ESD.84 Doctoral Seminar – Session 3 Notes
Guests Presenting: Joel Moses, John Sterman

Draft Session Design:

9:30 Welcome and Overview
9:40 Opening dialogue based on Internal Symposium articles by Joel Moses and John Sterman
10:00 Book Review by Jeroen Struben -- L. von Beralanffy, General Systems Theory (1968)
10:15 Presentation and dialogue led by John Sterman: Systems Thinking – Lessons from Systems Dynamics
11:00 Break
11:15 Presentation and dialogue led by Joel Moses: The Role of Systems Thinking in the Field of Engineering Systems
12:00 Exercise on methods associated with measuring degrees of uncertainty and degrees of complexity or Student presentation by Ozlem Uzuner on: Segmented, Hierarchical, Linear Thinking and Other Alternatives to Systems
12:30 Adjourn

Comparison of articles from internal symposium:

- The two papers complement each other – quasi-static structure or architecture of systems on the one hand and dynamics in the system on the other
- Both are concerned with networks and algebra
- Key issues around scoping the systems – knowing the architecture allows us to know what the boundaries are for a system
- Is the fundamental unit of analysis a structural component or an interactive "loop"?
- What is the difference between control theory and systems dynamics? Control theory does push into the non-linear domain, so it is pushing against the boundary of classical engineering science. Control theory is more focused on the solution as compared to the dynamic – the mathematics are similar. Large difference between devices versus human systems.
- Key point is that the building blocks in systems dynamics are people who have intention and a project orientation.
- Can you look at systems dynamics such as feedback and over-control and link them to structures that have robustness and flexibility
- The classic engineering approach is reductionist – some of the classification of components risks looking that way, but principles such as flexibility are not reductionist
- Joel Moses is presenting more of a systems architecture view – it is not clear how this works with intentional agents
- Contrast between network and tree structures
- Intention has to be interpreted in context – it is not modeled explicitly or independently in either approach
- Is there a parallel to the human genome project?

Book Review by Jeroen Struben -- L. von Beralanffy, General Systems Theory (1968):

- Beralanffy as a highly influential thinker point to more organic rather than mechanistic approaches to biology and other fields
- Overall tendency toward integration across fields and disciplines
- Concept of unity of science – not a pointing toward a single integrative theory, but multiple complementary theories sitting side by side
- Open systems theory is a key contribution
- Concept of steady state maintenance of a system
- Concern with regulative capacity within a system – drawing on then emerging field of cybernetics
- Focus both on experimental and theoretical approaches
- Observation that he seems to be constantly drawn to small units – such as cells in an organism
- This is a complex book – but the presentation is very readable
- Underlying ideology around the value of general systems theory for society as a whole

Discussion:

- The context of this is an apex of optimism around the value of an open systems approach
- Concept of information entropy
- Contrast between discreet bits of information versus flows of information
- Historically the enthusiasm for general systems theory was high, but it didn't go anywhere – beyond concepts of open systems, equifinality, etc.
- Biological models are not a useful foundation because it is not oriented to designing from scratch or tampering with a system (issues of flexibility, robustness, etc.)
- Biological models are also insufficiently transformative
- Interestingly, biology also struggled with the limits of an open systems approach and has made more progress drawing on more of a physics approach
- Note the poor track record of engineers and others when we interact with natural systems
- Intentionality is a common thread – as well as issues of time horizons, which are very different in biological versus social systems

Presentation and Dialogue with John Sterman:

- Fundamental limits of our mental models in comparison to the attributes of systems
- Structure of the system generates behavior – yet attributions to people's characteristics rather than to their circumstances
- Winston Churchill comment on the house of commons – we shape our buildings and then our buildings shape us
- Almost nothing is exogenous – the habit of mind of "closing the loop" to see how we impact what we think is exogenous
- What needs to be different in the way people are trained and in the way they interact to build more of a systems perspective?
- Leaning lots of formulas and equations, but not basic intuition on stocks and flows, feedback and other key concepts
- All decision are based on models and all models are wrong
- The key discipline is to make explicit latent assumptions built into a model
- Issue of markets that create unintended consequences – such as common goods (fisheries, etc.) – caution against panacea solution grounded in an ideology
- One of the hardest things to do is to scope the problem – the real power of systems dynamics is in driving a more disciplined thinking about the nature of the system

Presentation and Dialogue with Joel Moses:

- Bias toward maximizing theories of engineering systems
- Dialogue on the impact of background in electrical engineering versus background in mathematics and computer science – as an example – for approaching engineering systems as a field (emphasis on control systems versus emphasis on structure)
- Role of a life-cycle perspective on product design – to anticipate early the cost of later changes (70-80% of cost of software to the company happens after product completion and launch)
- Life-cycle perspective points to more of a platform approach
- Theories of systems do not focus sufficiently on the properties of systems – example:
    - Robustness – well developed in various engineering fields
    - Flexibility – opportunity for ESD
    - Safety – opportunity for ESD
    - Sustainability – opportunity for ESD
- Additional key concepts: complexity, uncertainty, architecture
- Software provides us with special purpose languages to create new states – such as the concept of a spreadsheet program – rules provide flexibility
- De Neuffville and Hastings are looking at a different view of flexibility – assuming it is possible to specify options a priori – as contrast to allowing for unknown options
- Tree structure – hierarchy – versus a layered approach – a different type of hierarchy – versus a network – which is non-hierarchical in principle, but can become that way as a result of hub and spoke dynamics
- Physical, energy oriented systems are highly interconnected and not easily addressed in a modular way – in contrast to engineering systems which can be addressed in more of a modular way
- Reductionism versus holism
    - Breaking problems into component parts versus treating the problem as a whole
    - Aristotle versus Plato – Logic (binary thinking) and scientific method for classification versus the just society as a layered society with chances for self-improvement
- Engineers need to be both reductionistic and holistic
- Contrast of reductionist tendency in the U.S. versus the holistic tendency in Japan versus the middle-ground in Germany
- Logic:
    - Discrete objects
    - Combinatorics
- Holistic approach:
    - Abstract algebra – sets and extensions among sets – an abstract, expressive meta-language
- Call for a particular kind of systems thinking: Systematic and precise about holistic phenomena

Additional dialogue on what we know about systems thinking:

- Mental models are limiting and enabling
- Abstract algebra may allow us to rise above the limits of our mental models – importance of compact language
- Concept of layering and social justice are common themes
- Communication engineers take a horizontal approach instinctively – because you can't approach the communications issues otherwise
- The most efficient system is less likely to be flexible – so there is likely to be a trade-off between efficiency and flexibility
- Need for periodic adjustment in the language or other governing structures