Integral System Dynamics
A Handout for Integral Sustainability

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Background

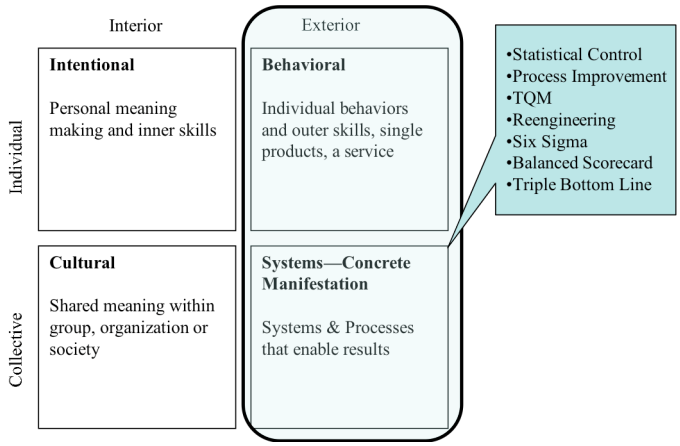
Integral Sustainability practitioners need tools that will help them apply the power of the AQAL model to diagnose and prescribe policies/initiatives that will create more sustainable businesses, institutions, social policy, and environmental health. Most organizations currently use exterior-based tools (It/Its, UR/LR) to determine how well they are achieving their objectives. Most of these exterior-based tools are insufficient. First, they aren't reflective of the exterior – they don't include elements of reality that reflect our current understanding of how the world works. Second, and it's no surprise to Integral practitioners, the tools do not include a comprehensive approach that includes other elements of the AQAL model.

This paper will present system dynamics as one of the more powerful tools for working on the exterior perspective, thus addressing the first limitation. Then I will present how standard system dynamics can be improved to include more of the AQAL model; this is the beginning of developing a theory of Integral System Dynamics (ISD). We will explore areas where other tools will be necessary to supplement ISD. Finally, I'll provide some next steps you can undertake to build your capacity to utilize the ISD approach.

Current Approaches for Working with the Exterior (It/Its)

By definition, exterior dimensions are observable/measurable. Approaches to monitoring and improving those dimensions apply strategies and policies to some form of performance measurement. Some of the more common approaches include process improvement, TQM, reengineering, Six Sigma, and Balanced Scorecards: learning organizations are assumed to apply some portfolio of these approaches. Management gurus tend to "preach" the value of their particular approach, while downplaying the value of others *and* the limitations of their own. Integral practitioners will understand the value of the portfolio (shown in the callout in the diagram), and that for particular situations Process improvement may be far more appropriate

Approaches to Analyzing Exterior Dimensions of Reality



than a balanced scorecard effort in an organization of a particular industry/field, where its leaders "center of gravity" is at a particular stage, and for a particular task (e.g. manufacturing plan). On the other hand, an NGO involved in policies recommending improvements in childhood nutrition may need to rise above the tactical weeds to implement a long-term approach (e.g. balanced scorecard, triple-bottom line accounting) in place.

Underlying all of these approaches are the *mental models* of the organization's leaders and stakeholders. Those mental models are the theories, assumptions and beliefs we use to understand how the world works and to make decisions. And whether they are applied to statistical control, process improvement, or strategy approaches like the balanced scorecard, those mental models often fall prey to common errors we tend to commit when building our mental models.

Common Errors in Mental Models

1. Focusing on events instead of patterns
2. Underestimating (or ignoring) inherent time delays
3. Assuming one-way causality (instead of feedback loops)
4. Not exploring potential unintended consequences to actions

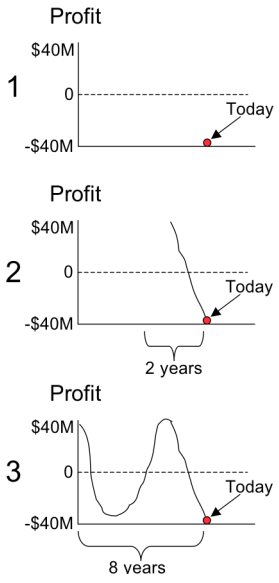
1. Focusing on events instead of patterns

Phrases indicating a focus on events include:

- "Our most effective salesperson just quit!"
- "We just lost our most valuable customer!"
- "The competition just beat us to market with an awesome product."
- "A species we care about looks to be extinct!"
- "Over 100,000 people may have been victims of genocide this year."

These phrases emotionally describe situations that puzzle, perplex—and often frustrate—the leaders and other members of organizations and society. They also demonstrate the power of an event to focus our attention. That attention usually incites reactionary consequences (such as layoffs, reassignments, extra bureaucratic oversight, endless research). However, a different perspective might lead to proactive and preventative strategies.

Three Different Perspectives of Organizational Performance



In the chart at right, note that management could focus on only today (just the current negative profit), the last couple years (a rapid decline in profitability), or the last eight years (a pattern of industry cyclicality). Based upon which of the three perspectives they choose, leaders will take dramatically different actions! With perspective 2, management would be "searching for those responsible." Adopting perspective 3 would lead to "Let's understand industry dynamics and…How can we adjust our organization?" In short, perspective 3 leads to questions regarding organizational sustainability with respect to industry cycles. The power of adopting a pattern-over-time perspective is transformative in guiding the strategies chosen by an organization's leaders!

2. Underestimating (or ignoring) inherent time delays

In many cases, decisions made today take years before they have the desired impact on the organization. For example, we are (now) familiar with how long it takes for CFCs to reach the ozone layer, and then dissipate into space. IT investments represent another well-known time delay. You may put several million dollars into the infrastructure today…it may be two years (and that's optimistic!) before the IT is completely on line. It may be another two years before the staff is trained to effectively utilize 100% of the technology's capabilities.

A more dramatic example of our inability to understand time delays has been demonstrated on thousands of executives, MBA students, engineers, and other really smart folk who've played the Beer Game and have been unable to manage their inventories of beer—even when the retail demand is linear without "noise." Anyone who's played this learning "game" and experienced wild inventory oscillations realizes how time delays inherent in a system's structure contribute to that system's performance.

Ignoring time delays is one of the major contributors to the common dynamic of "worse before better" that occurs when implementing organizational improvements.

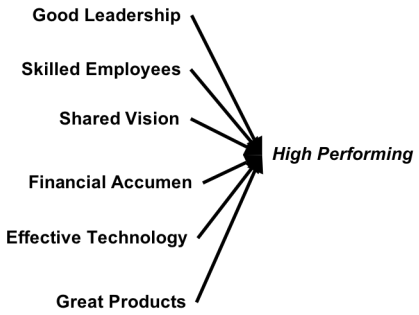
3. Assuming one-way causality (instead of feedback loops)

When asked the question – what creates a high performing organization? – it's easy to generate a one-way causality list such as in the One-way Causality diagram at right. Yes, if you want to be high performing, you need good leadership, skilled employees, shared vision, etcetera and ad nausea. Such lists quickly slip off the tongue: Here are the five essential elements of good leaders, our six critical success factors, the seven…

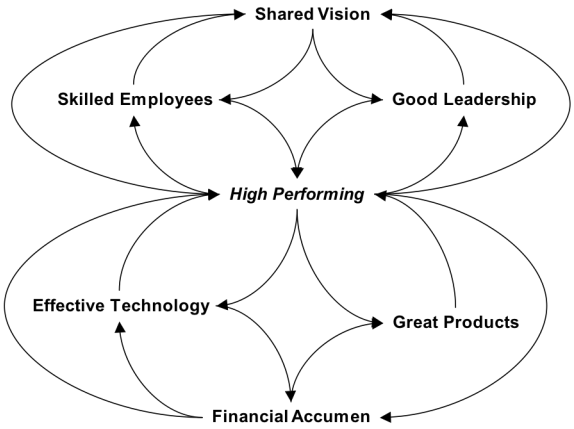
However, reality doesn't work that way. For example, it's probably the case that shared vision results from good leadership (and that financial acumen makes it possible to have effective technology, and several other circular relationships). The Feedback Causality diagram describes several feedback loops that are active in high performing organizations.

What makes a high performing organization?

One-way Causality



Feedback Causality

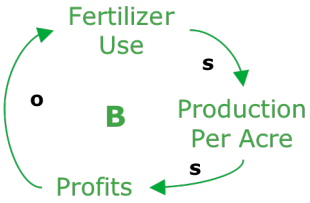


4. Not exploring potential unintended consequences to actions

"To fix this problem, all we have to do is X—no problem!" After this is heard enough times in an organization, employees begin to develop (rightly so) cynicism around overly simplistic

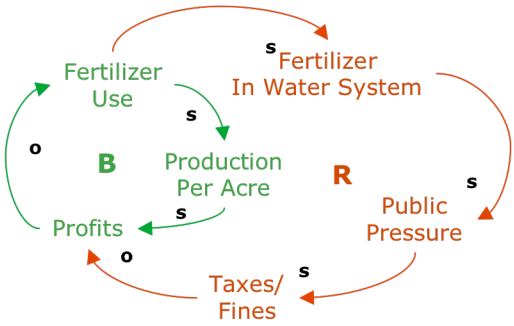
solutions to intractable problems. This is because reality is filled with unintended consequences (and very few "no problems"); and unintended consequences often result from overlooking important feedback loops!

Increasing Profitability
Simplistic Mental Model



In the Simplistic Mental Model at right is a balancing (B) loop works to keep profitability high for a farming industry. If profits decrease, then management can increase fertilizer use (the "o" means that as profits drop, fertilizer inputs go in the opposite direction—up). Production increases…and profits will increase (going in the opposite direction). The Balancing loop works to keep profits up to a comfortable level.

Increasing Profitability
Sophisticated Mental Model (with Unintended Consequences)



However, there are often unintended consequences that accompany such measures. In the more Sophisticated Mental Model picture, another loop is activated: increased fertilizer use increases fertilizer in the water system, increasing public pressure to "do something" and when natural resource managers implement taxes, the result is a *decrease* in profits! The R indicates it's a reinforcing loop, meaning that it tends to go in the direction it's already going. In this case, the unintended consequence is that a vicious cycle gets set in motion: lower profits leads to more fertilizer, which leads to taxes and *lower profits*—and then more fertilizer!

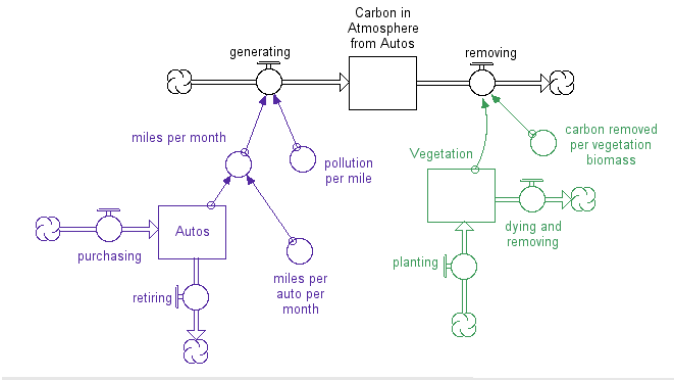
Using a mapping approach (e.g. causal loops or stock/flow maps) will help anticipate and avoid problematic unintended consequences.

System Dynamics

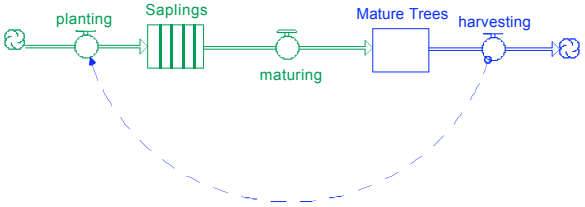
System dynamics (SD) is an approach that addresses the common errors in mental models just described. It is a field that, although first established in the 1950s, has since been applied to almost very other field. SD has been taught in MBA curriculums, applied by the World Bank in international development, used by nuclear scientists at Los Alamos, and implemented by NGOs in the field of sustainability. It can work with any of the exterior practiced described before (i.e. it can improve the mental models of those applying TQM *and* it can be used by national governments implementing a scorecard strategy). Specifically, SD requires a practitioner to utilize four components in building and improving mental models:

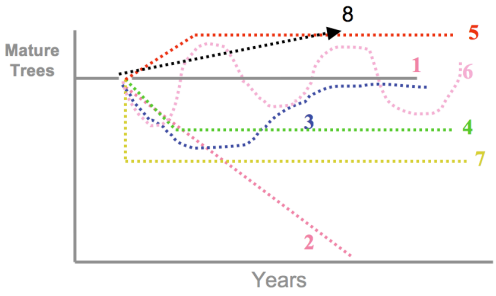
- Systems paradigm
- Visual mapping languages
- Simulation technology
- Scientific method

The systems paradigm (or worldview) includes viewing reality as made up of time delays, feedback loops, non-linearities – described earlier – all which can cause strategies to generate unintended consequences. The visual mapping language most commonly employed is causal loop mapping (also shown earlier), although a more fundamental mapping language is required to build simulations: stock and flow maps. Stock and flow maps more easily build theories of "how things work", and are convertible (via software) into computer simulation models. In the stock/flow map on carbon accumulation in the atmosphere, the stocks (rectangles) represent what's accumulating (carbon, vehicles, vegetation); the flows (pipes) represent activities (i.e. policy intervention points) that change the accumulations. The language creates a very rigorous causal map of how the pieces fit together. And the map can be simulated in a computer.



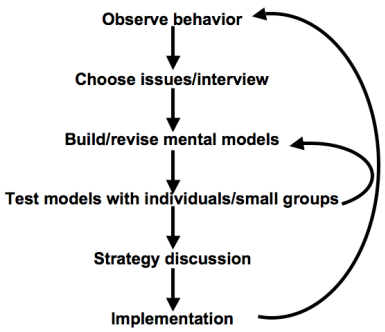
Simulations are an essential component of system dynamics: it is impossible to mentally simulate all but the simplest of models. While humans are very good at building visual relationships (we are great at pattern recognition!), we find it difficult to simulate out the implications of today's actions over wide spatial-temporal bounds (e.g. foreign policy, carbon emissions). In the Mature Trees map, individuals who are asked to simulate the impacts of a





one-time increase will come up with at least eight different predictions; in fact more than 80% will come up with the wrong answer. Recently, when a room of 25 senior engineers from a top-ranked aerospace firm were asked to take the mental simulation challenge, *no one* got the right answer!

Finally, the scientific method is the approach required for building and testing mental models. The process of building mental models is an iterative one: define the issue, generate an initial causal hypothesis, simulate/test with a computer, modify the hypothesis based upon simulation, and iterate until a useful hypothesis remains.



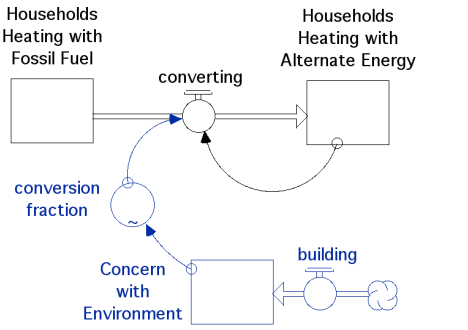
Applying an AQAL Perspective to System Dynamics As Currently Practiced

One strength of system dynamics is its integration of a rigorous visual mapping language with computer simulation. This strength likely makes it the most effective approach for understanding and representing exterior-based elements (systems, policies and infrastructure in the LR). Still, it has several limitations as currently practiced. Applying an AQAL perspective will highlight both the strengths and limitations; some limitations can be addressed by enhancing/advancing current practices, others require integrating/utilizing additional approaches. For the purposes of simplicity, this paper will only focus on a few aspects of AQAL, specifically quadrants, lines, and levels.

Quadrants

Including Interior Variables

Collective Concern for Environment Driving Adoption Rate



Although it is so effective at analyzing exteriors, system dynamics can represent interior dimensions of experience – in particular interior states of both individuals and collectives. For example, variables representing individual and collective morale, motivation, alignment of shared vision, etc…can, *and should*, be included in the analysis. Modelers can even represent individual leadership attributes. This will bring in both interior quadrants (LL and UL). Further, anyone involved in a mapping/modeling activity must remain aware that they, as mapmaker, are contributing to the view in the map – they aren't building models of *the system*, they are building a model of *their perspective* of the issues in the system. What they choose to map/model will be based upon their current worldviews, values, capacities – and what they think is "worth" representing.

Lines/Levels

The *cognitive* and *values* lines are two of the most important lines that influence what a mapmaker will represent with system dynamics. The cognitive line determines the mapmaker's ability to include increasing complexity in their maps: building models spanning several decades, including multiple time delays and feedback loops, and representing global scenarios requires a high level of cognitive capacity[1]. Similarly, what is mapped/modeled is determined by what the mapmaker values (values line): ego-centric individuals will want to primarily model their specific area of expertise while world-centric individuals will show concern for more global variables. Instead of focusing primarily on short-term profits (ethnocentric values), someone who is world-centric will likely want to include triple-bottom line measures (social and environmental).

In fact, it is likely that only certain stages of development will be attracted to system dynamics. Individuals whose center of gravity is in the Expert/Achiever stages in Suzanne Cook-Greuter's leadership development profile usually find system dynamics attractive. They see it as a tool that

[1] Thomas et al, Levels and Lines of Strategic Thinking—An Integral Approach, 2006, Integral University Business and Leadership Center

can help them "control and predict" future situations, and to create high performing organizations or effective social policies. Analytical thinking Achievers are attracted by the ability to apply engineering principles to social situations by building simulations. Individualists, on the other hand, are easily "turned off" by this control-oriented approach, and are likely to reject the system dynamics approach as limiting. For the above reasons, there are two camps of individuals who have emerged from the Learning Organization field (described in *The Fifth Discipline* by Peter Senge, a system dynamicist): 1) those who gravitate toward system dynamics and ignore the other disciplines (people-oriented, "soft"), and 2) those who ignore system dynamics and embrace the softer disciplines. Those at the Strategist stage (and beyond) are able to see the merits of both camps.

Relating Levels of Cognitive Development to System Dynamics

Low: Individuals with low cognitive development primarily think in concrete, rather than abstract terms. They exhibit less facility with abstract thinking tasks such as comparing strategic options. Regarding strategic thinking, people with low-level cognitive proficiency may create a simple tactical plan of action, but likely lack the abstract thought and innovative thinking needed to develop comprehensive long-term strategies. Any cause/effect hypotheses will likely be linear, and include only very close to their daily experience. Accurate self-reflection may be difficult, and introspection is uncommon except after major setbacks from a heavy disappointment, failure, or loss. They may be unable to reflect upon their own thought patterns and belief systems and tend to perceive the world unambiguously in terms that match known rules. They are typically resistant to and have difficulty integrating information incompatible with their held views. Their thinking is strongly affected by the opinions of authority figures.

Medium: People with medium level cognitive development engage the rational mind in thought operations performed on abstract objects such as selecting strategies among many options. Those at this cognitive level largely base their thinking and perception on reason and logic, evaluating varying ideas for compatibility with observable facts. Pattern recognition is more complex and abstract at this level; the person is more aware of direct causal relationships and consequences. Such individuals can develop strategic, long-term perspectives, which they convert into tenable plans containing fairly innovative strategies.

High: A high cognitive level provides for a complex combination of reason, context, and intuition that integrates and synthesizes thought operations and easily accommodates opposing viewpoints. Those at this level assume complexity and ambiguity, enjoy hearing alternative viewpoints and welcome seemingly incompatible perspectives as an opportunity to gain deeper understanding. The increased complexity of their pattern recognition skills allows them to discern subtle relationships beyond simple cause and effect, and to intuit far-reaching consequences. Those at this level tend to exhibit great complexity of thought and are able to design sophisticated yet elegant interdependent strategies.

System Dynamics Skills

We have already explored how the mapmaker (aka modeler) will influence what maps/models they will build – their stage of development along the cognitive and values lines will determine what they *can build* and what they *want to build* respectively. The following table presents these skills in more detail…and separates into skills associated with steps in the system dynamics process.

Skillset	*Specific Skills (how they are implemented will change as modelers develop across stages)*	*Useful Tools*
1. Identifying issues	❑ Getting out of the weeds ❑ Characterizing issues/problems as behaviors over time ❑ Defining a purpose ❑ Drawing system boundary	• Behavior Over Time Graphs
2. Mapping systems & processes	❑ Building Stocks and Flows Maps ❑ Identifying and Representing delays and inertias ❑ Mapping feedback loops ❑ Incorporating Non-physical concepts	• Stock/Flow Maps • Causal Loop Diagrams (CLDs)
3. Generating and testing solutions	❑ Using maps to identify potential policy levers ❑ Applying prototypical systems stories ❑ Identifying Unintended Consequences ❑ Using computer simulation models to build understanding	• Computer Simulation
4. Communicating & disseminating system insights	❑ Using stock/flow maps & models to facilitate group discussions ❑ Applying pre-built models to specific issues	• Storytelling Presentations • Learning Labs • Management Flight Simulators

Toward Integral System Dynamics

The integral system dynamics methodology is still in its formative stages; we are only now seeing how Integral theory sheds light on the limitations of system dynamics as it has been practiced over its fifty year history. Still, there are several guidelines that, if followed, will move standard system dynamics toward the potential of what a "fully integral" system dynamics could produce. Here are some of those guidelines.

1. Map issues, not systems

It's tempting to try to build a map/model of the system you wish to improve. People at earlier stages of development are prone to approach. The problem is that all models are necessarily simplifications of reality – and can by definition never equal the system. Integral practitioners will enter into the mapping/modeling process not to model every piece of the system, but rather to generate a set of assumptions that are the most useful when trying to explain what's happening and what might be done about it (with regard to a very *well-specified problem statement*).

2. Remember the mapmaker is inseparable from the map – maps are only mental models

Another guideline closely related to number 1 is to remember that maps aren't The Real World—they represent the mapmaker (his/her filters—which portions of the AQAL model they use; their levels of development, states, types, etc…). Build a variety of models. Discuss them. Use the process as a way of self-reflection as much as one of trying to understand the issue. What does the map I'm making tell me about where I am now? About the team that's building it? Etc…

3. Build the skills of mapping and simulating to issues ranging from tactical (daily focus) to high level strategic (decades focus)

In the beginning of this paper, I described how there are several approaches (e.g. process improvement, balanced scorecards) used to understand exterior phenomenon. The system dynamics approach can work for all of them! So, when trying to understand a process (usually a very tactical activity) you can use the system dynamics language of stocks and flows to map that process; and you can use simulation to test the impacts of any improvement initiatives. Similarly, you can use the mapping language to build Kaplan and Norton's strategy maps, and then create a dynamic scorecard with simulation software[2].

4. Apply the quadrant perspective – Include non-physical (interior) variables in the maps and models

The process of building formal organizational models (described more in depth shortly) to describe organizational performance often includes the warning "let's only include those things we can measure." Integral practitioners understand that the full range of experience matters, and that representing the interior perspective is essential to building understanding and for generating improvements. Include morale, burnout, trust, customer satisfaction, strategic alignment, level of cognitive ability, and other variables in maps/models.

5. Focus on a LL approach to build – use a process of group confidence-building to generate buy-in

By including multiple stakeholders from across "the system" in building the map/model, you will more effectively include other AQAL perspectives. First, you will ensure that more *typologies* are represented in the final "collective mental model." You can engineer the process by including different typologies if you know a particular typology across the stakeholders (e.g. Myers-Briggs, DISC, etc…). Second, a model can be developed to include an interface and a process that will allow learners with different learning styles (auditory, visual, kinesthetic) to experience the model to best impact their learning.

Third, the process of building a model and simulating it can often create "state" experiences that lead to transformative learning. When individuals/groups wrestle with scenarios they haven't thought of before, or come into contact with parts of the system they have been unaware of – the U-process (Scharmer & Senge) creates such situations – individuals/groups often transcend their current state and "see" things anew. These state experiences can fundamentally change the insights derived from modeling. Further, they can lead to individuals developing to higher stages of consciousness.

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[2] "Bob Kaplan and I have long believed that Dynamic Systems Simulation would be the ultimate expression of an organization's strategy and the perfect foundation for a Balanced Scorecard. …We have long been frustrated with the slow pace at which executives have embraced system dynamics. The strategy map approach, however, has created momentum. Strategy maps fall short of a true description of reality….they don't address time delays and feedback loops. However, they do force executives to make explicit their assumptions of causality. They do, then, provide a framework to test these hypotheses." In 2001, Norton, David, wrote this in a response to the article *A New Language for Leveraging Scorecard-Driven Learning*, Balanced Scorecard Collaborative, Harvard Business School Publishing, 2001

Summary

Although our understanding of Integral System Dynamics is only in its early stages, we do know that the approach shows great potential. System Dynamics is without question an extremely powerful tool for working with the exterior (It/Its) dimensions. It can be integrated with nearly all other approaches to exterior analysis. It can be enhanced into Integral System Dynamics by including interior dimensions and by understanding how to apply the AQAL model to both the analysis and the analyzers. By building skills in Integral System Dynamics and Integral theory, practitioners can increase the likelihood that their recommendations will lead to more sustainable solutions in today's complex world.

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