General Schemas Theory

The Advance of the Systems Engineering Discipline through an extension of Systems Theory

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General Schema's Theory is a new discipline that is meant to serve as an underpinning of Systems Theory which in turn is seen as the foundation of Systems Engineering. Systems Engineering is a new practical discipline in search of its foundations. One good place to look for that foundation is in the well established academic discipline of System's Theory. Unfortunately most of those who practice Systems Engineering have never been taught any form of Systems Theory. They only know about systems based on the hearsay of our technical culture in which almost everything is called a System so that the term has become next to meaningless because it is indiscriminately applied to everything. One reason to study academic systems theory is to dispel this indiscriminate usage and to inform the term "system" with meaning again. As we might expect the system schema can only have meaning if it is compared with other schemas of different kinds. In other words there are other things than systems in our experience. We are merely obsessed by systems schemas because for so long we had the idea that a different schema was central to our construction of the world. That schema was the form. From the time of the Greeks through the nineteenth century this one schema was dominant in our thinking and analyzing of things around us. This is probably because we are genetically and neurologically predispositioned to efficiently focus on the form schema within our experience. During the twentieth century we learned to appreciate the importance of the system schema as different from the form schema. Also in this century there was an interest in the pattern schema which was expressed in the structuralist school of thought[1]. Generally those who study systems are a different group than those who study forms or patterns. But George Klir in his Advanced General Systems Theory brought all three of these schemas together and constructed a way of thinking of all three together in his book on Architecture of Systems Problem Solving. It is this version of General Systems Theory from which I wish to take my departure in the construction of General Schemas Theory. The key idea that George Klir contributes is that of combining the best aspects of three different schemas to support a deeper understanding of phenomena. However, we do not have to stop at the consideration of just these three schemas, we can go on to consider all possible schemas and their interaction as a means of supporting our Systems Engineering

[1] Cf Levi Strauss The Savage Mind

practice by extending the academic study of other sorts of schemas not normally talked about even by academic theorists. What is strange is that schemas are developed in specialist disciplines as needed to study the phenomena in question, what ever that may be. It is unusual for the schema to transcend the discipline, as the system schema has by the establishment of general systems theory. General Systems Theory looks across all disciplines and identifies how the systems schema contributes to the understanding of phenomena in each discipline and attempts to produce generalizations about the system that cut across all disciplines and all uses of the system's schema. This is the only schema for which here is a meta-discipline of this sort. Rather almost all other schemas are bound within their disciplines and their various uses isolated by differences of terminology, differences of method, and differences of approach to applying the schemas in each case. It is only a few farsighted theorists like George Klir who have started to consider multi-schema configurations across disciplines, which he still calls Advanced General Systems Theory because the focus is still the systems schema. He considers the two lower level schemas below the systems schema, i.e. Pattern and Form and how they support and further explicate the systems analysis and synthesis with regard to understanding phenomena. We want to break out of the attachment to the systems schema and treat each schema in its own right and understand its interaction with other schemas in a way that allows any one schema to take center stage and consider the supporting role of other schemas to it. Any schema can be the figure on the ground of all the other schemas. This is the sort of analysis that only a new discipline of general schemas theory can carry out without prejudice to one schema over another. The point is that Systems Engineering practice calls upon us to take this step because it needs the cooperation of many schemas simultaneously to perform its work effectively and efficiently. The three schemas that Klir studies are a good start, but are not enough to support the full range of tasks of Systems Engineering practice. So it is incumbent on us to study the interaction and interrelations of schemas of various sorts and thus extend General Systems Theory into General Schemas Theory. That is made most urgent by the needs expressed by Systems Engineering which is attempting to build more and more complex systems all the time. This increasing complexity is exceeding the bounds of what the systems schema can support. Now we hear talk of Systems of Systems as the proximate extension of systems engineering. What is not realized is that the next schema up from the systems schema is not a doubling of the system but something emergent, something different that we have little expectation of in our attempt to talk of nested systems of systems of systems. What is the next level up from the systems schema is what is called here the meta-system schema. But this is just one of a whole series of emergent levels in the unfolding of the various schematic levels beyond the system but also below the pattern. Although we would like to focus on the relation of meta-systems to systems and the emergent properties of the meta-system over the system, it is necessary to do that in the context of a general schemas theory which explores all the schemas, rather than merely concentrating on a few.

If we wish to construct a fully fledged General Schemas Theory then the first challenge is to identify all the schemas that exist and understand their relations to each other. This is a hard problem because schemas for the

most part are developed in specialized disciplines to solve particular problems and even if the same schema is developed in different disciplines there is little cross pollination between the various formulations of the same schema in different disciplines. In other words we are attempting to do for all schemas what General Systems Theory has done for the system schema, that is look across all uses of any one schema across all disciplines and attempt to generalize about each schema's usefulness in these many different contexts. We can see how long it has taken to do this for the systems schema, a job that is not near completion. So how are we expected to do the same thing for all schemas within a brief compass of our research? The answer of course is to develop a hypothesis, i.e. using abduction. In other words I have read widely in many different disciplines. At some point I tried to start keeping track of when a new schema was being described. I have collected these observations and produced a hypothesis as to the extent of the proliferation of different schemas in various disciplines. Once this list is compiled and understood then we can begin to look for schemas that do not appear in the list, and we can also look to see how the same schema appears in various contexts, as well as how different scholars attempt to relate the various schemas. So here is my hypothesis for the hierarchy of schemas:

- Pluriverse
- Kosmos
- World
- Domain
- Meta-system
- System
- Form
- Pattern
- Monad
- Facet

When we look at this hierarchical list we see that each schema in the list is unique in its properties and characteristics, it is an emergent hierarchy, which I call the ontological hierarchy as opposed to the ontic hierarchy of emergent levels of things. We discover the emergent hierarchy of things through applying reductionism in science. Emergent levels of phenomena that we do not succeed to reduce we recognize as supervenient. However, the way we understand phenomena is by projecting generalizing schemas onto them which breaks up our experience of spacetime. The number of generalizing schemas is limited. Everything that emerges as phenomena must take one of these schematic articulations. This is prior to our categorization of them. This is at the point where we recognize the phenomena as residing itself within spacetime. In other words a phenomena first must articulate spacetime, prior to its categorization as to a specific type of phenomena, and prior to its individualization as a specific individual with its own unique characteristics, and prior to having a meaning assigned to it. We are talking here specifically about this so called mathematical or geometrical schematization which is identified by Umberto Eco as different from other uses of the term schema in Kant and the Platypus. The *locus classicus* of this concept is Plato's Timaeus where he talks about the two types of triangle that produce the Platonic solids related to the elements. Here geometrical forms are used to describe minimal articulations of spacetime as a way of producing envelopes in which the qualities of "Platonic forms" might manifest. Here we will not go deeply into the genealogy of the

concept of the schema. But we merely want to note that it shows up very early in the Western Tradition, and appears prominently in Plato, Kant and Heidegger's interpretation of Kant. In Plato there are two types of "forms" inside and outside spacetime. The forms inside spacetime, that are articulations of the receptacle, are produced from geometrical schemas. In Aristotle these two extremes are conflated into a theory of how spacetime bound substances have essences that are immanent to them. Aristotle develops his theory of categories to define all the ways you can talk about these things. Kant takes up and modifies the category theory in his own way but ties it to spacetime through the concept of the schema. Heidegger points out how the Transcendental Imagination was an independent faculty in Kant's first critique, but it was subsequently relegated to a lesser position in the hierarchy of the faculties. Heidegger uses this change in the importance of the Transcendental Imagination as the basis for showing how Kant had come close to his idea of *dasein*. But we note that it is from the Transcendental Imagination that schemas arise as projections of partitions on the plenum of spacetime. So it appears that the schema plays a fundamental role in the transition from Kant and Husserl's transcendental idealism based only on Pure Being to the Heideggarian concept of there being a difference between Pure Being and Process Being that show up as different modes of being-in-the-world. This inaugurates the postmodern era in which different kinds of Being are identified. Ultimately four different types of Being are discovered in the work of Heidegger, Merleau-Ponty, Derrida and others. The impact of the fragmentation of Being is very profound revolutionizing modern continental philosophy, in spite of the lag in recognition by Analytic strains of philosophy which still cling to the dream that all philosophy can be done within Pure Being. Instead of following out this genealogy of the concept of the schema and how it plays a crucial role in the revolution in our understanding of Being in the last century, we will merely note that schemas have a long and important role within the Western philosophical tradition that should be explicated in order to understand the relation of the schema to other fundamental concepts such as essence, Being, Platonic Forms, Time, Spacetime, etc. Here instead we will merely define the schemas that we are interested in as geometrical or mathematical following the usage of Umberto Eco who clearly distinguishes these kinds of schemas from other later uses of the word later in the Western Tradition after Kant. The word is used in a bewildering variety of ways and this should not confuse us if we stick to the use of the concept as propounded by Plato and then Kant. However, because the meanings of these philosophers systems of thought have various interpretations this way of defining the schema has limited usefulness.

Let us return to the list of schemas that have been proposed above, and to the distinction between this ontological emergent hierarchy and the ontic hierarchy which might include gaia, social, organisms, organs, cells, molecules, atoms, particles, quarks, strings. Any of the ontological schemas can be applied to any of the ontic hierarchy thresholds. There is a multi-schema projection on any one ontic emergent threshold of phenomena. This is a source of endless confusion in science. One scientist will be talking of a cell as a form, while another will be talking about it as a system, or another will be talking about it as a meta-system. They will end up talking past each other because the projected template of understanding is

different in each case. However, in each case there is a projection of Being onto the ontic particular in a specific form of understanding. *Dasein* is composed of Talk[2], Discoveredness[3], and Understanding[4]. We use words to talk about schemas projected by understanding on phenomena. By this process we discover not just the phenomena as pregiven but ourselves as pregiven. Talk must always be about something. What it is about generally is the application of the template of understanding to some level of the ontic hierarchy of phenomena. Talk ultimately evolves into Theorizing. Discoveredness is the pregiven preontological horizon of our experience that we explicate with our theory. Understanding is based first and foremost on the projection of schemas, which delimit phenomena in spacetime so that they can be categorized and then recognized as individuals. The odd thing about us is that we locate ourselves in spacetime, theorize about ourselves and project the same templates of understanding from the ontological hierarchy on ourselves as we do any other phenomena.

We have taken the normally emphasized schemas of system, form, and pattern and added several others both above and below them each having its own emergent characteristics. Guessing what these other macro and micro schemas might be is the trick here, and that guess comes from a broad reading of the Scientific and Philosophical literature. We want schemas that would be generally recognized by multiple disciplines as significant. But we also want to stretch the limits and go slightly beyond what is merely universally acceptable in a way that is consistent with the rational expansion of the series. Thus, it is clear that the next thing down from a pattern must be a monad, but we also know of monads that are faceted like quarks in particles and so we can consider that the lowest schema in our series might be the facet. Basically the monad is the smallest unified object. But it always seems that there is some patterning below what ever level we project as the lowest so the facet allows us to explore that patterning even if we cannot distinguish the component as a separable object. In the other direction we run into a different problem which is that we have no single concept for the schema that is next higher in the hierarchy from the system. Thus this has been called the meta-system. It is seen as the inverse of the system, and thus can be described as an environment, context, situation, milieu, and in other terms that are similar. The lack of a specific word for this ontological threshold is a source for much confusion. However above that level there are again general words that cover the higher level ontological schemas, i.e. domain, world, kosmos, and pluriverse. With the pluriverse again we are pushing the envelope by admitting the hypothesis of the Many Worlds from physics that posits that our kosmos is not the only one to exist which is the simplest hypothesis that comes out of quantum mechanics that might explain its eccentricities. But domain, world and kosmos are fairly standard terms that can be understood by almost everyone. Domain means a discipline, as a department in the university. A world is as it is described by Heidegger, the all encompassing human lifeworld[5] within which we live our lives. This is distinct from the Kosmos which is projected beyond everyday experience to attempt to comprehend the physical universe within which our world is

[2] rede
[3] befindlichkeit
[4] verstehen
[5] Husserl's term

embedded. We get glimmers that our kosmos may not be the only one from quantum mechanics so it is good to define that level of abstraction just in case. The point of the ontological hierarchy of the schemas is to produce a set of nested templates of understanding that will allow us to comprehend phenomena that we discover as onticly given at various emergent levels. This particular series of schemas is as good a place to start as any in our search for a complete set. Each of these has been developed in at least one discipline. They seem about the right distance apart in terms of the spacing of their emergent levels. They are each significantly different from each other in terms of their organization and characterization. If we could understand how this set of schemas might work together then we would be in a much better position to understand the relation of the system and the meta-system to each other which is considered by this author to be of the utmost importance because by understanding their differences then we open up the possibility of understanding the special systems which lies between these two central thresholds. However, first we must attempt to understand the whole set of schemas as they work together as a context for understanding the system and meta-systems and then the special systems.

Now here we would like to advance a theory of schematization. This theory comes out of a study[6] done by the author of the various representations of schemas formalized in various disciplines. We will not talk about those various formalizations here. That is mainly because they are each tied to a specific discipline. Rather we are searching for a way to generate the hierarchy of the schemas which is not connected to any discipline but which brings out their mathematical or geometrical nature. Plato posits the 'receptacle' which is undifferentiated spacetime. He then posits that this plenum must be broken up and he gives this job to his Demiurge. The Demiurge creates two types of triangles and those are used to build the platonic solids which are then seen as convex polytopes in which "Platonic Form" qualities, like earth, air, fire and water, may enter and exit spacetime. In other words there is a marrying of quantity and quality at the micro level of phenomena giving rise to things that might be seen as particulars with organized essences rather than merely bundles of properties. What we want to do is to find a mathematization that is similar to this but more general and universal. When we survey mathematics for such a generating mathematical object what appears as most appealing is Pascal's triangle. Pascal's triangle is a pyramid of numbers produced by adding the digits in the previous line to get the digits of the current line. It produces an infinite triangular pattern of numbers which turns out to be central to the development of mathematics.

```
       0                        -2d
       1                        -1d
     1 0 1                       0d
    1  2   1          line       1d
   1 3   3   1     triangle      2d
 1 4  6    4  1   tetrahedron   3d
1 5 10  10   5  1 pentahedron   4d
```

The important point about the Pascal's triangle for our purposes at the moment is that what it generates is an image of the minimal solid for each dimensional space. This has been well known for a long time and is used by mathematicians for many purposes. What I

[6] See http://holonomic.info

have discovered is that each Schema has images at two different dimensional thresholds. So for instance the form has both two and three dimensional images. The pattern has both a two and a one dimensional image. I hypothesize that the hierarchy of ontological schemas corresponds with the dimensional unfolding of the Pascal triangle in such a way that each schema has two images on adjacent dimensional thresholds. In this way the schemas interlock with each other. One image is a positive image and the other is negative. The negative image of one schema at the same level fits into the positive image of the other schema at the same level and thus these schema images interlock with each other like Russian dolls.

```
       0        -2d void null
       1        -1d null facet
     1 0 1       0d facet monad
    1  2   1     1d monad pattern
   1 3   3   1   2d pattern form
 1 4  6    4  1  3d form system
1 5 10  10  5  1 4d system meta-sys
```

The Pascal Triangle is a way to project partition on spacetime plenum though the unfolding of dimensionality. It simply unfolds by addition starting with one and then dividing one by one to create the space within which the dimensional unfolding occurs. By defining the minimal solid for each dimension we then create the interlocking of the dimensions since the minimal solid has one less dimension than the space in which it appears. Ours is a four dimensional world but objects in this world are three dimensional. The production of the minimal solids embodies the object within the dimension. The minimal solids are all space filling[7] and thus they define the whole space. Now in each dimension we can use Euler's laws to define the number of platonic solids in that dimension. In the case of the third dimension there are five, in the case of the fourth dimension there are six, in all other dimensions there are three platonic solids. But knowing the minimal solid in each case allows for the other solids to be deduced. Now because of the three dimensional nature of solid objects in our four dimensional world we normally do not explore higher geometries which we can define algebraically despite not being able to represent them without distortions. But this does not mean that we don't project higher dimensions regardless of the limits of the space we are trapped within. Thus I propose that the series of schemas continues to unfold according to the same pattern up to at least the pluriverse. I propose that the schemas always have images on two dimensional thresholds and that this defines how they interlock with each other.

```
        -1            -3d source
         0            -2d void null
         1            -1d null facet
        10 …           0d facet monad  (origin)
       1  2 …          1d monad pattern
      1 3   3 …        2d pattern form
     1 4  6  …         3d form system
    1 5 10  10  …      4d system meta-sys
   1 6 15 20   …       5d meta-sys domain
  1 7 21 35  35  …     6d domain world
 1 8 28 56  70  …      7d world kosmos
1 9 36 84 126 126 …    8d kosmos pluriverse
1 10 45 120 230  …     9d pluriverse unknown
```

One of the key things that Heidegger says about *dasein* is that it's Being overflows as an ecstasy. Part of this ecstasy could be seen as the projection of higher dimensional organizations onto phenomena. The Pascal triangle is a simple model of how this can be an additive process but one that grows exponentially as each level as 2^N elements. But this projection of templates of understanding is more than just a dimensional projection because each schema has its own characteristics that are emergent in relation to the last threshold. The templates of

[7] check for accuracy

understanding are constrained by this dimensional unfolding which partitions spacetime, but because of the emergent qualities of each level the organization of each schema is different from those before or after it. Each schema spans two dimensions and connects them as the dimensions connect two schemas each. Thus the schemas are the complementary opposite of the dimensionality not the dimensional articulation of spacetime itself. Dimensionality and the Templates of Understanding represented by the schemas serve as mutual limits. Things understood must be understood within the framework of dimensionality. Understanding itself as reason folds back and develops math and geometry to understand dimensionality. They are mutually limiting. One partitions spacetime in order to have an envelope that encompasses that which is to be understood. The other gives a transformational infrastructure between dimensions. Form appears as two and three dimensional. Dimensions are connected by schemas and schemas connect dimensions. The two together give the intellect something to categorize and something to assign meaning to.

Plato studied the Form. He thought that form had two dimensional embodiments that were the substrate for the expression of qualities. But today we know that form is not the only schema, and thus we must use Pascal's triangle to express the dimensional articulation of these other schemas that overflow our physical world with dimensional representations that go beyond our three dimensional objects in a four dimensional world. What we understand best are those schemas that are the same or less than the limit of objects in our world. However, we use the other dimensions to comprehend complexity of interrelations between things in our world. For that we need the concept of the meta-system, domain, world, kosmos and pluriverse which have higher dimensional embodiments. But because their dimensionality exceeds that of our world we have a much harder time defining these macro schemas to our satisfaction. But they are an essential way in which our understanding overflows our embodiment, just as our talk overflows our comprehension, or our discoveredness overflows our ability to define and delineate everything we know leading to what Michael Polanyi calls tacit knowledge.

There is a lot more to say about the relations of the schemas to each other. For instance that each schema is produced by the conjunction of the two adjacent schemas, that they form an autopoietic ring which like the Ourobouros eats its own tail. But our mission here is to merely present the key idea that differentiates the schemas from each other which is the unfolding of the Pascal Triangle where each schema comprehends two dimensions and thus is allowed to nest with its adjacent schemas. This shows that there are discrete bounds on the unfolding of the schemas tied to a crucial structure in mathematics. Each schema is therefore a series of transformations between its two dimensional images. Lower dimensional images serve as representations for higher dimensional images. Thus a two dimensional outline seen as a form is a representation of the three dimensional shape of a similar form. Representation then gets passed down through the hierarchy. Two dimensional outline can be seen as a two dimensional pattern which then can be transformed into one dimensional patterning say on a TV screen or computer screen. This passing down of representational images to lower dimensions is the basis of the technology

underling the preservation and transformation of representations in our culture.

Implications

It is odd that this way of defining the schematic hierarchy has not been discovered before. Perhaps I have just not read widely enough, but in my journeys I have not found any formulation of this sort of the complementartity of the schemas and the unfolding of dimension through Pascal's triangle. It is strange because when we look at the things around us what we find is just a small set of schemas that encompass everything that emerges. In fact, if you concentrate on that aspect of Being it becomes extremely oppressive because you see that despite the variety of the kinds of things in the world, the schematization of those things is very limited. It also means that the search for other schemas left out of this account is on. In other words once you know what the hypothesized set of schemas is then it is easy to look for anomalies and violations of that pattern, especially once it is known how the schemas nest with each other. It is as if the mind starts with a very narrow range of schemas into which it slots experience and once slotted into a schema then it goes on to characterize the kinds of things that are enveloped by that schema. The fact that the same thing can appear in the guise of different schemas is all that gives variety at the schematic level. It is important to note that for each dimension there is an ambiguity as to which schema will be selected for instance form and system both apply to three dimensional entities. This indecision as to what schema will be selected in any particular case produces an undecidability which can be described with Derrida's concept of Difference. However, we tend to schematize very narrowly. It is only later that science tries on different schemas to some phenomena that are normally slotted as a particular schema. This leads to various views of the phenomena which different schemas attempt to comprehend. First we have a very narrow schematization, then a wider categorization into kinds, and then we recognize individual unique characteristics, and after that we assign an interpretation or meaning. Notice that this progression gets wider and wider as we progress through the stages of the recognition of the unexpected event. There is more and more room for different choices and different outcomes, but at the schema level we start off with a very few choices as to how we will schematize something. These choices are arranged hierarchically into a series of emergent levels of possible projections of envelopes onto the plenum of spacetime. Once the envelope has been fixed then the characteristics of what lies in that envelope is determined in order to discover its kind. The fixing of the envelope is an automatic and unconscious process in most cases. But on second approach we might try other envelopes on the phenomena to see whether they fit it better or not. This is like the optometrist trying on the various lenses when you get your eyes checked. We pick the one that makes the phenomena clearest. But without the artificial lens then we are stuck with our first pigeon holing of the phenomena that occurs unconsciously or naturally prior to the trying of various artificial lenses. If we begin to look at the set of schematic lenses themselves we see that they form a very narrow range of different possibilities. They nest with each other and span the various dimensions. It seems that the ecstasy of *dasein* is primarily an overflowing of dimensions within a setting of bounded

dimensionality. But this overflowing of dimensionality is bound to the understanding of *dasein* who is projecting schemata in the very process of the ecstasy of dimensional projection. Understanding bridges dimensions by binding pairs of dimensions together in a single schema. It creates a hierarchy of nested schemas so that there are no gaps for phenomena to fall through. It is a fractal net with nested niches for catching phenomena. Once the phenomena are caught by the partitioning of spacetime then they can be characterized as to their nature, or essence by looking at the constraints on their characteristics. Plato saw this as a process of matching up the eternal Platonic Forms to the characteristics within the spacetime envelopes. Aristotle saw this as looking at the immanent essence within the substance of the spacetime envelope about which certain categorical propositions might be stated. Kant on the other hand saw the categories as *a priori* and that the line between that at the *a posteriori* is breached by the schemata of time. The hand over to categorization, then individuation, and then the positing of meaning do not concern us here. What we want to focus on is the geometrical or mathematical schematization itself. Notice that the Pascal triangle is a mathematical anomaly which produces not just geometrical but also algebraic results. It is used to understand the structure of polynomials. But it also represents the structuring of 2^N unfolded articulations which are the fundamental structure of Boolean systems. Thus the Pascal triangle is very fundamental in mathematics and a cross roads between different mathematical categories. The fact that it structures the schemata as well is a little known fact that has tremendous consequences. These consequences are as Plato predicted. Spacetime has to be broken up for anything to be isolated and recognized. This breaking up may be as he says in terms of the two versions of form represented by triangles and platonic solids. But we see more generally that the form is not the only schema and so we must strive to understand the relations between forms and other schemas and how they relate to each other in the hierarchy determined by the articulation of dimensionality produced by the Pascal triangle. This intertwining of unfolding dimensionality and the templates of understanding gives structure to something that otherwise could be very nebulous. Once we look around ourselves taking this structure into account we see that there are very few templates of understanding. However, we do not feel constrained by them because there is slippage between dimensions within the same template. There are intertransformations between dimensions made possible by the same schema existing in two dimensions at the same time. So although the schemas are limited their effectiveness is doubled because they operate in two dimensions at the same time and this allows them to nest with each of the adjacent schemas providing coverage of the full range of phenomena from micro through meso to macro. We see that the fundamental function that the schemas seem to provide is to locate the phenomena on a particular scale regardless of the ontic level of emergence that is being focused on at the moment. This scaling of phenomena allows us to take its measure with respect to ourselves. When Protagoras says, “man is the measure of all things” we can see in the schema the attempt to take that measure by our projection of the schema onto phenomena and by that to achieve some scaling of the phenomena in relation to ourselves. But also the fact that there is an overflow of dimensionality means that we also get some measure of complexity when we take that

measure of the phenomena because we have extra dimensions at the higher levels where me can handle increased complexity of the phenomena beyond the bounds of what we are normally used to at the meso-scale. Thus the schemas combine measurement of scale and measurement of complexity in the same projection. As we build more and more complex systems which are in terms of scale larger and larger we need the upper reaches of these schemas in order to cope with the size and complexity issues that these systems generate.

The key point is that when we design something, we use the schemas as a template for our design. It is a projective device within ourselves for comprehending our environments, including the artificial ones we create. Understanding the schemas is the bedrock on which all Systems Design activities must be based. This is why as Systems Engineers we should be interested in understanding general schemas theory. More that just systems theory it is general schemas theory that should be the foundation of our discipline. Every system we build is a partitioning of spacetime in some way before it is a distribution of kinds of design elements. As systems become more and more complex and in scale larger up to global we need higher and higher levels of the schemas in order to have templates of understanding fitted to these larger and more complex configurations that no longer can be described as systems or even systems of systems. Each schema can be applied to itself to form a hierarchy, so we have forms within forms within forms, or systems within systems within systems, or patterns within patterns within patterns. But this nesting of schemas with respect to themselves is different from the nesting of different schemas in relation to each other. The nesting of the same schema does not produce a different kind of understanding like moving to another schema does. It is as Bateson says in Mind and Nature the comparison of different sources of information that gives a higher quality information about a topic. Merely doubling or tripling the same schema with respect to itself does not improve our information about the configuration. But contrasting schemas does improve our information about the configuration in a quantum leap of comprehension. Templates of understanding working together give us much better information and knowledge about the configuration we are studying than does merely nesting the same schema within itself. Interacting schemas are a powerful device for achieving ultra-efficacious compression of the configurations of elements we are designing to work together.

The major threshold that we must pass is from the system to the meta-system. This threshold is difficult to pass because culturally we are not attuned to meta-systems. This is shown by the fact that we have no common name for this schema, where as we have common names for all the others. Culturally we have a blindness to the meta-system, which is the inverse complementary element to the system. Meta as a word has different meanings. Here it means “beyond.” It is what lies beyond the bound of the system both inside and outside. When we nest a system within a system within a system it is the meta-system that separates the various instantiations of the system schema at the various levels of abstraction. The best way to think about the meta-system is that it is like the universal Turing machine and the system is like the Turing machine. The meta-system is like the operating system on a computer and the system is like an application that runs on the operating system. Meta-

systems are the media, the operating system, the environment, the ecosystem, the situation, the milieu, the context of the system. Notice that in our hierarchy of dimensions that the system/meta-system schema pair is right in the middle and related to the fourth dimension. The structure of the dimensions of geometry are very important to the workings of the schemas. The fourth dimension in particular has some odd features that no other dimension has. Notice that the form/system/pattern series of schemas is at the second and third dimension, the dimensions in which most of our experience occurs. This is why George Klir's combination of these schemas into an Advanced General Systems theory is so powerful. At the level of the third dimension there are five platonic solids mentioned by Plato but known of by human beings since Neolithic times. But when we go to the fourth dimension we find there are six platonic solids, more than any other dimension. Higher dimensions rather than getting more complex are actually less complex in terms of regular solids. Also there is the fact that the space within dimensions peaks out at the seventh dimension which is the level where the world or kosmos appears. So the actual structuring of the dimensions themselves give us some intimation of the nature of the schemas. Something different is happening at the level of the fourth dimension and the seventh dimension that we need to pay special attention to as we develop our geometrical or mathematical schemas theory. Part of the specialness of the central meta-system/system four dimensional layer is that it is here that the special systems appear. The special systems are intermediate or partial thresholds between the major thresholds of system and meta-system. These secondary or partial thresholds within the hierarchy of schemas have special properties that are ultra-efficacious. We do not go into detail concerning these anomalies here[8]. But the three special systems are called Dissipative Ordering, Social Symbiotic, and Reflexive Social. They can be defined by using the Hyper-complex Algebras as a guide. Through these algebras they provide a model of interpenetration that in fact moves though the whole hierarchy of the schemas. Each higher schema can be considered to be a meta-system in relation to the system of the lower schema. This analogy allows us to place the intermediate levels between each pair of adjacent levels. In this way the set of schemas becomes a model for how to understand the interpenetration of phenomena. But this is not the only way to look at the relations between the levels of the hierarchy of schemas. We can pair them starting from the ends and working toward the middle. In this way there is a relation between pluriverse/facet, kosmos/monad, world/ pattern, domain/form, meta-system/ system. Also it is clear that the first two of these pairs are beyond experience where as the other three are applied to phenomena in experience. Notice that the spaciousness of the seventh dimension marks one of these boundaries. The opposite of this is the one dimensionality of the monad/pattern. The zero dimensionality of the facet/monad is also a loss of spaciousness at the other end of the spectrum. What is important to realize is that the negative dimensionality represented in the Pascal triangle needs to be interpreted as well. For instance the zero between the ones at the level of the zero dimension is the even zero of emptiness, as contrast to the odd zero of negative one dimensionality which is an image of the void. In mathematics there is a controversy over whether zero is odd or even,

[8] See paper Reflexive Autopoietic Dissipative Special Systems Theory by author at http://archonic.net

or both. But we think here it is important that we distinguish between even zero and odd zero. Even zero is the origin point, while the sources of the meta-system are on the other side of odd zero beyond the tip of the Pascal Triangle stalagmite. Beyond that tip is odd zero which is equivalent to the Taoist concept of Void which is distinguished from the Buddhist concept of Emptiness that is associated with even zero. Beyond odd zero is the stalactite which is the negative image of the Pascal triangle. In that negative triangle the sources are arranged for what appears within the positive Pascal triangle. However, this takes us more deeply into the concept of negative dimension. It is in negative dimension that the connections are made between interpenetrating parts of the various dimensions that unfold in the positive Pascal triangle. Those models of interpenetration are the hyper-complex algebras that unfold in the negative dimensionality of the negative Pascal triangle that acts as a stalagmite. There is a single source that gets differentiated in this negative dimensionality. That single source appears at negative three dimensions. We are learning that there is such a thing as negative entropy, negative information, negative energy, negative matter (anti-matter). It is little surprise that there is something called negative dimensionality in which the interpenetration of things externally separate in spacetime occurs. Bells Theorem in which electrons that were together stay in contact across spacetime is an indication that this is a reality. Since everything was together in the Big Bang then Bells Theorem is our way of understanding how everything actually is connected via negative dimensionality. In fact we can think of the Big Bang as the transition from negative dimensionality to positive dimensionality. Our world and universe are here in positive dimensionality but this is the tip of the iceberg above the level of negative dimensionality in which everything interpenetrates. All this interpenetration is funneled though a single source singularity and that is what unifies everything in the universe. The more differentiated sources at the higher levels of hyper-complex algebras are the means by which the various dimensional levels interpenetrate. For every level of external dimensionality there is a hidden level of non-manifest dimensionality at which a specific model of interpenetration occurs based on the hyper-complex algebras at that level. Negative dimensionality is a new mathematical concept that has not really been developed by mathematicians. But it comes as a natural spin off of the interpretation of the Pascal's triangle as a framework for the structuring of the schemas. Why is there a symmetry breaking so we only see positive dimensionality? We can ask what is prior to this symmetry breaking. We note that this is the same symmetry breaking that distinguishes Being from Existence. The negative dimensionality of the stalagmite Pascal Triangle is the model of existence. By only recognizing the positive Pascal Triangle then we suppress the recognition of existence and instead concentrate on Being, that which appears in positive dimensionality. But even in the positive Pascal triangle we find hints of negative dimensionality at the top which is mathematically uninterpreted. If we recognize the negative dimensionality of the top of the Pascal Triangle then it is a small step from that to recognizing that there is a stalagmite that is the complementarity of the stalactite of the Positive Pascal Triangle. This allows us to apply to these two triangles the picture of the meta-system that is composed of Source, Origin, Arena, and Boundary. The source is in the negative dimensions. The origin is the zero point at the zero dimensional boundary. The

Arena is opened up by the positive dimensions. The boundary is the thresholds between the dimensions themselves. Thus if we view the Pascal Triangle as having a negative complementary triangle then we have a complete picture of a meta-system within which the schemas unfold as various types of systems of understanding each with its unique characteristics and range of applicability. Schemas bridge dimensions and thus give coherence to the dimensional unfolding that would merely be discontinuous otherwise. Pairs of schemas inhabit a particular dimension giving the possibility of their nesting and thus the communication of representations between schemas.

Horizons of Future Research

Our endeavor has been to paint a picture of what General Schemas Theory is about. This is, of course, only a beginning. One line of research has to do with the use of the concept of the schema within the Western Philosophical and Scientific Tradition. We need to provide a genealogy of this concept in order to understand exactly how this geometrical or mathematical concept of the schema differs from other uses which could cause confusion. But also this genealogy will provide the grounding necessary in order to understand the meaning of the schemas in relation to other key concepts within the tradition. But once General Schemas Theory is understood better then we can better define the difference between the key schemas of system and meta-system. This distinction is fuzzy for our culture, but crucial because it defines the relation between the systems we build and the environment. Global warming is an example of a failure for systems designers to understand this interface well enough. But also we need to understand not just meta-systems but the other higher schemas because we are quickly becoming not just environmental (meta-system) engineers, but also domain engineers and world engineers, and perhaps as F. Dyson predicts we will eventually become kosmic engineers as we eventually engage in planetary terra-forming, and building more and more systems that bridge interplanetary space and someday perhaps even interstellar space. A key to this understanding of the use of the higher schemas is the further development of General Schemas Theory in such a way that we build on the foundations laid here to understand the various formalisms of schemas that have been developed in various disciplines and their relations to each other[9]. But once the various schemas have been understood in relation to each other, then the focus should be upon the system/meta-system distinction and how that prepares the way to understand the special systems, and ultimately the Emergent Meta-system which is a formation composed of the special systems and the normal system that gives a model of the meta-system. The meta-system is a conjunction of the normal system and the three special systems. Because each level of the hierarchy of schemas is by analogy a meta-system to the one below it and a system to the one above it, then this emergent meta-system formation is propagated throughout the hierarchy of schemas. But each of these levels of understanding, from schemas to system/meta-system distinction, to special systems, to emergent meta-system needs to be laid out and explored in order to have a complete understanding of this extension of General Systems Theory that might serve as a foundation for Systems Engineering. By this process Advanced General Systems Theory becomes General Schemas Theory and Systems Engineering becomes Schemas

[9] See http://holonomic.info

Engineering. And hopefully though this we will gain a very sophisticated theory of not just how to build isolated systems, even isolated nested systems of systems, but how to integrate those systems of systems into meta-systemic environments and ecosystems, into domains, and into worlds. This will give us a natural leverage that will allow our systems to be more efficient and effective, i.e. efficacious, because instead of going against the grain of the larger schemas into which they fit we will be able to adapt them better to these larger emergent schematic configurations. This is a development of a very advanced foundation for Systems Engineering. It is informed by developments in Mathematics, in Physics, and Continental Philosophy. Systems Engineering research has the charter of bringing this new discipline up to speed on what is germane that is happening in these other disciplines. We live in a time which is a renaissance with regard to the development of knowledge in many different disciplines. Systems Engineering should take advantage of as much of this learning as possible in order to establish its own credibility. For the most part Systems Engineers are not trained in these other disciplines and thus should have some source of exposure as to what is happening that is of interest in other fields and some consideration of how these new developments might affect the practice and definition of Systems Engineering. Systems Engineering researchers should do more than just redefine what has already become common knowledge within the discipline. Rather we should seek to produce solid foundations for our new discipline and connect those foundations to the important discoveries in other disciplines. How better to do that than to inaugurate a General Schemas Theory which will look at how all schemas are used across disciplines and make that the basis of our Systems Engineering practice.

Next Steps

Establishing General Schemas Theory is only the first step in the journey that we need to travel in order to produce a solid foundation for Systems Engineering Practice at the academic level. The next step is to understand the relation of the schemas to an extension of the mathematical categories. Our mathematical categories are built on set theory. But it turns out that set theory and its associated syllogistic logic is only one of several different fundamental categories that need to be the basis of our Systems Engineering practice. We need to explore the complement of the set category which is the mass category. This mass category has its own pervasion style logic that is fundamentally different from syllogistic logic. These two complementary logics and their associated fundamental categories need to be explored as a basis for understanding the emergence of system characteristics that cannot be comprehended using Set theory alone. It turns out that we still have a way of speaking in our language that respects the mass way of approaching things rather than the set way of approaching things. In The Discovery of Things[10] by Wolfgang-Rainer Mann it is shown how Aristotle changed the direction of our tradition from mass orientation prior to him toward a set orientation. Other cultures such as the Indian and the Chinese have mass oriented ways of looking at things. But for us it is best to balance these two perspectives rather than going too far in the opposite extreme. We can use the transition from Set approaches to Mass approaches to comprehend the transition from Design to execution or operation of the systems we

[10] 2000 Princeton UP ISBN: 0-691-01020-X

design. The schemas themselves are set oriented. But the ontic hierarchy that describes emergent thresholds of phenomena are themselves mass oriented intrinsically. Thus as we move from the ontological hierarchy to the ontic hierarchy there is a natural transition from set to mass approaches. We need to apply these approaches from each level of the ontological hierarchy (logos) of schemas to each level of the ontic hierarchy (physus) of phenomena. Informing the schemas with the fundamental categories of set and mass and their associated logics provides a different way of understanding the transition from design to execution or operation of systems. We design set like components but when they are executing and operating they become mass like. The mass way of approach gives us a much needed way of understanding this discontinuous transformation between these two approaches to things. There may be other such fundamental categories[11] and logics that should also be developed in relation to schemas theory in order to understand better the relation between the schemas we project and the things that exist in nature that these projections are applied to, including those artificial things we design that are suppose to fit into natural and artificial surroundings.

Ultimately there is a relation between the logos of the physus and the physus of the logos that needs to be bridged. The mathematical categories exist in a non-dual realm of order between these two extremes. On the one had logic exists as the physus of the logos. In other words logic sets fundamental constraining limits to our reason which have a strength like a physical law. On the other hand the schemas act like the logos of the physus because they are the first projections onto the physus as envelopes of spacetime prior to categorization. Between the mathematical categories and logic there is model theory. Between the mathematical categories and the schemas is the representational theory. Between the schemas and the logic is the philosophical categories. Representations are built up from the application of the mathematical categories to the schemas of understanding. But because our mathematical categories have excluded mass like approaches then we do not understand that representations have a dual which Deleuze calls repetitions. The recognition of the difference between set and mass approaches opens up the problem of difference. Difference along with Identity is one aspect of Being among those others of Falsehood/Truth, Illusion/Reality, and Absence/Presence. Recent philosophy has turned from an emphasis on the positive aspects of Being to attempting to understand the negative aspects of Being. This whole question of the negative aspects of Being is introduced once we realize that logic is split between at least mass and set approaches. This is why a deep understanding of this problem needs to come to terms with the philosophy of Deleuze and other postmodern philosophers. We need to deal with the philosophical categories and how they organize our representations and models. In this light the category theory of Ingvar Johansson[12] is of interest as an extension of Husserl's Phenomenology which takes up where the Transcendental Idealism of Kant left off. By reconceptualizing the philosophical categories, the highest concepts, and then recognizing the difference between representation and repetition as an image of

[11] i.e. Reserve and Field approaches

[12] http://hem.passagen.se/ijohansson/

the set/mass approaches that appear in the mathematical categories and logics, then we get a feeling for how the schemas must have to be framed to operate in this more complex environment. As templates of understanding they must manage to negotiate the reframing that occurs with the comprehension of new categories and new models and repetitions beyond representations. In this way our understanding of the relation between physus and logos and the non-dual of order between them grows more mature. We are able to understand some of the fundamental limitations that have been placed on our thoughts by not understanding well the role of the schemas. We understand logic and mathematical categories well. What we do not understand well is the schemas and how we project them and how they affect our experience of things in nature. They both help and hinder our being able to see them clearly. We need to be able to understand how we look through a glass darkly at nature because of our various projections in order to be able to factor out the distortions and artifacts of those projections. It is the role of Systems Engineering Theory to attempt to sort out these thorny issues and present as clear a picture of the state of the art understanding to the practitioner. Our design methods and our concepts of the products and processes that we deal with in development need to be informed by this sort of state of the art discussion of the limitations and strengths of our schemas[13].

Conclusion

Systems Engineering is a new discipline. New disciplines do not just show up without effecting existing disciplines. It seems that the vision of Systems Engineering that has been promulgated so far is that we can just add it on to Hardware and Software Engineering to get a complete picture of the Engineering discipline, perhaps sprinkling in a bit of Specialty engineering for spice. But, in fact, Systems Engineering's emergence as a discipline from industry rather than academia, like software engineering before it, will cause all the other disciplines to transform in the new interdependent landscape that is created between disciplines. Systems Engineering is the glue that holds together other disciplines and tries to get the best out of each of them in the systems development process. But Systems Engineering's lack of foundations actually calls for a radical reunderstanding of the relations between fundamental aspects of our tradition. We have emphasized up to this point logic and mathematics but have played down the role of schemas in our comprehension of the world. Now with Systems Engineering schemas become important again because a system is a schema, and to understand what a system is we must contrast it with all the other schemas, in the process we learn that we need a schemas theory and that leads to a definition of Schemas Engineering as an extension of Systems Engineering. Once we recognize that our understanding of schemas must change then that calls us to look at the relations between schemas to logic and mathematics again. There we find that both logic and math are not adequate to account for effects we discover in Systems Engineering activities. Math is missing the fundamental category of the mass as opposed to the set. Logic is missing the pervasion logic that corresponds with the mass category. When we add the mass and pervasion logic then we find our models are not adequate because they deal only with the aspects of identity, presence and

[13] See "Vajra Logics and Mathematical Meta-systems for Meta-Systems Engineering" INCOSE 2002 http://archonic.net

truth leaving out reality. We also find that our philosophical categories are inadequate so we are forced to go beyond Aristotle, Kant and Husserl to a formulation more like that of Ingvar Johansson. Since we have added the mass approach we see that affects our understanding of representations and we need to add the concept of its dual, which is repetition talked about by Deleuze. So the whole cycle from logos, to physus, to order and back again is transformed. And Systems Engineering is at fault for this transformation of our tradition, because it's arrival is in fact an emergent event. It is rewriting not just history but also future possibilities and forcing on us new theories about fundamental aspects of our tradition. It seems that most of the academics and practitioners associated with this new discipline are denying that this arising of a new discipline is an emergent event. But I think that if they look deeply into it this position of denial cannot be maintained for long. It is crucial to get the best possible methods and ways of understanding ever more complex and larger systems into the hands of our practitioners as soon as possible. The force of technological change is leaving us behind. We are attempting to build a new world with outmoded methods and theoretical and philosophical foundations. We need to work on upgrading these foundations as quickly as possible in order to meet the challenge of the future in which Systems Engineering will play an important role.