And we find in

[20] Badiou, Alain, and Oliver Feltham. *Being and Event*. London [etc.: Bloomsbury Academic, an imprint of Bloomsbury, 2015.

Peirce the attempt to reintegrate those insights back into Kantian Philosophy in the context of Pragmaticism.

Once we have the Dialectical Whole then there is a model for synthesis and we find that synthesis has to take into account the *internal relations* between the content and the form, in effect this means that it is focused on Essence, which are the constraints on the possible variation of attributes that allow something to stay of the same kind but display variation.

Hegel develops the idea of Essence and the Notion in his Logic. But the best example of this comes in the Genetic Phenomenology of Husserl that distinguishes the Passive Synthesis from the Active Synthesis which are another way of talking about the difference between A priori and A posterori that takes into account the necessity of the Now as the moment when the phenomena appears, and the Co-now gets cast as absence that counterbalances presence, or as difference that contrasts to identity, or as illusion (irreality) that is distinguished from reality, or fiction that is differentiated from truth. When we build a design of an artificial system that is an active synthesis then we can analyze it actively to produce judgements. The focus of Husserl as was that of Frege is on Judgement as the most important moment in the display of the capacity of Reason. But just like for Logic these active syntheses must rely on passive synthase that are given to us in experience. And that is based on a priori synthesis and a priori analysis. And that is where we get the Kantian Meta-epistemic field of the mathematics that describes the difference between Analysis/CoAnalysis and Synthesis/CoSynthesis come into play. And this necessity of passive synthesis preceding active synthesis is not normally taken into account by both Systems Science and Engineering whether related to Systems or Software and must be considered from a philosophical point of view. And thus, we see the importance of Genetic Phenomenology for understanding the way that Synthesis shows up as produced by the unconscious as the basis for Analysis as well as A posterori Synthesis, i.e. the Designs of the Artificial Systems that we build. Even though Passive Synthesis takes us back into unconscious processing which is mysterious and is studied by Cognitive Science and Psychology we need a general Phenomenology like the Field of Consciousness[21] of Gruwitsch as a background for out understanding of the field in which active synthesis takes place. But once we graduate into the realm of active synthesis then we have the FMCs which give us a picture of the evolution of the Synthesis that is mathematically rigorous which we can use to conceptualize the nature of the Synthetic Whole. And there is not just the system but all the Schemas are synthetic wholes related to different pairs of dimensions. The FMCs are organized according to the Philosophical Principles and that is what gives the FMC series its internal teleology. Thus, the PP which is based by C.S. Peirce on the Pascal Triangle gives us a teleology of development that is extended by B. Fuller and which we complete in our work on Emergent Design (http://emergentdesign.net). The FMCs give us the mathematical understanding of the nature of the System and its place within a genetic series of the FMCs. And then the Schemas give us the various kinds of Synthetic Wholes that can be used as templates of understanding in relation to the various dimensions with regard to the organization of things in spacetime. All this shows up when we ask the Epistemological Questions (Who, What, Where, When, Why, How, Which-one, etc.) and find that these are aligned with the lattice of Methodological distinctions. In the middle of this lattice is where the hierarchy of components is produced (the How). Husserl, and Carnap both advocated a constructive approach to building up various formal systems. And

[21] Gurwitsch, Alan. *The Field of Consciousness*. Pittsburgh, Pa: Duquesne Univ. Press, 1964.

we assume that Architectural Design is the same, but we look at the wider context of all the methodological distinctions to get a structure that covers the whole lifecycle of Development. But it is in the FMCs especially that which is related to the Groupoid/Multiple that gives us the ability to build syntheses artificially of which Pascal's Triangle and Pascal's Tetrahedron are the canonical examples. Simplicies are the simplest regular syntheses in each dimension. We can build those up with Groupoids in a constructive way. And that is the basis for constructing any synthesis of any dimension. And so, we solve the fundamental problem of the basis of the production of syntheses. This is a miracle because as far as we know this is the only thing in math that produces syntheses additively. All other syntheses in math are given passively. So, it does not have to be a mystery. But it takes this wider context to realize how the syntheses given to us by Groupoids makes possible the production of synthetic architectures in Systems or Software Architectural Design and development. The groupoid appears as part of the Groupoid/Multiple FMC and that is the dual of the Dialectical Whole. These wholes are assumed to be systems but they may be any of the Schemas. And these schemas are the materials[22] out of which we build artifacts by composition. But that actual building occurs at the level of the Order/View Hierarchies where the Epistemological distinctions are made and the hierarchy of architectural components appears in the gap in the lattice of Methodological distinctions. Thus, Dagger theory gives us the complete context for the building up of syntheses and these are also the interface between the various worlds (ontological regions) that harken back to Husserl's levels of bracketing in Ideas I. And so, in this way we create a context within which to understand the process of building up of the Syntheses that underlie Architectural Design of Systems of various kinds. And thus, we make what would be otherwise mysterious somewhat clearer or at least less opaque than is currently the case as far as the tradition is concerned which has nothing to say about Synthetic Theory.

Appendix:

We modify our outline (**bold**) based on what we have learned in this working paper.

Metaphysical and Epistemological Philosophy of the standing Western Worldview as a tradition

- **Kantian Meta-episteme** and Hegelian Critique reconciled by C.S. Peirce
  - **Kantian Meta-episteme**
    - **Analysis/Co-Analysis**
    - **Synthesis/Co-Synthesis**
    - **Space/Time – Geometry/Algebra**
    - **Missing discipline of Topology as Co-Geometry/Co-Synthesis**
    - **Analysis related to Co-Algebra which embodies State Machines and Computation results**
    - **Field of combination of four mathematical disciplines**
    - **Apriori/Aposteriori**
    - **Now/CoNow**
    - **Analytic Aposterori**
  - Phenomenology
    - Static

[22] Lawson, Hilary. *Closure: A Story of Everything*. London: Routledge, 2002. 'Material' in the sense the word is used by Lawson.

        - Constitutional
        - Genetic
            - Husserl
            - Heidegger
            - Merleau-Ponty
            - Deleuze
            - Henry
    - Hermeneutics
        - Gadamer: Truth and Method
    - Dialectics
        - Trialectics (Work in Hegel, vanishing mediator)
        - Quadralectics
        - Pentalectics
    - Fundamental Ontology
        - Meta-levels of Being
            - Pure, Process, Hyper, Wild, Ultra Being
            - Puntel: Structural Systems Ontology
        - Aspects of Being
        - Individual and Social Scopes of Emergence
        - Emergent Events
            - Paradigms
            - Epistemes
            - Epochs and Eras
        - Worlds Theory
            - Carnap: Logical Structure of the World
            - Cassirer: Philosophy of Symbolic Forms
            - Logic: Frege, Wittgenstein, Russell
                - Copi: Ramified Higher Logical Type Theory
                - Axiomatic Platforms
                - Homotopy Type Theory
                - Set Theory and Mass Theory
                - Syllogistic and Pervasion Logic
                - Category Theory
                - Ipsities in Aggregate
            - Structure of the World based on Fibered Rational Knots
            - Pleroma – Field out of which the worlds arise
            - **Dagger Theory**
                - **Four Causes giving Sufficient Reason for Synthesis**
                - **Philosophical Principles – Final Cause (teleology)**
                - **Foundational Mathematical Categories (FMCs) – Formal cause**
                    - Four constituting Egos and their reflectivity, refractivity & diffraction

        - **Set/Mass with Syllogistic and Pervasion Logic**
            - **Continuity/Discontinuity distinction**
        - **Groupoid/Multiple vis Dialectical Whole**
        - **Site/event locale vs Holon**
        - **Singularity vis Holoid**
        - **Singular**
    - **Schemas – Material Cause**
        - Design Science
        - Formalisms
            - Mathematics
                - Matroids
                - Groupoids
                - Topoi
        - Systems
            - Holonomics
            - Systems Science
                - General Systems Theory
                - Concrete Universal Theory
        - Meta-systems
        - Structuralism based on Patterns
        - Other Schemas
        - Klir's Formal Structural Systems Theory
        - Emergent Design (http://emergentdesign.net)
    - **View/Order Hierarchies as Epistemological Categories – Efficient cause**
        - Emergent Design
            - Systems Architecture
            - Software Systems Design
                - Individual Designed Software System