

*Opening Speech in Plenary Session on*  
**Modelling and Analysis of Safety and  
Risk in Complex Systems  
(MA SR -2007)**  
**Saint-Petersburg, RUSSIA**  
September 4-8, 2007

by

**Professor J.D.Agarwal**  
*Professor of Finance & Chairman*  
**Indian Institute of Finance**  
**Delhi, INDIA**  
[ida@iif.edu](mailto:ida@iif.edu)

# Introduction

- Modeling and analysis of Safety & risk in Complex systems has assumed new dimensions with increasing complexities and changing environment in the world economy.
- The world has become a global village.
- As the world is shrinking in size in terms of economic operations, large systems are becoming more complex & vulnerable than ever before.
- Risk which was associated with time in the past has now become an instant phenomenon.
- In situations, when extreme steps are taken by some, systematic risk is overtaken by unsystematic risk.

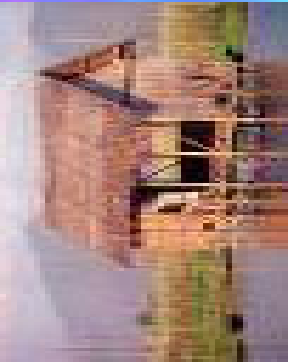


# Modeling, Scientists & Specialists



- Models are symbols of perfection and lead to perfection and make this world more beautiful, safer, meaningful and facilitate living an enormously good life.
- Models have helped simple organizations to emerge as mega and complex systems and facilitated risk mitigation.
- Today's world is a result of yesterdays' models and contributions from scientists and specialists to make this world great, risk free, people happy, prosperous and feeling safe.

# Modeling, Scientists & Specialists



- Models may either evolve over a period or result of scientific thinking and born out of creativity, innovation, need to improve & of course a scientist's secret urge to make his humble contribution to his field of specialty to be a living human - across cultures, religions, geographical boundaries even after his death.
- I salute these scientists & specialists who have given this world so much at the cost of their own comfortable & luxurious living by spending their life in labs, in libraries, on their computers for major part of their lifetime.

# Modeling, Scientists & Specialists



- Even in sleep, their sub conscious mind is working on some problem, discovery, or complexities of the model to seek solutions to complex problems to make this world what it would be tomorrow.
- Most of these scientists are not expecting praise, position, publicity, power or money for their contributions and are satisfied if their models are useful to the society.
- Result of the sacrifices of scientists and their models in complex system are clearly visible.

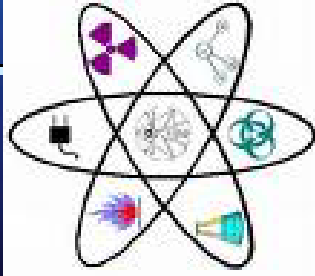
# Modeling & Analysis of Safety

- Safety is a matter of major concern for the state, corporate and people.
- Models for safety & security against evils prevailing in society required at global level.
- Major areas of concern :
  - Safety from natural disasters such as earthquakes, floods, droughts, tsunamis etc.
  - Safety of plants, factories and buildings specific.
  - Safety against disasters which are man made such as terrorist attack.
  - Safety against volatility of international/national markets, money laundering, corruption, foreign exchange fluctuations, bribing.



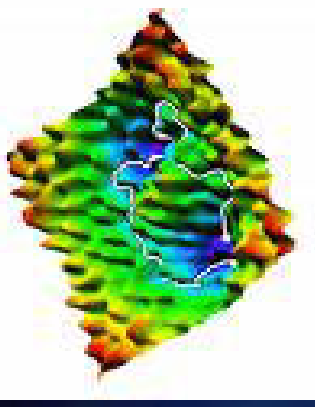
# Modeling & Analysis of Safety

- Some of the models even require refinements using extensively probabilistic models, simulations and stochasticity in the models.
- Scientists and specialists are involved in bringing refinements but at times the models fail because there is not enough support from the business or political leadership in getting such models

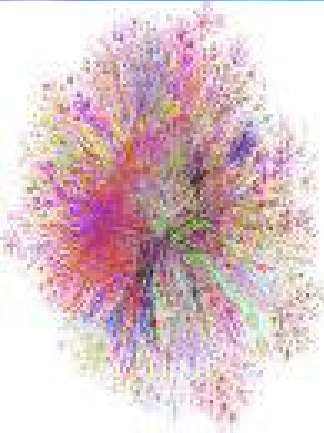




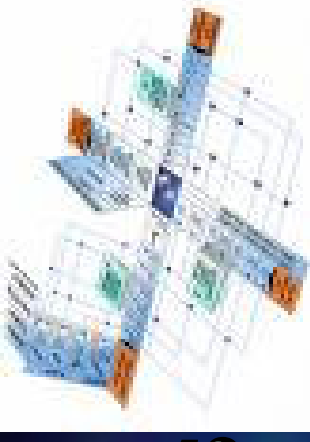
# Complex Systems



- Encompasses research approach to problems in many diverse disciplines.
- Design and development costs for extremely large systems could be significantly reduced.
- Complex Systems is a new approach to science that studies how relationships between parts give rise to the collective behaviors of a system and how the system interacts and forms relationships with its environment.
- Complexity theory takes its roots into Chaos theory which remains deterministic.



# Complex Systems



- Complexity is non-deterministic & gives no way whatsoever to predict future (*Prigogine*).
- The emergence of complexity theory shows a domain between deterministic order and randomness which is complex.
- Study of complexity is the opposite of the study of chaos (*Colander*).
- Complexity is about how huge number of extremely complicated and dynamic set of relationships can generate some simple behavioural patterns.



# Complex Systems



- Simulation has emerged as the most common performance evaluation technique.
- Long execution times needed for sequential simulation models hamper evaluation.
- Slow speeds led to interest in use of parallel execution for simulating large-scale systems.
- Use of Parallel simulation, is hindered by lack of tools for integrating parallel model execution into overall framework of system simulation.
- Another drawback to use of simulations is the cost of model design and maintenance.

# Risk & Uncertainty in Complex Systems



- Risk Mgmt. is managing future uncertainties.
- High quality decision-making serves the purpose of risk management.
- Risk & uncertainty in economics is not new.
- Decision is balance between what we believe to be true & what we are forced to predict.
- Decision involves the analysis of available information and ultimately the selection of a choice among alternatives with varying degrees of uncertainty.

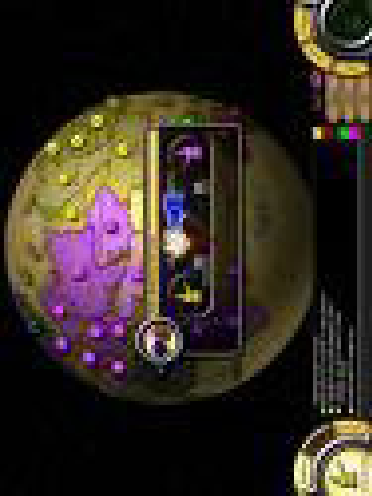
# Risk & Uncertainty in Complex Systems

- Better decisions are informed, reasoned, and balanced, while in poor decisions, risks are understated and returns exaggerated.
- Risks are residual uncertainties left behind when decisions are made without perfect information.
- High quality decisions are in which magnitude of the risk of being wrong is understood
- Sources of uncertainty in decision-making.
  - Known-unknowns
  - Unknown-unknowns
  - Analytical-bias



# Risk & Uncertainty in Complex Systems

- Large number of problems complex systems, require that decisions be made in the presence of uncertainty.
- Decision-making under uncertainty is further complicated by presence of integer decision variables to model logical & other discrete decisions in multi-period or multi-stage setting.
- Effects of risk and uncertainty on asset prices, on rational decision has increasingly engaged the attention of professionals of capital markets and business finance in recent years.

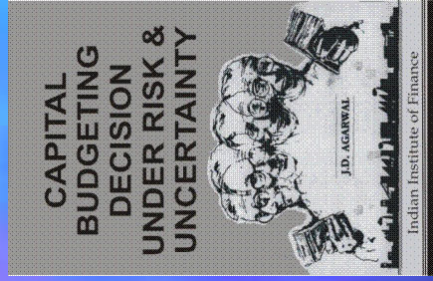


# Modeling & Analysis of Safety & Risk in Complex Systems: Recent Developments

■ Another area of concern or managing risk and uncertainty in complex systems is **Capital Investment and Portfolio Investment**.

■ Most of the literature in capital investment and portfolio decisions under risk and uncertainty has mainly followed three trends:

- (1) Simplistic Approach,
- (2) Portfolio Theory Approach and
- (3) Mathematical Programming Approach.



© The copyright in this software is held by the Indian Institute of Finance, New Delhi, India. All rights reserved. The Institute is a registered institution for all educational purposes.



# Recent Developments : (Simplistic Approach)

- The first type of approach is to use a simple criterion by suggesting a simple modification in the deterministic criterion.
- Some of the capital budgeting decision techniques that have been suggested in the past and belonging to this type are payback, risk adjusted discount rate, and certainty equivalent approach.
- This approach although in practice is highly tractable, cheap, quick and easily understood, but is less intellectually satisfying.



# Recent Developments : (Portfolio Theory Approach)

- Probability distribution simulation approach, decision tree analysis, utility theory and sensitivity analysis used to measure return & variance on capital employed, as measure of risk.
- More recent approach treat some of model parameters as random variables.
- Based on erroneous assumption that firms pursue single goal while firms pursue multiple goals & conditions of certainty never exist.
- **Stochastic Goal Programming Model and Fuzzy Goal Programming Model developed by me could provide possibly good solution.**

# Recent Developments : (Capital Investment Approach)

- Capital Investment in production area involves selection of fixed assets under conditions of uncertainty regarding future product demand.
- Over the second half of the 20th century, optimization found widespread applications.
- Traditional approach to capital budgeting breaks down when the complexities of production environment are considered.
- To deal with the problem, a hierarchical optimization model with ability to reflect multiple conflicting goals is necessary.



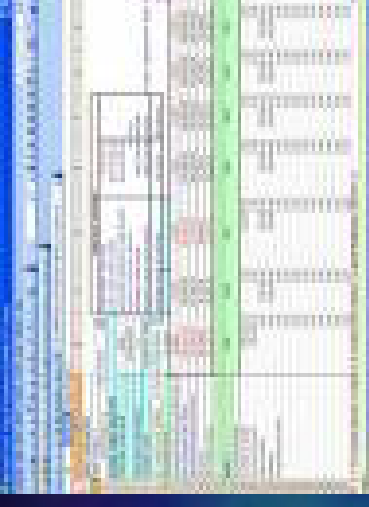
# Recent Developments : (Capital Investment Approach)

- Approaches to optimization under uncertainty have followed a variety of modeling philosophies.
- In particular linear programming was used for maximizing net present value of project selected subject to some budget constraint.
- Existence of multi-conflicting goals measured in incommensurable units may preclude this translation.
- While few models provide for inclusion of multiple goals, they do not reflect the problem of uncertainty of future product demand.



# Recent Developments : (Capital Investment Approach)

- Chance-constrained capabilities as a supplement to regular Integer Programming Model, this deficiency can be compensated for.
- Solution approach to the capital budgeting problem in production area provides practical advantage over linear programming by inclusion of multiple conflicting goals measured in incommensurable unit.



# Recent Developments : (Capital Investment Approach) Agarwal (1978) Model

- Stochastic Goal Model for Capital Budgeting Decisions under Uncertainty takes care of uncertainty situations.
- Primarily mathematical programming model involves various quantitative techniques particularly probability theory, times series iterations, mean variance approaches, simulation & sensitive analysis to incorporate & handle parameters affected by uncertainty.
- Information about some of my models are available in my books and articles and also on our website:

**<http://www.iif.edu>**





THANK YOU

# Thank You !!!

- I must thank the members of this august house, the scientists and specialists, ladies and gentlemen, for their very kind patient hearing.
- I am sure each one of us would be wiser and wealthy with the research work sharing with other scientists during the international scientific school

**Thank you for your  
Patience**

---