Palisade 2012 Risk Conference

Smart City Orchestration via Integrated Decision Analytics

DAY 1   15:00 Wed. April 18th 2012 – Waterloo Room, IoD, London

Palisade EMEA
2012 Risk Conference

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A Play in Four Acts

Act I Introducing characters

a) Smart City
b) Sustainability
c) Complex systems
  - Technical infrastructure
  - Markets & behavioral economics

Act II Complication…

– Increasing complexity…
– Narrow analytics causing chaos to reign supreme!

Act III Action!

– Demonstration via Palisade Decision Suite v6 beta

Act IV Resolution

– Principles of integrated analytics

Epilogue

– Organizational valorization

Act I

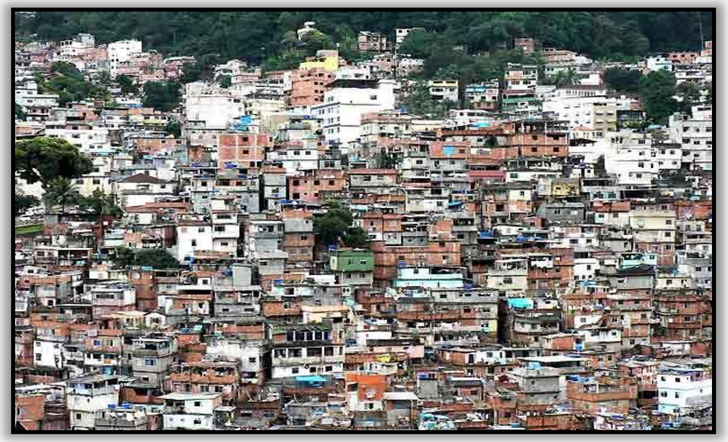
Cast of Characters

A. Smart Cities
B. Sustainability
C. Complex systems

A. Motivation: Why 'Smart Cities'?

2010
- ~50% (3.5 of 7B) living in urban areas*
- Rapid urbanization in emerging nations

2030
- ~60% (5 of 8.3B) will be living in urban settings ~



- **Dickensian byproducts**
  - Environmental degradation
  - Slums / labor exploitation
  - Sewerage & water quality
  - Disease & pandemics

2050
- ~70% (7 of 10B) of globe in urban settings ~

- **Urbanization**
  - From rural to economic opportunity
  - Energy ladder
    - firewood, dung, diesel, batteries, grid
  - Food ladder
    - subsistence, staples, meat, processed, fast

* *United Nations Population Fund (www.unfpa.org)* ~ *UN Department of Economic and Social Affairs*

A. Failed Cities

- **<u>Biblical & ancient</u>: political**
  - Moral judgment
    - Babylon, Sodom & Gomorrah
  - Disaster - Atlantis (apocryphal)
  - Socio-economic implosion - Rome
- **<u>Disaster</u>: failed infrastructure**
  - Flooding - New Orleans
  - Water management - Brisbane
- **<u>Market collapse</u>: macro-economic crisis**
  - Economic - Detroit
  - Overgrowth – Calcutta, Delhi
- **<u>Collapse:</u> ecological collapse**
  - Warfare & disease - Mayan & Aztek
  - Environmental change - Anasazi
  - Ecological collapse - Easter Island
  - Overexploitation – Greenland Norse
- **<u>Dystopian</u>**
  - Blade Runner, 1984, Brave New World

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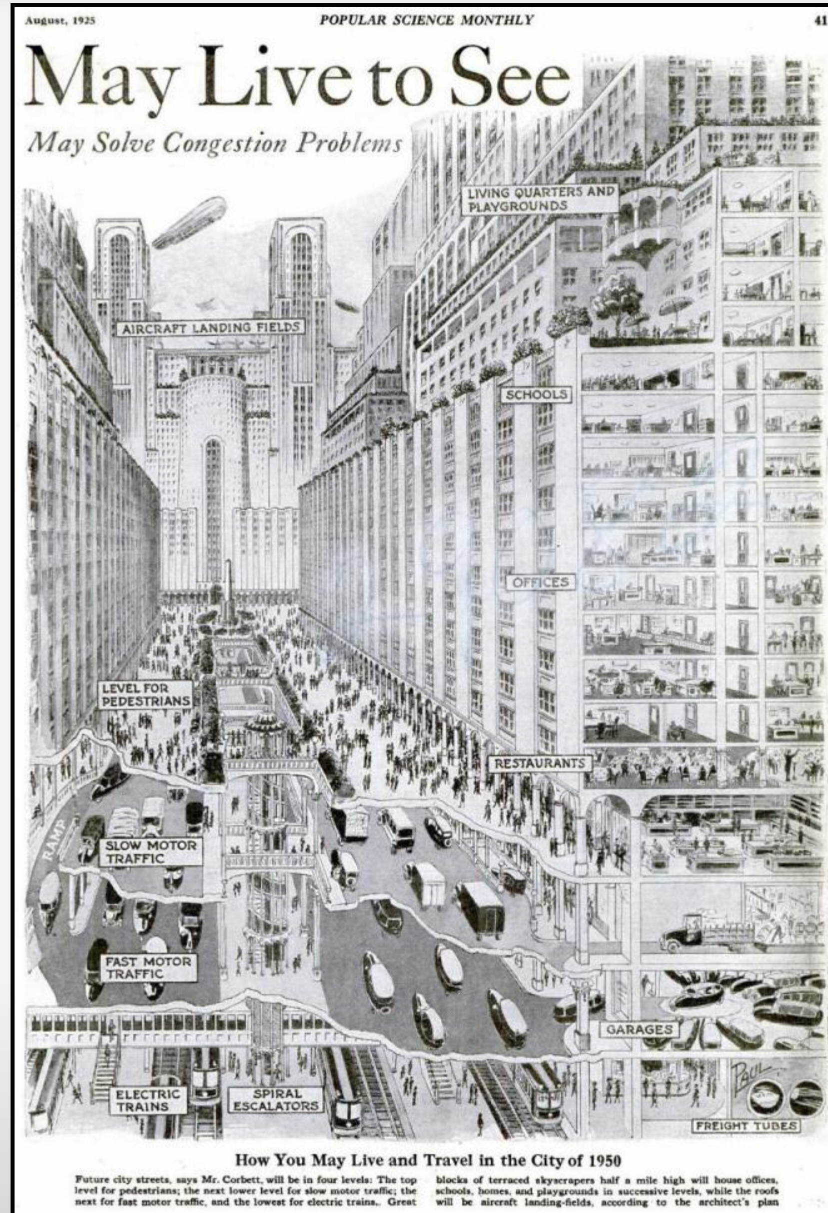
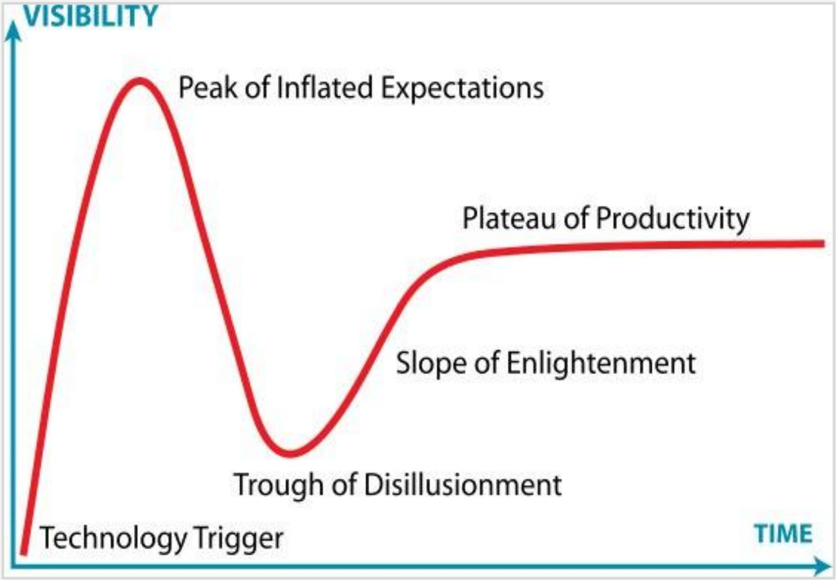
A. Techno-Utopianism

- **City on a Hill**
  - ‘Kingdom of God’
  - Social idealism
  - Enlightenment project
  - Architecture & morality
- **Science Fiction**
  - Atlantis & Shangri-La
  - Technology as vehicle



A. What's in a Name? What do we mean by 'Smart'?

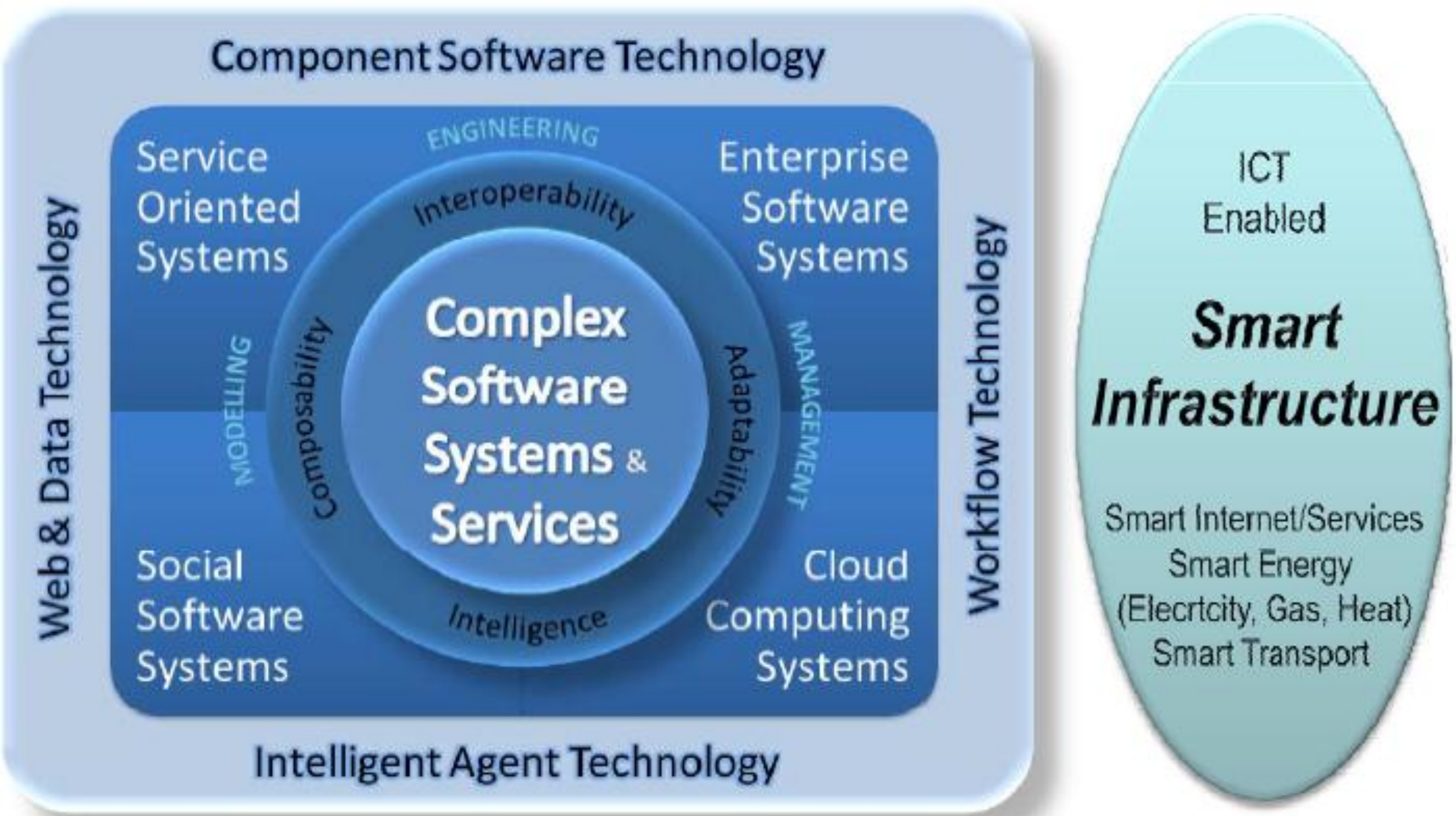


Gartner 'Technology Hype Curve'

- **Marketing hype?**
  - Science fiction futurism
  - Gartner 'Hype Curve'
  - 'Greenwashing'
  - Tokenism
  - Austerity measures

- **Reality?**
  - Technical convergence
  - Cloud / 'Internet of Things'
  - Embedded sensor networks
  - Advanced analytics / Big Data
  - 'Nudge': socially aware design
  - Developing implementations

A. Smart Infrastructure

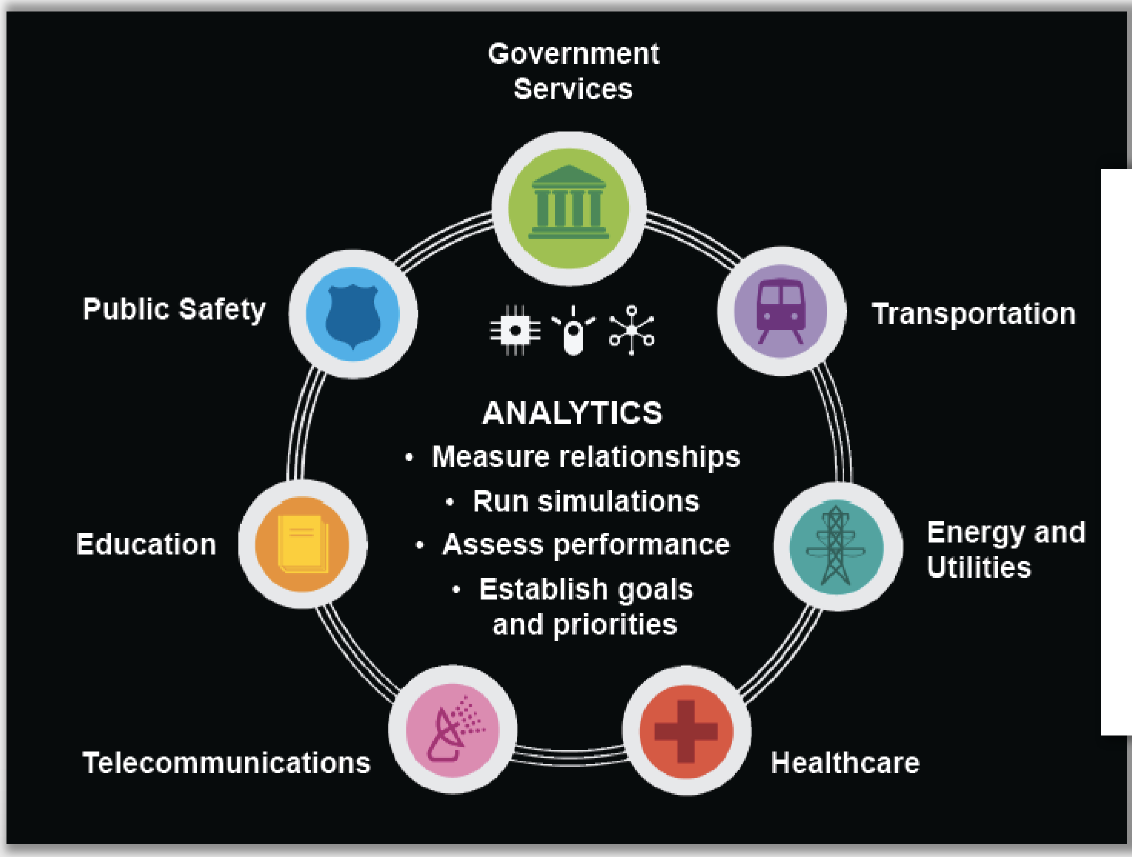


> Complex Software Systems ► ***Large-scale distributed systems***

- formed by a collection of many interacting software entities (components, sub-systems, systems)
- operating in heterogeneous, dynamic and decentralised environments

Kowalczyk, R. Enabling Smart Infrastructure with Intelligent Agent Technologies. www.cetinia.urjc.es/en/node/382

A. IBM's Smarter Planet Architecture



Amini, L. 2010. The Role of Technology in the Transformation to Smarter Cities. IBM Corporation.

A. Smart City Working Definitions

"The use of Smart Computing technologies to make the critical infrastructure components and services of a city—which include city administration, education, healthcare, public safety, real estate, transportation, and utilities—more intelligent, interconnected, and efficient."

Washburn, D., Sindhu, U., Balaouras, S., Dines, R. A., Hayes, N. M., & Nelson, L. E. (2010). Helping CIOs Understand "Smart City" Initiatives: Defining the Smart City, Its Drivers, and the Role of the CIO. Cambridge, MA: Forrester Research, Inc. Available at http://public.dhe.ibm.com/partnerworld/pub/smb/smarterplanet/forr_help_cios_und_smart_city_initiatives.pdf.

A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens.

Hall, R. E. (2000). The vision of a smart city. In Proceedings of the 2nd International Life Extension Technology Workshop (Paris, France, Sep 28). Available at http://www.osti.gov/bridge/servlets/purl/773961-oyxp82/webviewable/773961.pdf.

An instrumented, interconnected, and intelligent city. *Instrumentation* enables the capture and integration of live real-world data through the use of sensors, kiosks, meters, personal devices, appliances, cameras, smart phones, implanted medical devices, the web, and other similar data-acquisition systems, including social networks as networks of human sensors. *Interconnected* means the integration of those data into an enterprise computing platform and the communication of such information among the various city services. *Intelligent* refers to the inclusion of complex analytics, modeling, optimization, and visualization in the operational business processes to make better operational decisions.

Harrison, C., Eckman, B., Hamilton, R., Hartswick, P.,
Kalagnanam, J., Paraszczak, J., & Williams, P. (2010).
Foundations for Smarter Cities. IBM Journal of Research
and Development, 54(4). DOI: 10.1147/JRD.2010.2048257.

Emerging Smart Systems Applications…

Bleeding edge…

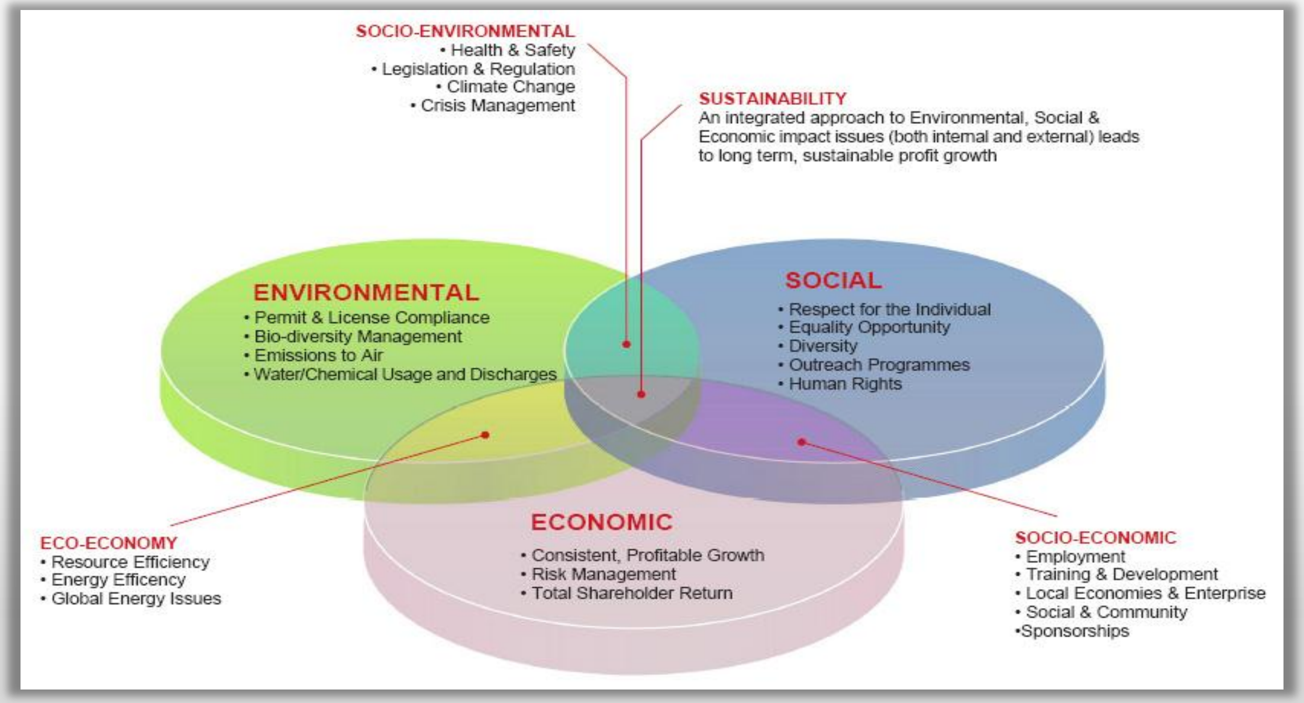
- Military drone network orchestration
- Military campaigns & provisioning
- Intelligence & security networks
- Cloud Computing infrastructure

Active Smart City associated…

- Smart Grids (electricity networks)
- Water management (i.e. Dutch flood management)
- Waste management (i.e. smart sewerage treatment)
- Transport networks (i.e. train & highway optimization)
- Oil & gas pipelines
- Advanced supply chain management (i.e. Walmart)
- Telecommunication networks

B. What is ‘Sustainability’?

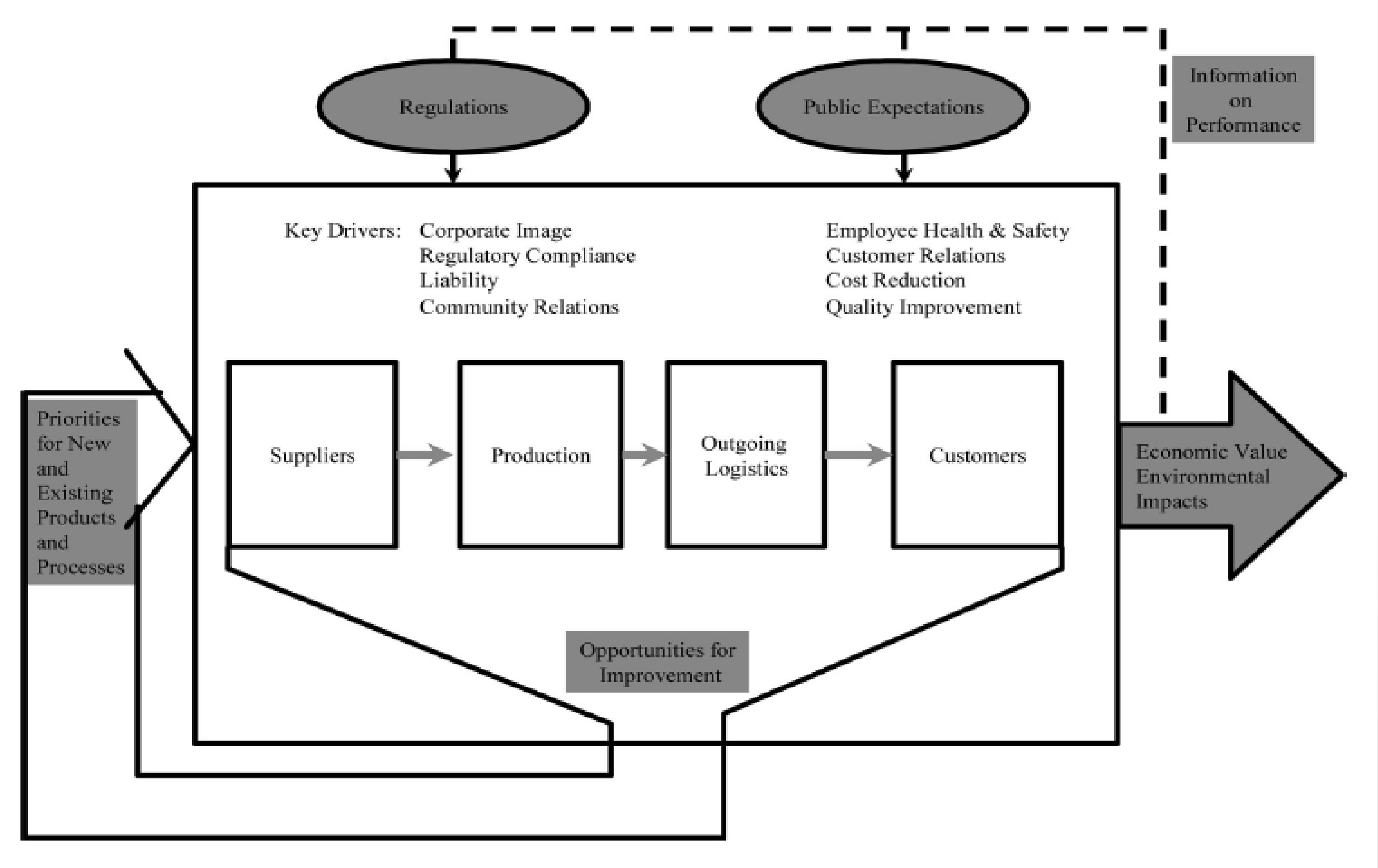
- **Austerity => conservationism populism?**
  - Malthusian scenarios (millennialist in nature)
  - Regulatory distortions & ‘tragedy of the commons’…
  - ‘Greenwashing’ and tokenism?
- **Market profit maximization!**
  - Multi-stakeholder, multi-criteria ‘satisficing’ of broad profit motives
    - ‘How to Measure Anything’ D. Hubbard www.howtomeasureanything.com
    - ‘Natural Capitalism‘ - P. Hawken, A. Lovins, L. Lovins www.natcap.org



Staff, V. T. L. (2008). "Sustainability - The Solution Matrix." Retrieved December 3, 2011, 2011, from http://www.verifysustainability.com/Pie%20Diagram/PieDiagram_Open_Page.aspx.

B. Sustainable Supply Chains

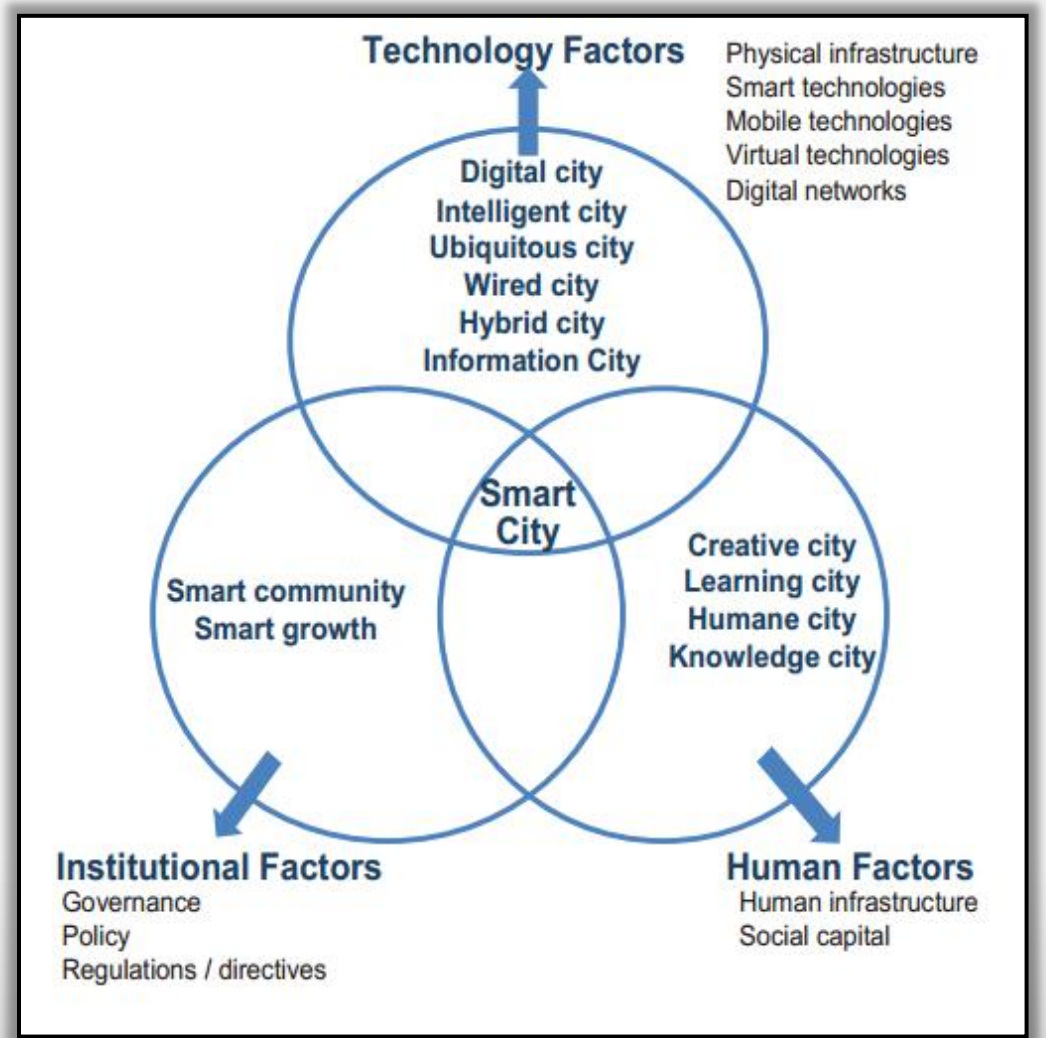
- **Advanced technical supply chain management outpacing understanding of macro-systemic effects**
  - **+** *Commercial*: WalMart, NetFlix, Amazon, Dell, Zara
  - **-** *Resource*: Enron, U.S. Housing Crisis, trading scandals



Kleindorfer, P. R., K. Singhal, et al. (2005). "Sustainable Operations Management." Production and Operations Management **14**(4): 10.

Smart City: Complex System Optimization

- Multi-stakeholder
- Multi-criteria utility optimization
- Emergent hybrid technology solutions as mediator
- Advanced analytics as facilitator



Nam, T., Pardo, T. Conceptualizing Smart City with Dimensions of Technology, People, and Institutions. The Proceedings of the 12th Annual International Conference on Digital Government Research.

Review: Smart Cities => Complex Analytics

- ***Smart Systems*: emergent hybrid technologies**
  - networked infrastructure that…
  - uses sensors and communications technologies…
  - to better utilize or sustain resources via analytics…
  - addressing a broad notion of efficiency or optimality
- ***Multi-Stakeholder*: multi-criteria interests**
  - each of whom evidence bounded rationality…
  - and autonomy in striving after incentives…
  - whom together result in a ‘market equilibrium’
- ***Complex systems*: management** *
  - Orchestration (not control)
  - Dynamic stability (not formal equilibrium)
  - Shifting ‘regimes’ of stability & volatility
  - Emergent behavior presages phase-changes

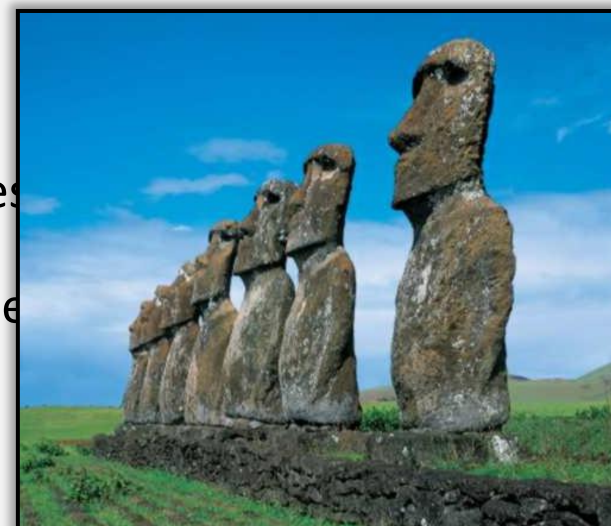
** Otherwise less represented in ‘Smart City’ research*

Act 2 – Complication: Rise of Complex Systems

- Complexity
- Poverty of insight
- Ourselves…

Collapse: J. Diamond

- **Factors**
  1. Key resource exhausted
  2. Environmental/climate change
  3. Relations with partner societies
  4. Relations with hostile societies
  5. Political, economic, cultural, socials factors

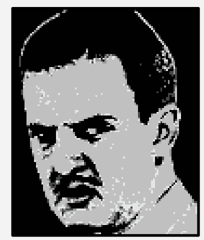


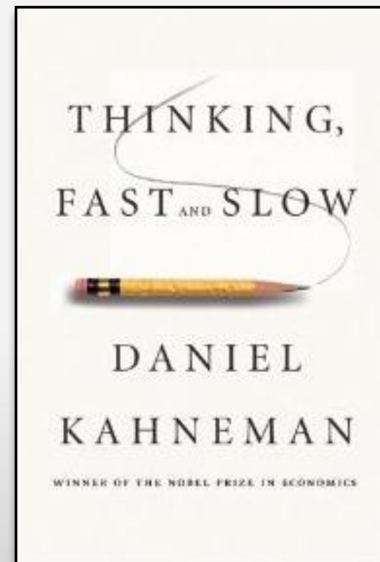
- **Why did they not see?**
  - 'Boiling frog' syndrome
  - Conflict of interest: short-term interests of elites long-term health of broader society
  - Factors are multiple: can not solve just one, nee address complexes
  - First & second order derivatives of function
    - i.e. not 'wealth', but functions
- **Once and future crisis**
  - Dickensian conditions of industrial revolution Britain
  - Legacy of Liberal Industrial Capitalism
  - How to prevent the decent into great human & environmental costs?

Decision Making Behavioral Biases

- **We are ‘boundedly rational’**
  - We suffer incomplete information
    - Information is ‘expensive’
    - There is more & more of it (sorting costs)
  - Prone to particular cognitive ‘biases’

- **Two decision making systems**
  - **System 1**
    - Fast & emotion/impression driven
    - Often priming us unconsciously
    - Often effective, but can mislead
    - Stories: *“The bitter butler stole the money!”*
  - **System 2**:
    - Slow & deliberate
    - Checks, but susceptible to System 1 biases
    - Fact assessing: *“There has been a cash shortfall”*

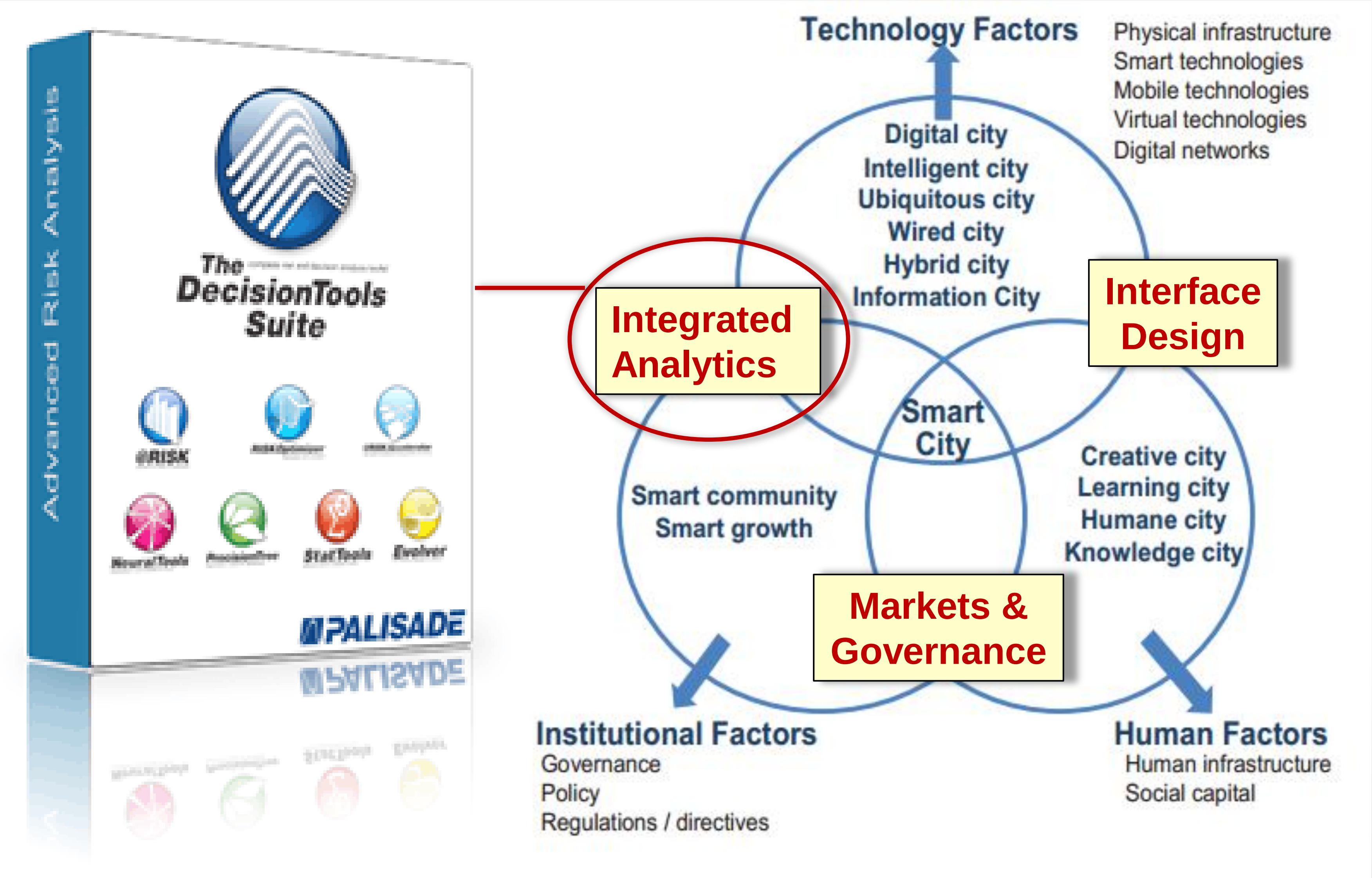




Smart City: Complex Techno-Economic Phenomenon

- **Cities are 'complex' systems (beyond 'complicated')**
  - Evidence unpredictability / volatility
  - Long-term prediction difficult (i.e. weather & stock market)
  - Emergent behavior (unexplainable behavior via interactions)
  - Sensitive in periods of non-linearity (small effects = large perturbations)
  - Require redundancy, safe-guards, emergency procedures…
  - Border between **discrete** and **continuous systems** views
- **… connect to larger human behavioral systems**
  - Supply / Demand decision making
  - Market trading / purchasing dynamics
  - Consumer behavior (i.e. commuters on transport network)
- **… aggregate probabilistic aspect**
  - Requires intensive data analysis
  - Susceptible to trends analysis & forecasting
  - Multi-system analysis & optimization

Smart City: Revised Definition



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Act 3 - Action!

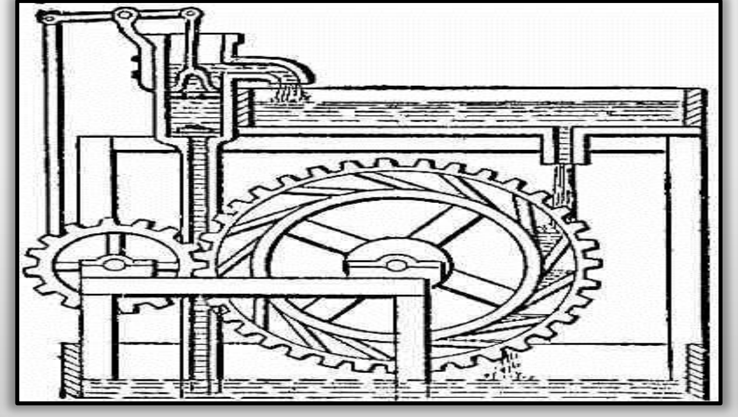
Enter Advanced Analytics

- Integrated analysis
- Sophisticated analytic tools

Palisade Decision Suite

TOOLKIT…

- Simulation
- Sensitivity analysis
- Optimization
- Correlation
- Econometrics
- Decision Trees
- Real Options



PALISADE DTS

- @Risk
- PrecisionTree
- NeuralTools

- StatTools
- Evolver
- TopRank
- RISKOptimizer

EXAMPLE USES

- **Supply chain optimization:** electricity
- **Market price uncertainty:** heating oil
- **Cost control:** staple foods
- **NPV:** infrastructure projects (Olympics!)
- **Risk Management:** flood protection
- **Optimization**: transport networks
- **Commodity uncertainty:** fuel supply

Smart City Advanced Analytics

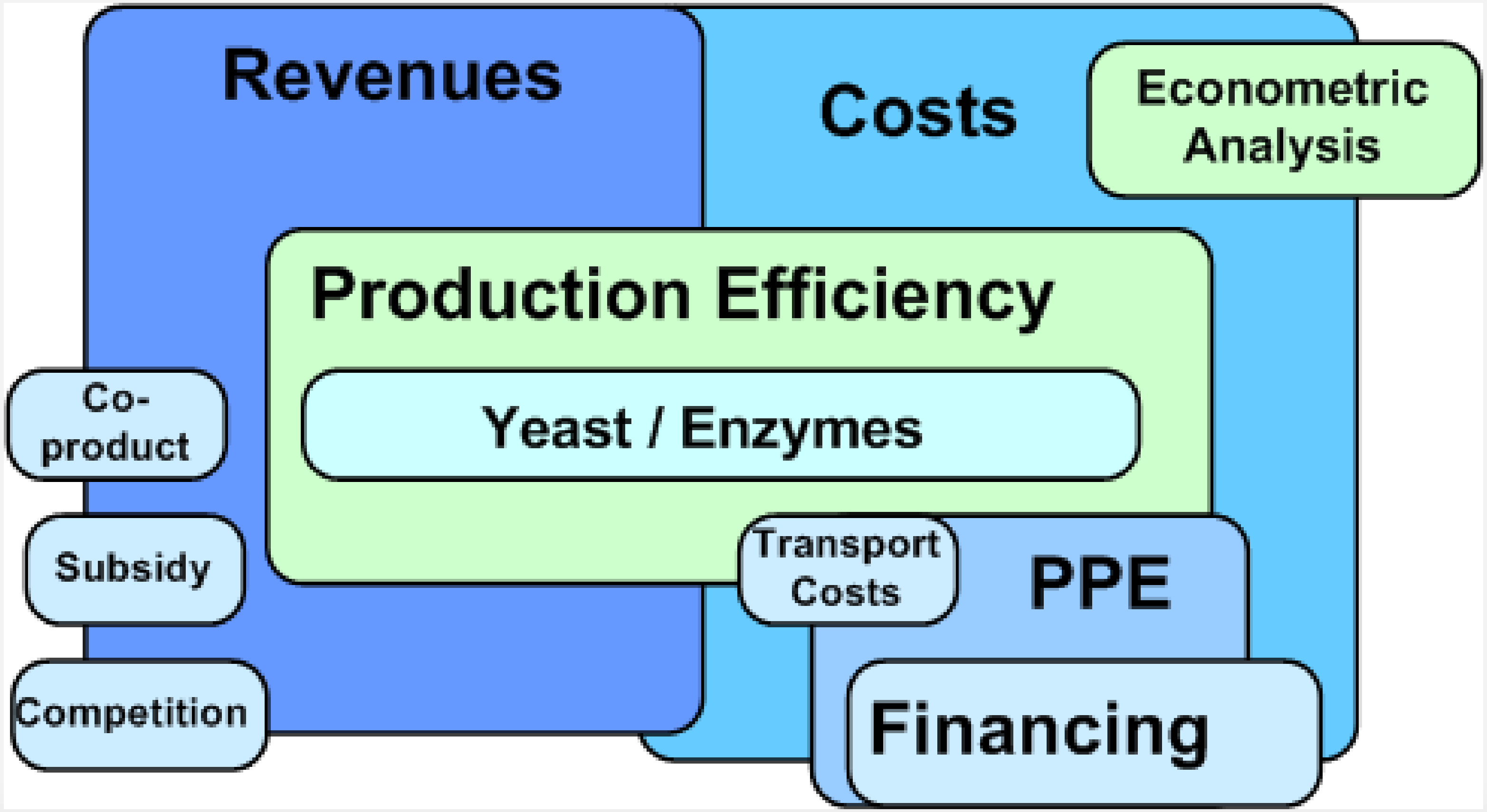
- *Analyzing & optimizing complex systems*
- **Context of 'sustainability'**
  - **Technical**: optimization of infrastructure
  - **Economic**: market structures / regulations
  - **Behavioral**: institutional & consumer decision making / games
- **Smart City Optimization**
  - **Technical operation of physical infrastructure**
    - Optimization, investment decision making
  - **Economic analysis**
    - Market price optimization, optimal market design, regulatory design
  - **Behavioral**
    - Supply chain management (i.e. Bullwhip effect), consumer / citizen behavior (book: *Nudge*)

Case 1: @Risk - Economic Behavioral Simulation

- *Hippo.xls*
- *Included example in installation*
- Market competition simulation
  - Mrkt size
  - Usage per Hippo
  - Chance of competitor entering market
- NPV distribution result

Pigco			
Price	$ 2.20	Compet %age	0.2
Unit Var Cost	$ 0.40	Year 1 Market Si	1000000
Interest Rate	0.1	Year 1 worst sha	0.2
Entrant Prob	0.4	Year 1 most likel	0.4
		Year 1 best shar	0.7
Year	1	2	3
Market Size	1000000	1050000	1102500
Use per hippo of our drug	0.433333333	0.346666667	0.277333333
Competitors (beginning of year)	0	1	2
Entrants	1	1	0
Unit Sales	433333.3333	364000	305760
Revenues	$ 953,333	$ 800,800	$ 672,672
Costs	$ 173,333	$ 145,600	$ 122,304
Profits	$ 780,000	$ 655,200	$ 550,368
NPV	$2,435,545		

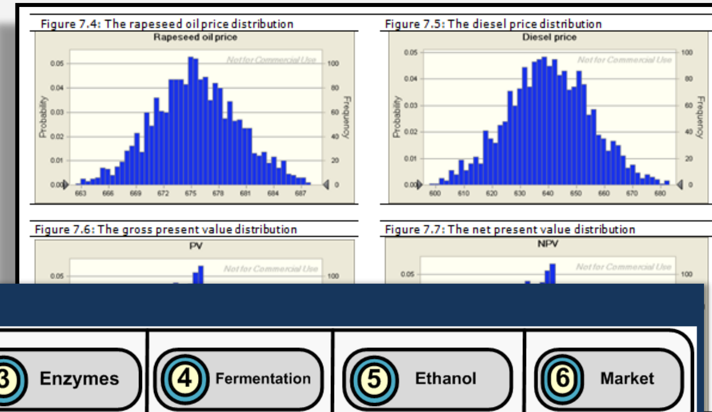
Case 2: @Risk - Biofuel Technical Production

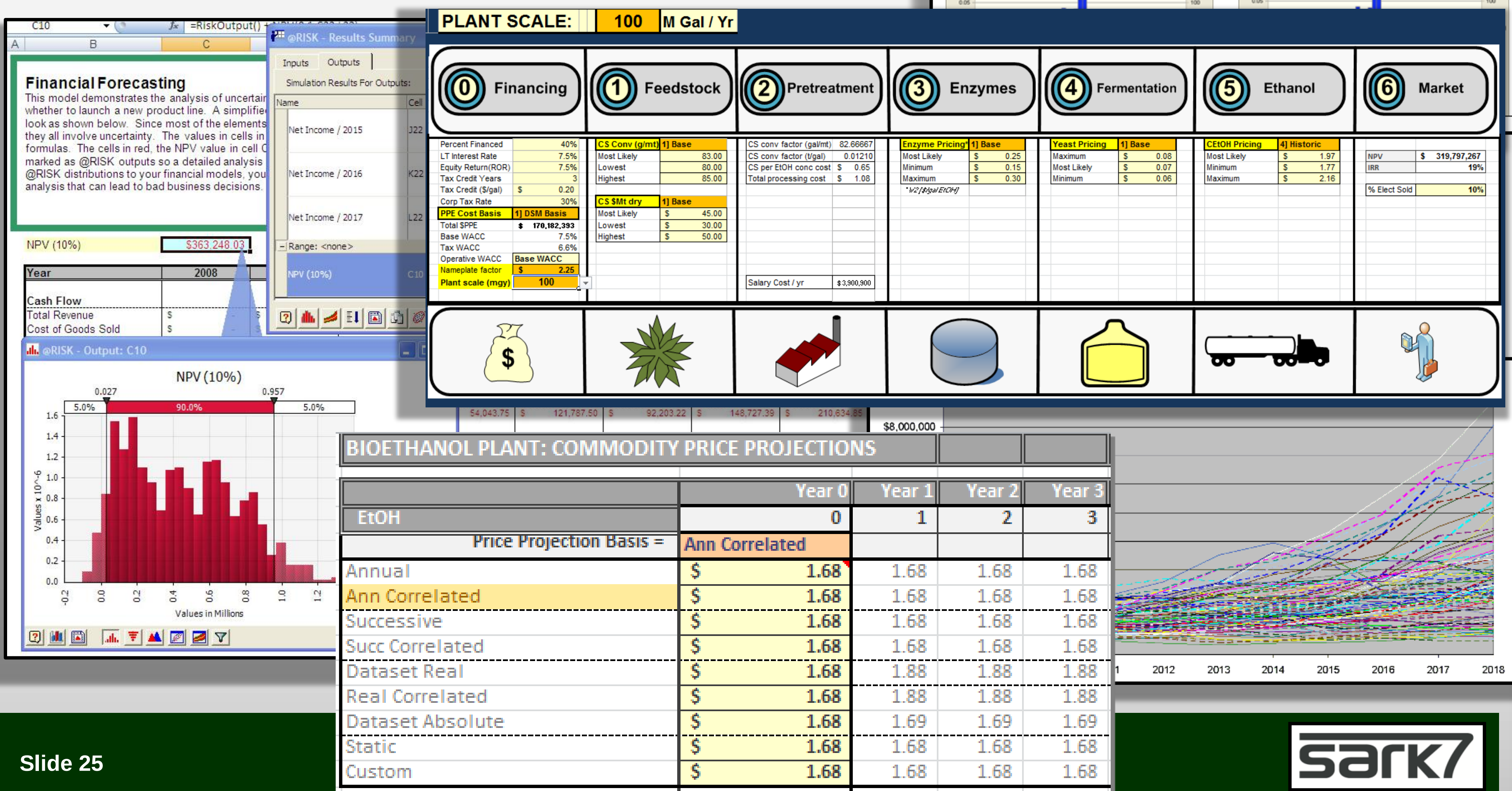


- *Mongeau, S. 2010. Cellulosic Bioethanol Plant Simulator: Managing Uncertainty in Complex Business Environments. 2010 Palisade EMEA Conference*
- US NREL research + U of Oklahoma – CEtOH calculator
- Iterative development working with industry experts

Case 2: @Risk Analysis

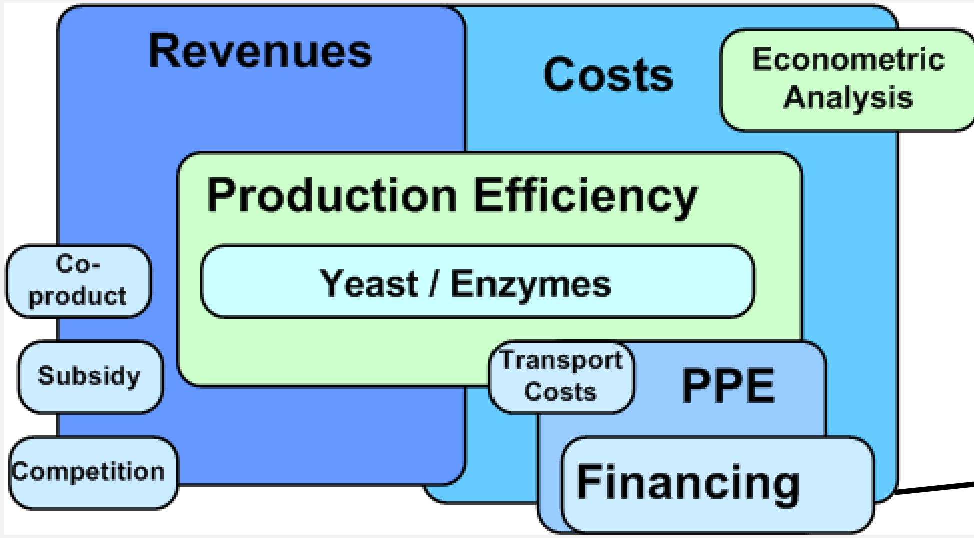
- Dynamic NPV analysis
- Probability distributions for all major variables
- Multiple outcome simulations run (1000's of times)
- Aggregate probabilities and sensitivities emerge





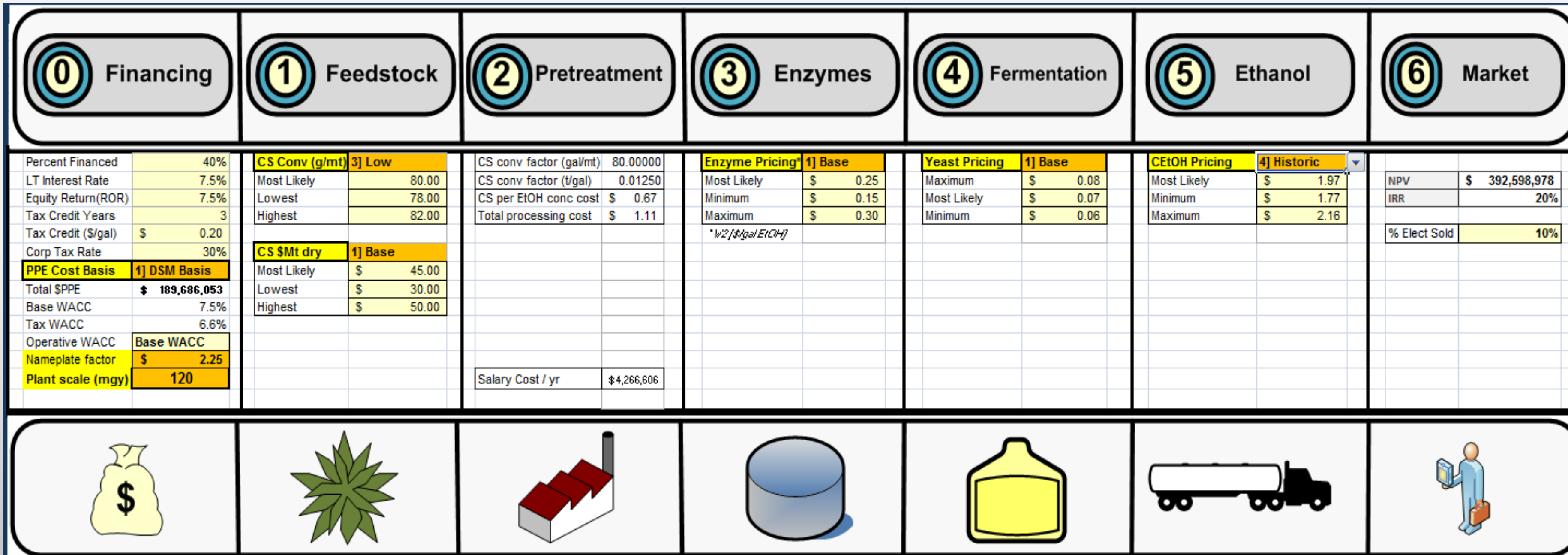
	Year 0	Year 1	Year 2	Year 3
EtOH	0	1	2	3
Price Projection Basis =	Ann Correlated			
Annual	$ 1.68	1.68	1.68	1.68
Ann Correlated	$ 1.68	1.68	1.68	1.68
Successive	$ 1.68	1.68	1.68	1.68
Succ Correlated	$ 1.68	1.68	1.68	1.68
Dataset Real	$ 1.68	1.88	1.88	1.88
Real Correlated	$ 1.68	1.88	1.88	1.88
Dataset Absolute	$ 1.68	1.69	1.69	1.69
Static	$ 1.68	1.68	1.68	1.68
Custom	$ 1.68	1.68	1.68	1.68

Case 2: TopRank & RiskOptimizer



MONTE CARLO SIMULATION

- Iterative development working with engineers / experts
  - US NREL research
  - - U. Oklahoma CEtOH model



Percent Financed	40%
LT Interest Rate	7.5%
Equity Return(ROR)	7.5%
Tax Credit Years	3
Tax Credit ($/gal)	$ 0.20
Corp Tax Rate	30%
PPE Cost Basis	1] DSM Basis
Total $PPE	$ 189,686,053
Base WACC	7.5%
Tax WACC	6.6%
Operative WACC	Base WACC
Nameplate factor	$ 2.25
Plant scale (mgy)	120

CS Conv (g/mt)	3] Low
Most Likely	80.00
Lowest	78.00
Highest	82.00

CS $Mt dry	1] Base
Most Likely	$ 45.00
Lowest	$ 30.00
Highest	$ 50.00

CS conv factor (gal/mt)	80.00000
CS conv factor (t/gal)	0.01250
CS per EtOH conc cost	$ 0.67
Total processing cost	$ 1.11
Salary Cost / yr	$4,266,606

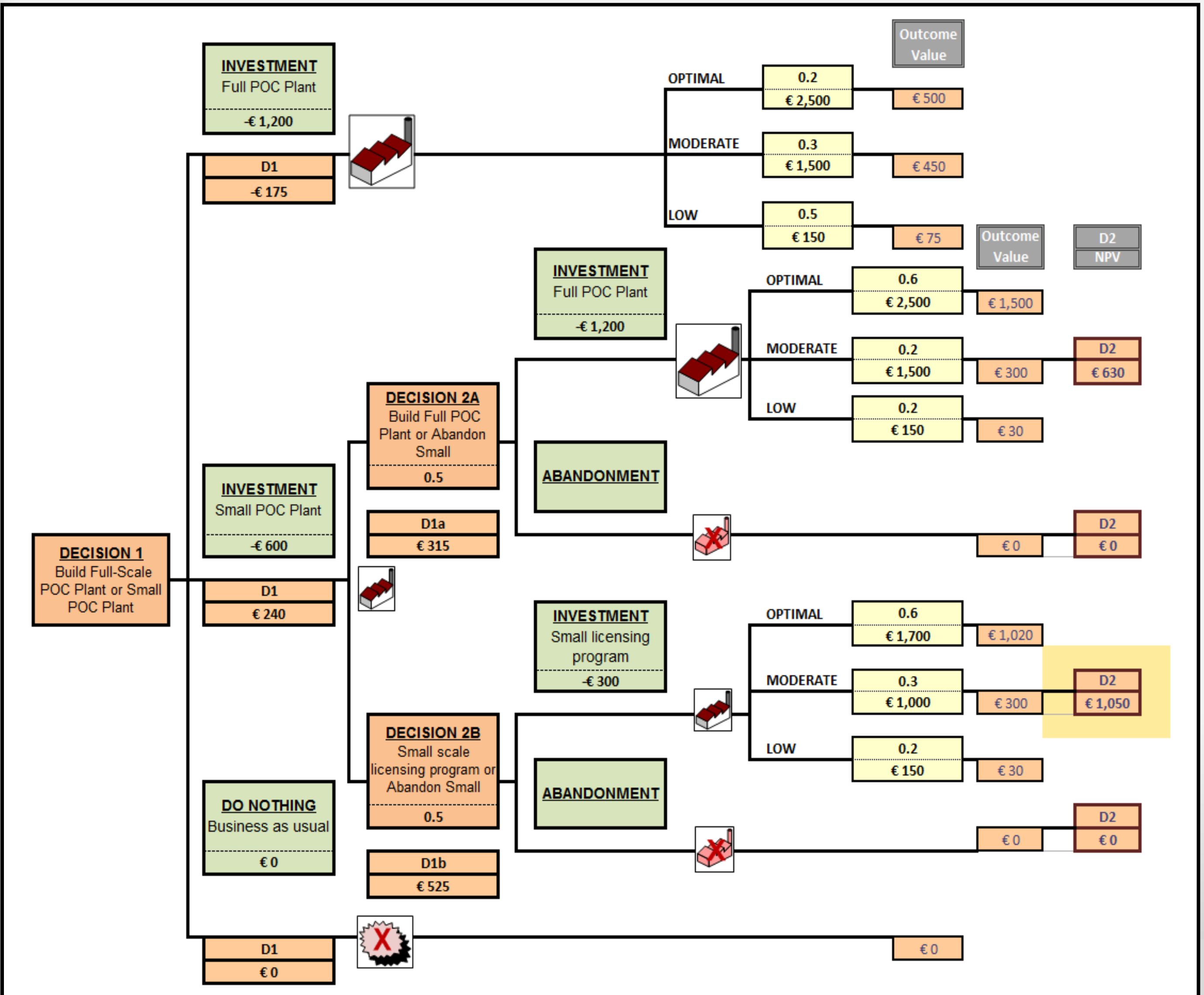
Enzyme Pricing*	1] Base
Most Likely	$ 0.25
Minimum	$ 0.15
Maximum	$ 0.30
*W2 [$/gal EtOH]	

Yeast Pricing	1] Base
Maximum	$ 0.08
Most Likely	$ 0.07
Minimum	$ 0.06

CEtOH Pricing	4] Historic
Most Likely	$ 1.97
Minimum	$ 1.77
Maximum	$ 2.16

NPV	$ 392,598,978
IRR	20%
% Elect Sold	10%

Case 2: PrecisionTree Decision Analysis



1. Add management decision points, investments required, and probabilities
2. NPV valuation of each node in scenarios (DCF)
3. Work backwards to probabilistic 'inherent value' of management option to expand/contract at each step
4. Choose for highest NPV value at each decision point
5. Revise as probabilities, decisions, and values as time progresses

Case 2: @Risk & PrecisionTree Integration

1

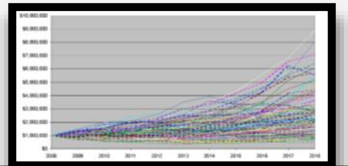
Feedstock, Ethanol & Oil Price Analysis

Investment Simulation

Revenue w/ Competition Simulation

Costing Analysis

2



Monte Carlo Simulation

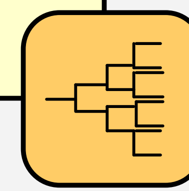
- Oil price scenarios
- Investment costs
- Revenues (Ethanol & Byproduct, Carbon Credit)
- Feedstock variable costs
- Energy costs, yeast & processing costs
- R&D costs
- License income
- Market competition

3

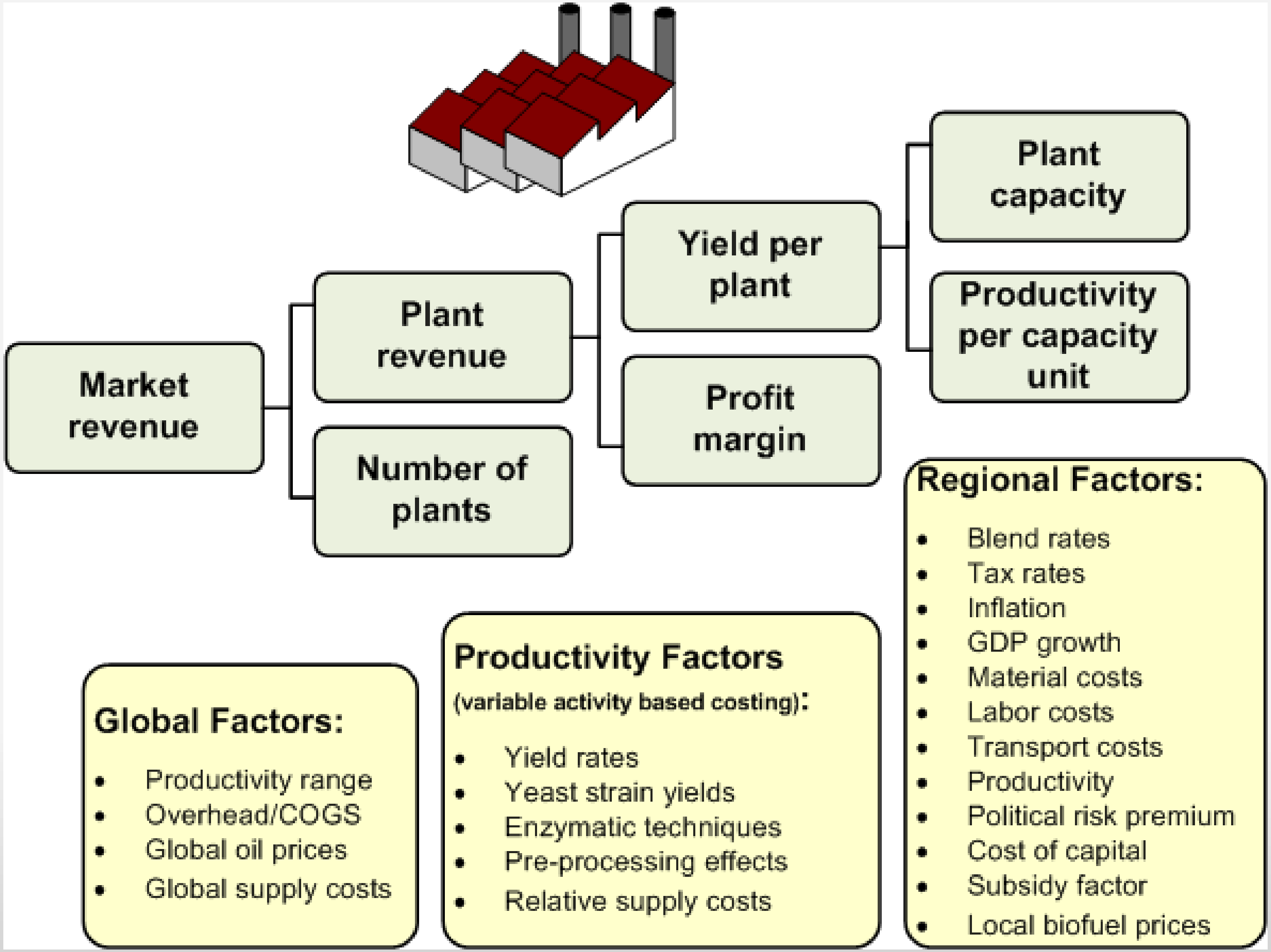
NPV & σ
CEtOH
NPV Model

4

Decision Tree Analysis

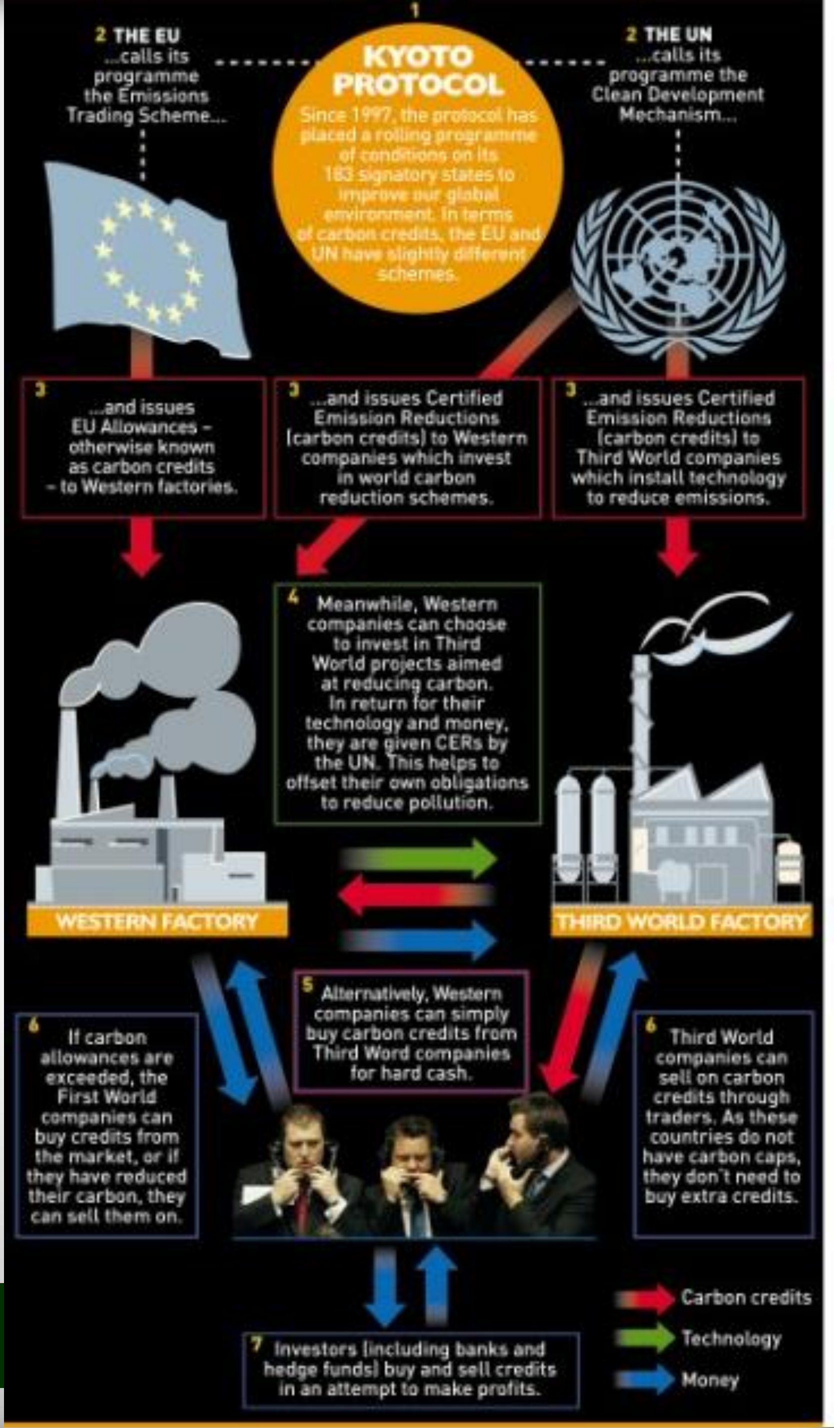


Case 2: Integrated Techno Economic Behavioral

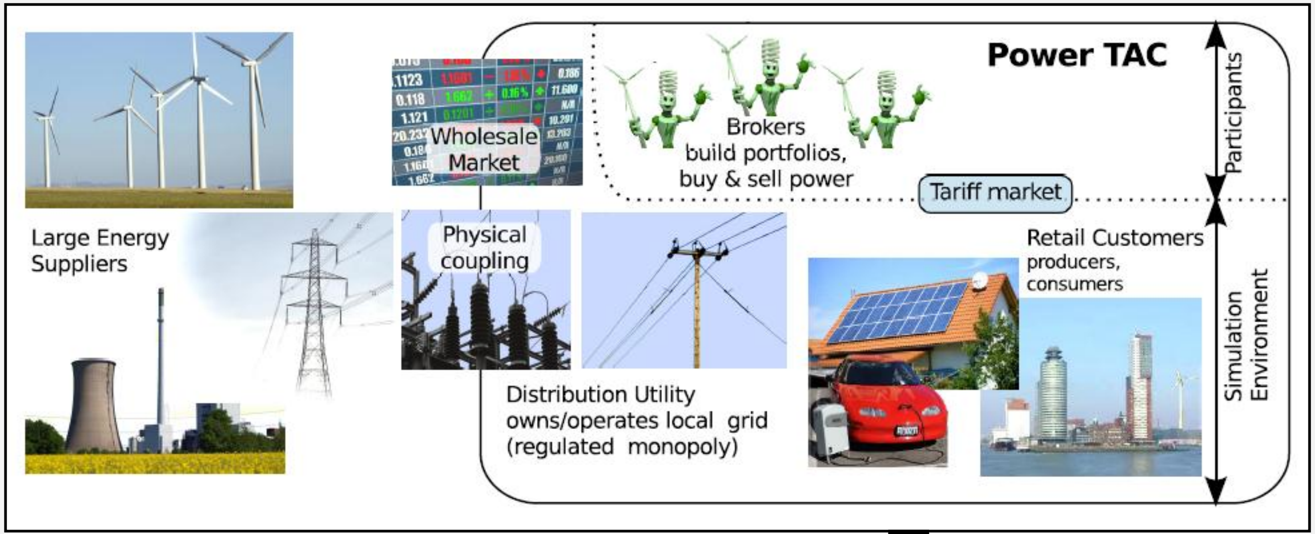


Case 3: Carbon Credit Trading

- Mandated sustainable credit market to offset global CO2 emissions
- Market trading scheme
- Secondary investment market
- Can be modeled & analyzed in detail via Palisade tool suite to study market operation

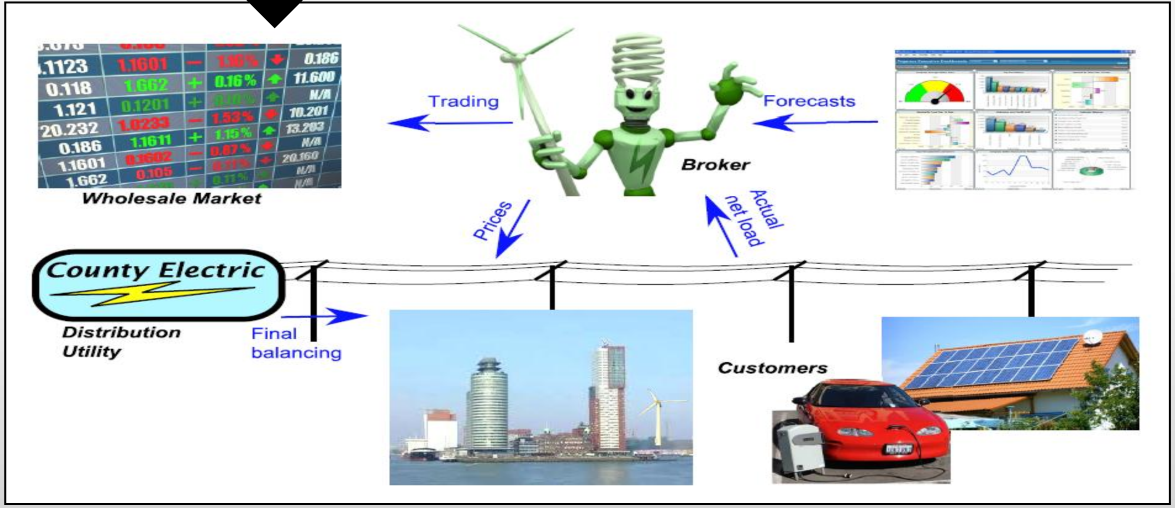


Case 4: Electricity SmartGrid



- Complex infrastructure
- Technical Economic Behavioral integration

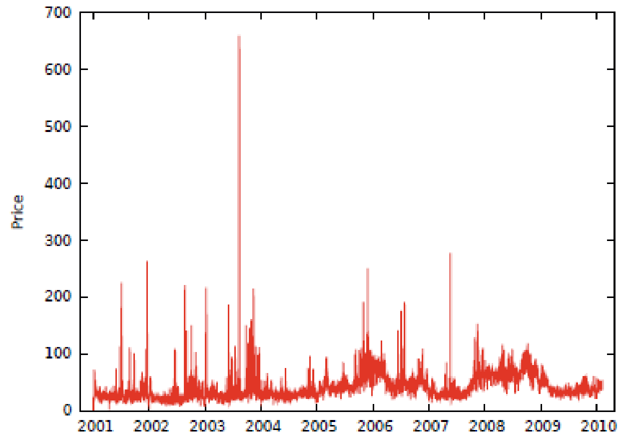
- Broker market design
- Inclusion of Smart Metering & renewable grid re-sales factors



Case 4: StatTools - Electricity Price Analysis

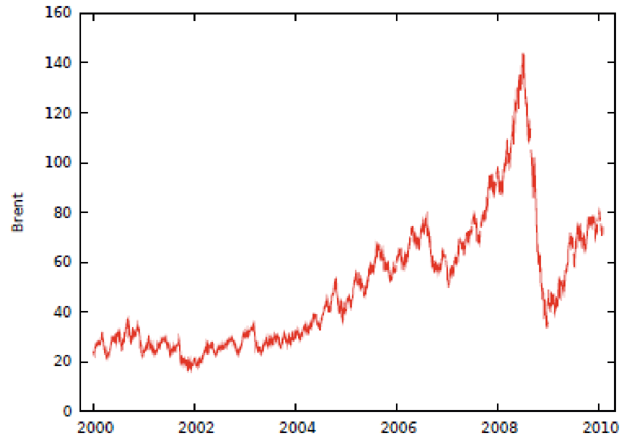
Day ahead electricity:

Mean-reversion
Non-constant volatility
Spikes
Seasonality (volatility)



Oil prices:

Trends
Non-constant volatility



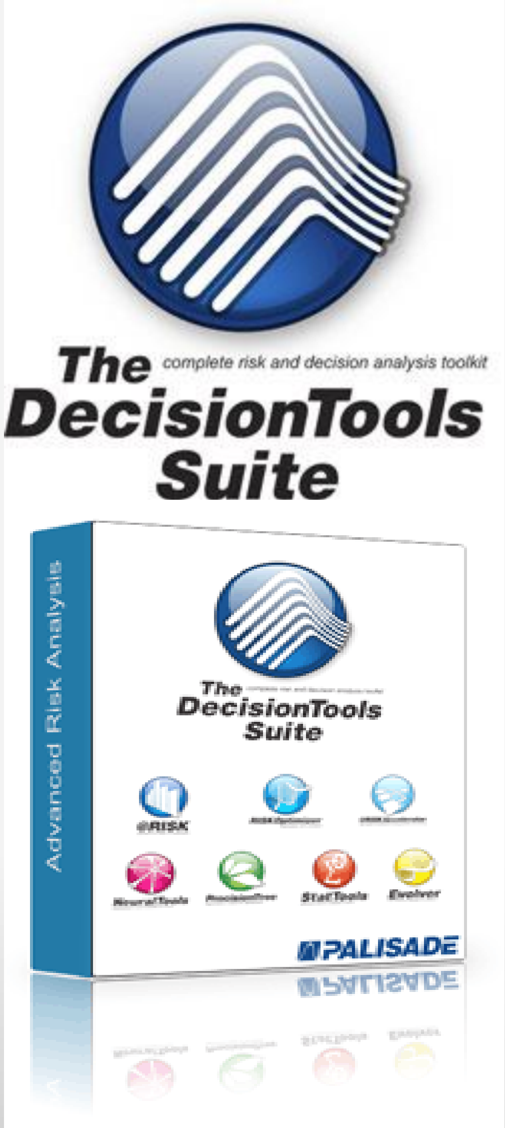
Huisman, Ronald. Erasmus School of Economics “Measuring price risk in the short run”
Huisman, Ronald. (2009) “An Introduction to Models for the Energy Markets”

Case 4: SmartGrid – Better Market Designs Needed

- Enron as CASE STUDY
  - Perversion of regulatory scheme
  - Collusion, cartels & monopsonies
  - Perversion of regulators / public interest
  - Orchestrated blackouts, price hikes
- Increasing uncertainty: complex grids
  - Smart Metering
  - Additional of renewable electricity re-sales onto grid (i.e.: wind, geothermal)

<u>Process</u>: Optimizing Complex Systems

1. Framing (stakeholders)
2. Analysis
   - Management Science (OM, OR) ‘toolkit’
   - Econometrics & statistics
3. Modeling
   - Integrated multi-systems models
   - Structured method (i.e. SysML)
   - Understanding of key dependencies
   - Attention to interfaces
     i.e. discrete to continuous
4. Verification & validation
5. Simulation
   - Multi-framework
6. Optimization
7. Iterative design
8. Valorization



Act 4 – Resolution
Integrated Analytics

- Overview of integrated analytics

Integrated Analytics

- **Smart Cities?**
  - Complex ‘systems of systems’ challenge
  - Multi-stakeholder market decision dynamics
  - Goal: ‘elegant’ policy & market architectures
- **Modeling & analytics**
  - Sustainability: efficiency / satisficing
  - Multiple stakeholders
  - Semi-regulated markets
  - Combine technical, economic & behavioral analysis
  - Integrated anlaytics
  - Need for organizational verification & validation
  - Valorization
- **Palisade**
  - Excellent analytics suite: analysis, simulation & optimization
- **Advocacy**
  - Beyond simple optimization
  - Need for deep complex systems analysis

Clemen, R., Reilly, T. 2004. Making Hard Decisions with DecisionTools Suite.

Decision Analytics Perspective

- **Integrated Techno-Economic Behavioral Analytics**
  - Framing
  - Data analysis
  - Model building
  - Verification & validation
  - Simulation
  - Optimization
  - Organizational valorization
- **Integrated research foundations**
  - Operations Management
  - Behavioral Operations
  - Behavioral Economics
    - Game Theory
    - Biases in decision making
    - Market Design
- **Complex systems diagnostics**
  - *Example*: gene networks, metabolic disorders

Guidelines for Complex Integrated Models

- **Assumptions**
  - Far from innocuous!
- **Modeling process is crucial**
  - Verification
  - Validation
  - Valorization
- **Goal is not forecasting!**
  - Pan-systemic understanding
  - Emergence in complex systems
  - Orientation towards risks & opportunities

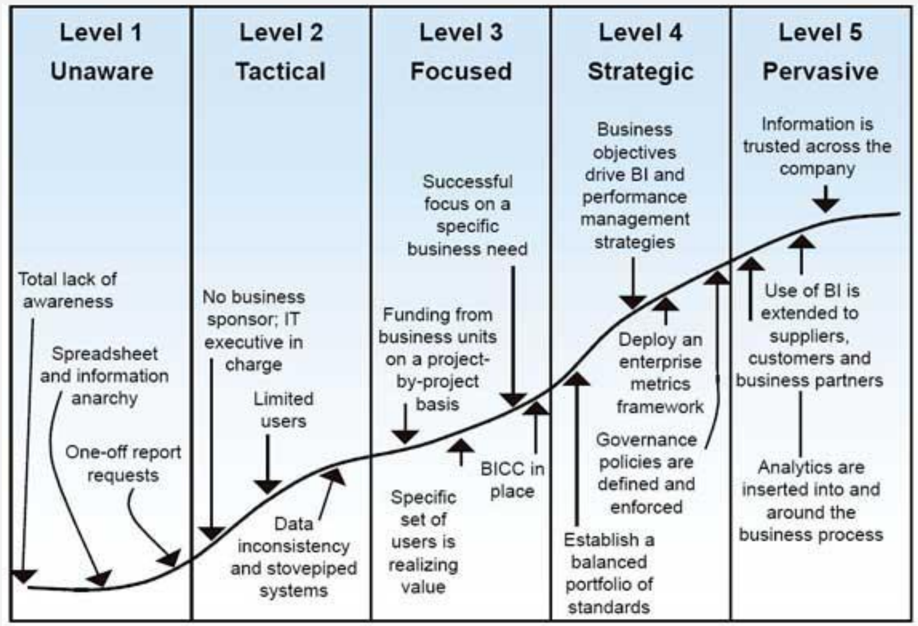
Epilogue

Organizational Adoption

- Organizational valorization
- Moral & ethical considerations
- Appendix / references
- Conclusion / questions?

Organizational Maturity Factors

- **Metrics**
  - KPI
  - Balanced Scorecard
  - Six-Sigma
- **Processes**
  - BPM
  - Decision Making
  - Design & interpretation of analytics
- **Maturity models**
  - Business Intelligence (BI)
  - Knowledge Mgmt (KM)
  - Business Analytics (BA)
  - Decision-Making



BI = business intelligence

BICC = BI competency center

Source: Gartner (December 2008)

Moral & Ethical Considerations

Sim City Example

- Urban Policy student created mega-city…
- 'Magnasanti': 6m (micromanaged) inhabitants
  - http://www.youtube.com/watch?v=NTJQTc-TqpU
  - http://www.vice.com/read/the-totalitarian-buddhist-who-beat-sim-city
  - Life expectancy: 50 yo
  - "There are a lot of other problems in the city hidden under the illusion of order and greatness--suffocating air pollution, high unemployment, no fire stations, schools, or hospitals, a regimented lifestyle--this is the price that these sims pay for living in the city with the highest population. It's a sick and twisted goal to strive towards. The ironic thing about it is the sims in Magnasanti tolerate it. They don't rebel, or cause revolutions and social chaos. No one considers challenging the system by physical means since a hyper-efficient police state keeps them in line. They have all been successfully dumbed down, sickened with poor health, enslaved and mind-controlled just enough to keep this system going for thousands of years. 50,000 years to be exact. They are all imprisoned in space and time."

APPENDIX

Interdisciplinary Research Perspective

1. Social & Management Science

- Economics
- Urban Planning
- Organizational Management
- Human Interaction Mgmt (HIM)
- Information Management (IM)
- Political Science
- Mgmt of Info Systems (MIS)
- Operations Management
- Decision Support Systems
- Computational Org Science

2. Mathematics & Computer Science

- Operations Research
- Computational Game Theory
- Multi-agent Simulation
- Econometric Forecasting
- Network Theory
- Formal mathematics
- Decision Support Systems

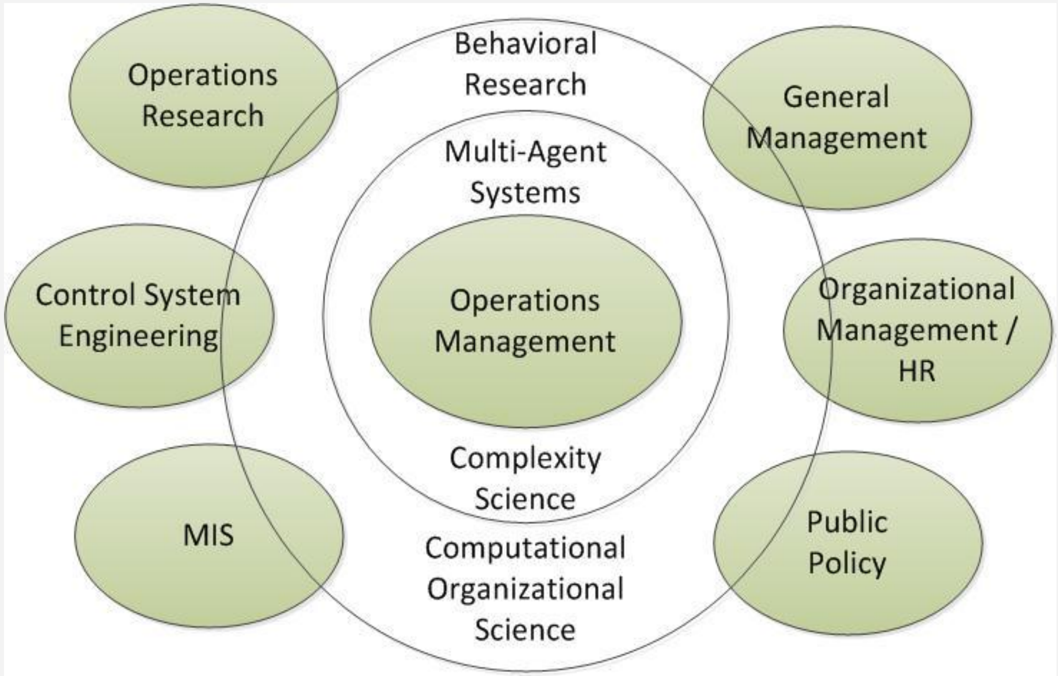
3. Engineering

- Control Systems
- Complex Systems Controllers
- Smart Systems
- Sensor Arrays
- Decision Support Systems

Technical Perspective

- **Computer Science**
  - Optimization of complex systems dynamics
  - Focus on algorithmic / mathematical equilibrium, efficiency, optimization, and/or 'satisficing'
  - Draws from formal mathematics, game theory, & economics (equilibrium)
- **Engineering**
  - Formal machine control systems
  - Control of complex, non-linear systems: focus on automation
  - Draws from cybernetics, control theory, differential equations, non-linear dynamical equations (optimization)
- **Systems Theory**
  - More probabilistic
  - Greater understanding of fuzzy logic, probabilistic challenges
- **Emerging methods**
  - Network Theory, Multi-Agent Simulation, Complexity Management
  - Promising emerging methods
  - However, not explicitly oriented towards issues of Human Interaction Management (HIM) (organization-machine interfaces)

Operations Management Perspective



- Multi-layered, systems-of-systems analysis
- Techno-Economic Behavioral analysis
- <u>Challenge</u>: how to verify, validate & valorize?

Organizational Perspective

- **Organizational perspectives**
  - Change Management
  - Operations Management
  - Computational Organizational Science
  - Human Interaction Management (HIM)
    - Business Process Management
    - Six Sigma, Lean, etc.
    - Balanced Scorecards
- **Complexity management**
  - Grappling at a conceptual level with applying multi-disciplinary understanding of complex systems (i.e. physics) to social complexity
  - Social Science just beginning to adopt suitable research methodologies to address notions of complexity in organizations
    - Multi-agent simulation
    - Network theory
    - Game theory
    - Complexity science (emergence, unpredictability, conflicting regimes, etc.

Organizational Management Perspective

Organizational Management Principles for Orchestrating Smart Systems

- 1) What are 'Smart Systems'?
  - What are core characteristics of Smart Systems?
  - What patterns exist in architecture of Smart Systems?
  - How have approaches to Smart System architectures evolved with technology & knowledge advancement?
- 2) What control & management challenges are presented by complex Smart Systems?
  - What methods for control and orchestration are emerging?
  - What role do advanced decision making principles / technologies play in orchestration?
- 3) Best practices in interfacing Smart Systems with complex organizations?
  - How have IT Architectures and Organizational Architectures co-evolved?
    - Knowledge based view of firm
    - Computational Organizational Science
    - Computational Agents as Organizational Agents (Agency, perverse incentives, heuristics)
  - What are best practices related to interfacing organizational decision making and smart system decision making?
  - Architecting 'The Edge': where are crucial orchestration points between organizational & smart systems?

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More Information…

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  - Complexity Science
  - Application in social science
  - Organizational studies
- Control systems
  - Non-linear systems
  - 'Smart Systems'
- Energy markets
  - Forecasting & control
- Multi-Agent Systems
- Operations Management
- 'Smart Supply Chains'?

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