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Presenting:

Application of Game Theory to Business Decisions
by Christine Clarke

DAAG Conference 2003

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Application of Game Theory to Business Decisions

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DAAG 2003

Integrating Decision-Making Techniques

Outline

- ## What is Game Theory?

- ## Case Study

- ## Game Theory and DA - similarities, differences and complementary uses

Why approach decisions using a variety of methods?

- All decision problems are not created equal
- All decision-makers don't think the same way
- Different perspective

Different tools for different sources of complexity, often at different stages in a project

Source of complexity:

Lots of information to sort through

External factors and influences

Relationships & links between key variables

Value of key variables in defined courses of actions

Other players & their actions

Tool to use:

Linear programming

Scenarios

Systems Analysis

Probabilistic tools – e.g. DA, real options

Game Theory applications

What's a Game? What's Game Theory?

Webster's Dictionary:

- "A situation that involves contest, rivalry or <u>struggle</u> – one in which opposing interests **given specific information** are allowed a **choice of moves** with the **objective** of **maximizing wins** and **minimizing losses**"
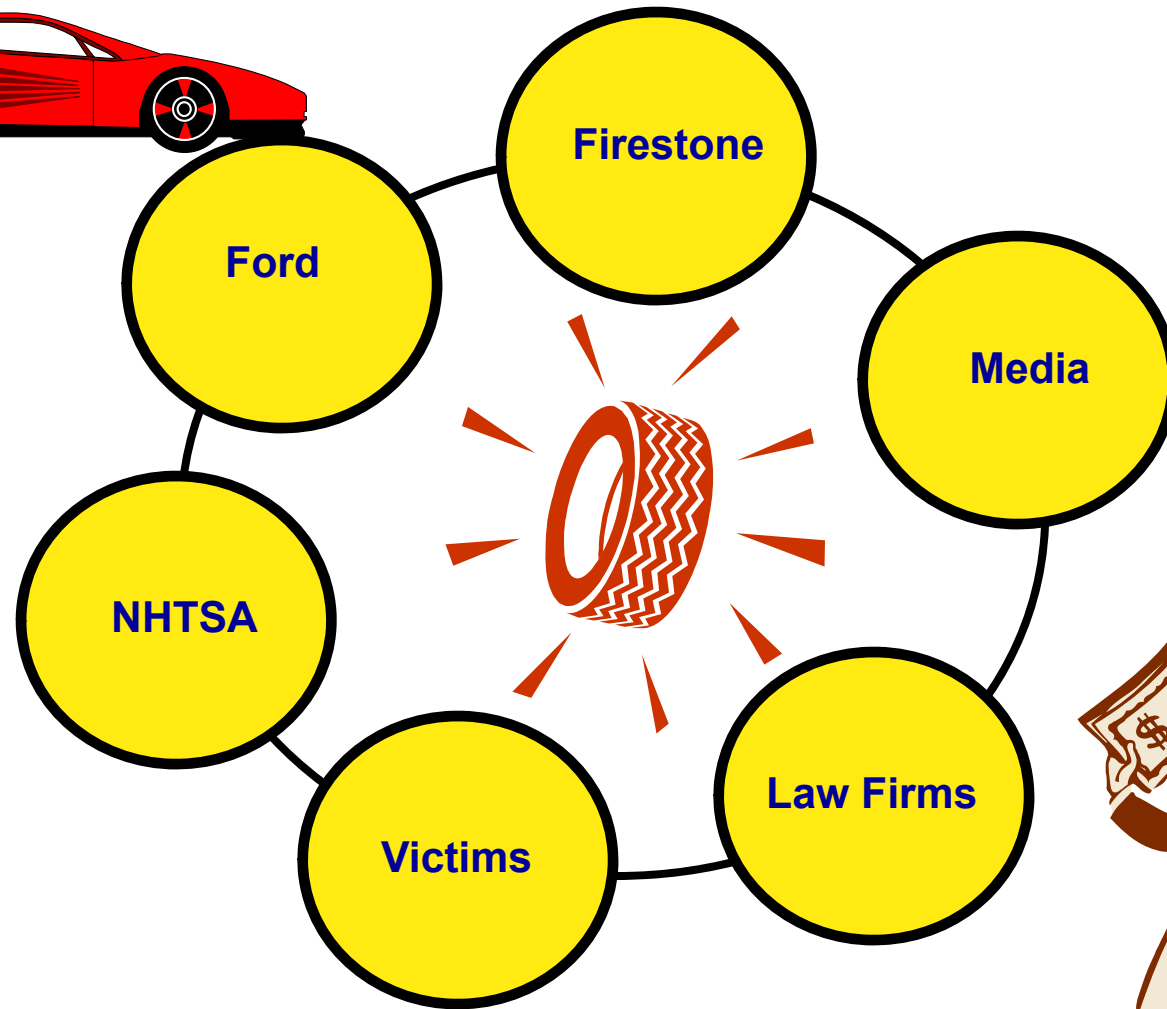
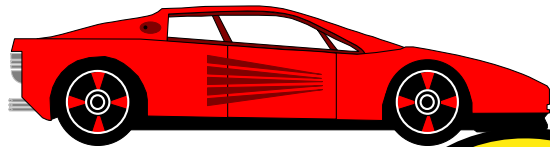- The mathematics of human interactions

Business Application to Game Theory

- The formal, theoretical basis is Game Theory
- Game Theory discussed today is based on a business application developed by Open Options Corporation and is ordinal and non-cooperative
  - Ordinal – based on rankings or orderings
  - Non-cooperative game theory – focuses on a win for one side
  - It is an "asymmetric prescriptive-descriptive" approach

What's Needed?

- **Given specific information and choice of moves** - Extract and organize relevant knowledge about ourselves and other "players"

- **Objective of Maximizing wins and Minimizing Losses** – Structure and analyze knowledge to gain insight

- **Mathematics of human interaction** – Utilize a combination of **facilitation techniques** and software-based mathematical tools

Key Components of a Game Theory Problem – By Example

Firestone

Ford

Media

NHTSA

Law Firms

Victims

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Game Pieces: What's a Player? Option? Preference?

Player

- Any individual or organization involved in the issue who can take actions that affect the outcome.
  - Can be a category – a grouping of interested players
  - Can be company, department, individual, etc.
  - Can be us, government, customer, competitor, supplier, etc.

Game Pieces: What's a Player? Option? Preference?

Option

- An action that any player can choose to take or not take that impacts the others involved in the issue.

  - High level strategies

  - Must have opportunity to take or not take option

An Example of Players and Options

Buyer
1) Walk away
2) Make low bid

Seller
3) Hold price firm
4) Offer warrantee

Game Pieces: What's a Player? Option? Preference?

- **Preferences**
  - List of options, ordered from most important to least important, for each player
  - Each is either positive, negative, or conditional
  - Positive sign - desirable for the player
  - Negative sign - not desirable
  - Conditional - sometime desirable, sometimes not.

Example

Buyer
1) Walk away
2) Make low bid

Seller
3) Hold price firm
4) Offer warrantee

More Important

Less Important

Buyer Preferences:

4

•The most important option for the buyer is being offered a warrantee.

Example

Buyer
1) Walk away
2) Make low bid

Seller
3) Hold price firm
4) Offer warrantee

More
Important

Less
Important

Buyer Preferences:

4

-3
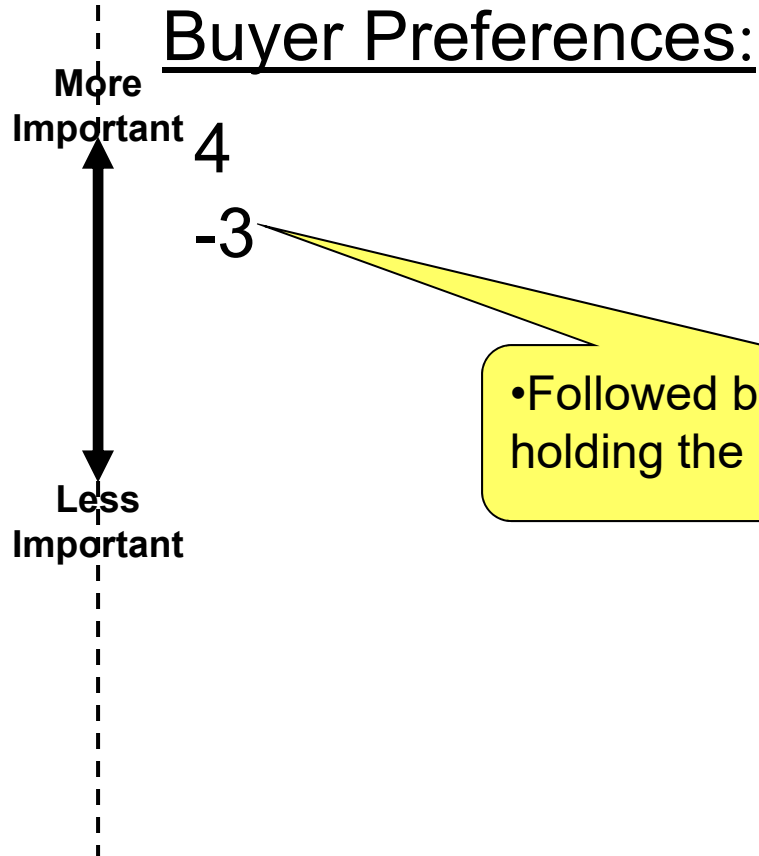
•Followed by the seller **not** holding the price firm.

Example

Buyer
1) Walk away
2) Make low bid

Seller
3) Hold price firm
4) Offer warrantee

More Important

Less Important

Buyer Preferences:

4

-3

1 if -4
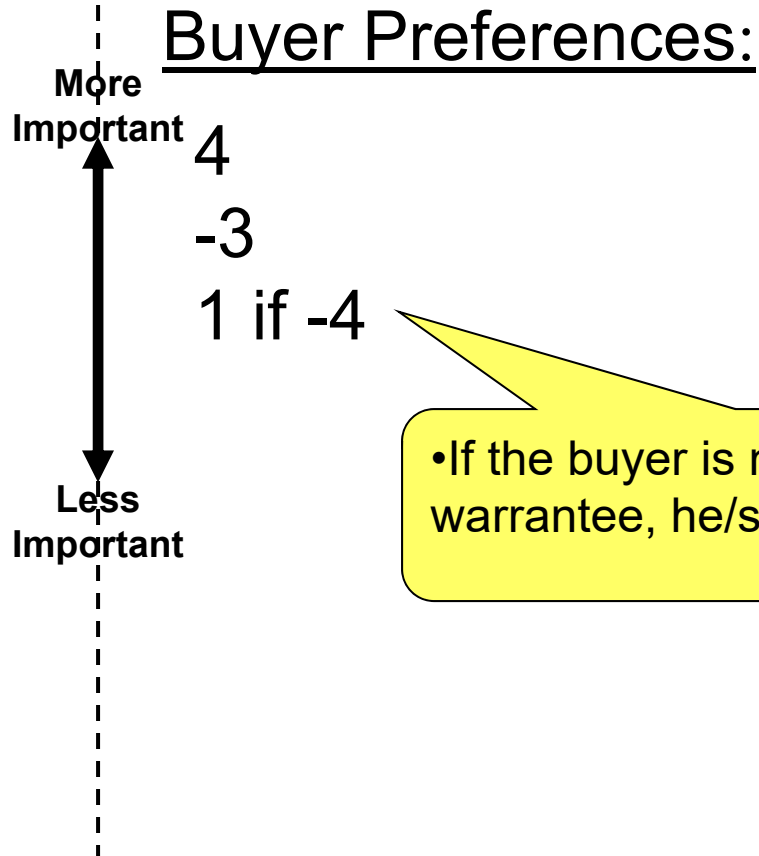
•If the buyer is not offered a warrantee, he/she will walk away.

Example

Buyer
1) Walk away
2) Make low bid

Seller
3) Hold price firm
4) Offer warrantee

More Important

Less Important

Buyer Preferences:

4

-3

1 if -4

2
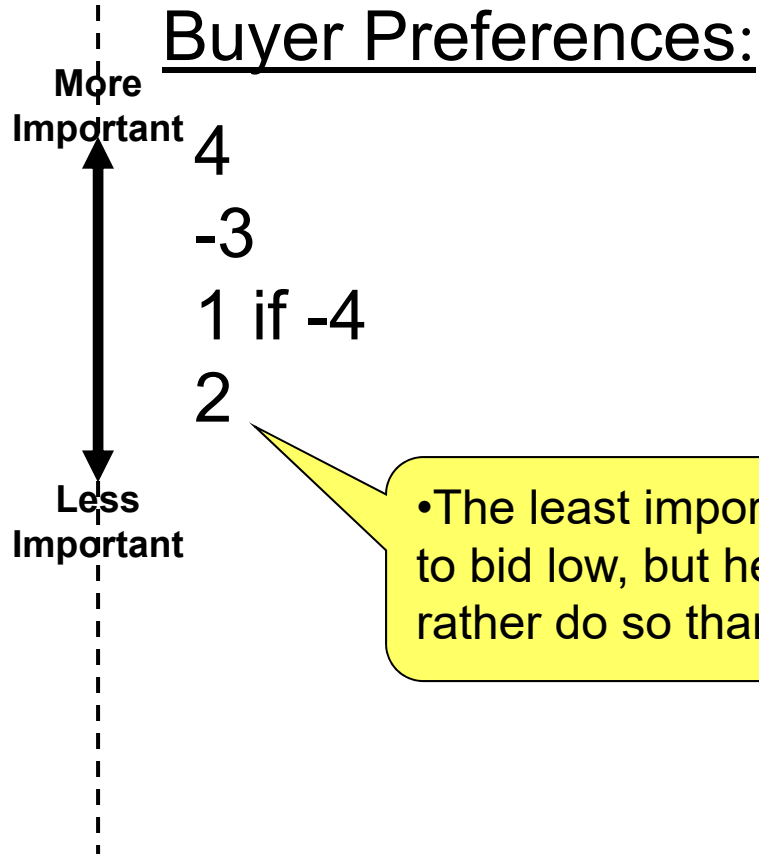
•The least important thing is to bid low, but he/she would rather do so than not

How does it work?

- **The application works because of three technical innovations embedded in the Open Options Process:**

1. The option form of the game

2. Lexicographic preference trees

3. Fraser-Hipel sequential stability – a foresight-based solution concept

Lexicographic Preference Trees

- A preference tree orders all options in a model from most preferred to least preferred for the player

- It does this by taking advantage of the *lexicographic* nature of human preferences

- Lexicographic means like a dictionary: B follows A, and AB follows AA, etc.

- By observation, humans tend to behave according to lexicographic or conditionally lexicographic preferences among options.

Outcomes Can Be Rank-Ordered

Buyer
Preferences: Best……………………………Worst

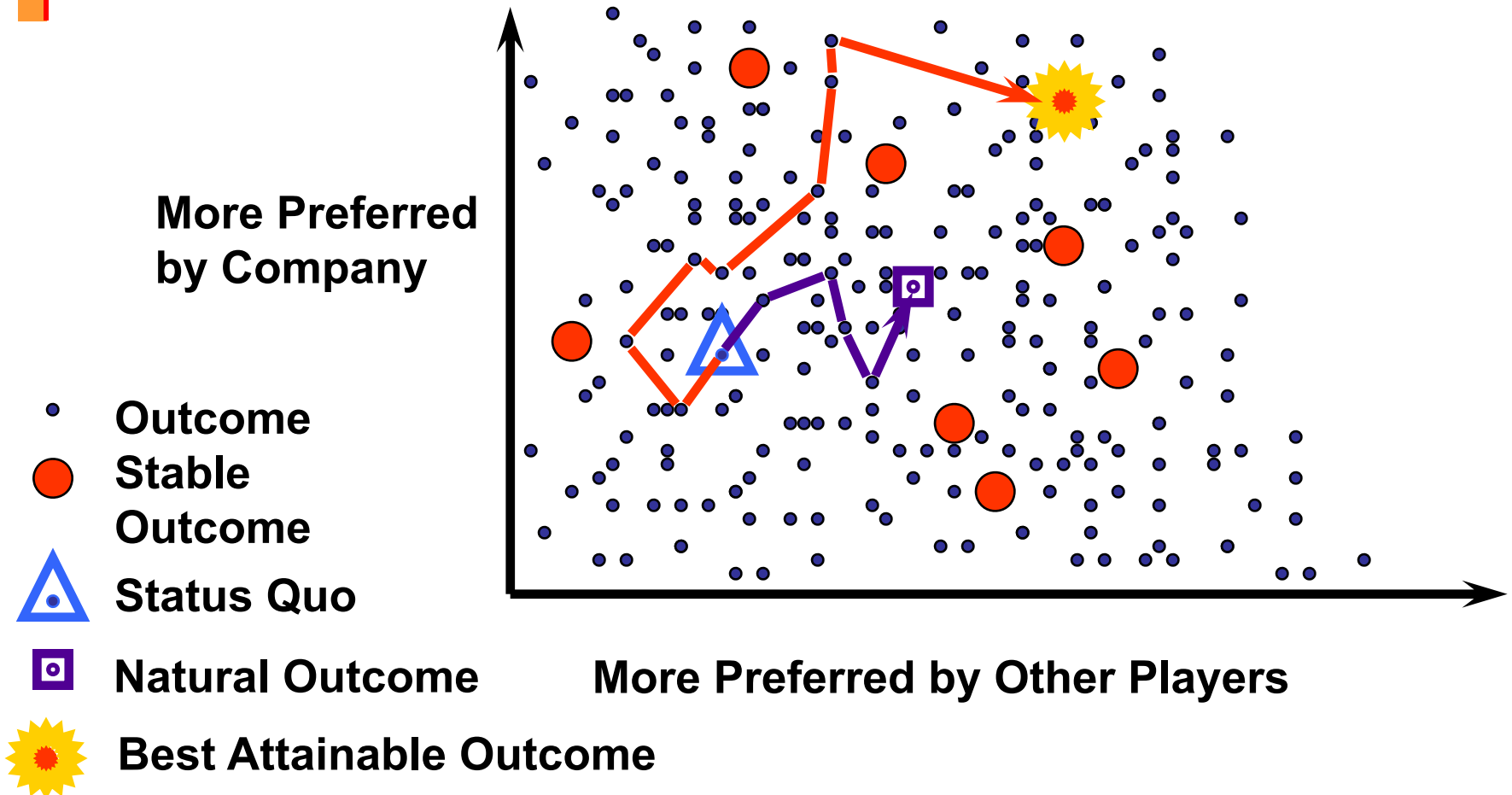|	Best							Worst
4	✓	✓	✓	✓	✓	………	✗	✗
-3	✓	✓	✓	✓	✗	……….	✗	✗
1 if -4	✓	✓	✗	✗	✓	……….	✗	✗
2	✓	✗	✓	✗	✓	……….	✓	✗

Outcome Definitions

Status Quo: an outcome under consideration, usually what is happening currently.

Stable Outcome: an outcome in which each player can be expected to maintain its current option choices – a Fraser-Hipel sequential equilibrium

Natural Outcome: what will likely happen if players follow their interests directly – often the Nash equilibrium.

Best Attainable Outcome: The stable outcome best for the player that can be achieved through strategic choice of options from the Status Quo

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Strategy Space And Paths – Looking Forward and Reasoning Backward

More Preferred by Company

More Preferred by Other Players

- • **Outcome**
- 🔴 **Stable Outcome**
- 🔺 **Status Quo**
- ▣ **Natural Outcome**
- ✴ **Best Attainable Outcome**

Natural and Strategic Outcomes – Integrate with DA

What is the best competitive strategy for Bombardier?

- Use Game Theory to Focus DA on a Few, Strategic Alternatives (may not be all of Bombardier's available options)
  - Frame and Evaluate the Natural (Best) and Strategic outcomes
  - Focus on "owned" options
  - Develop uncertainties and assessments to account for other players' options

Strategic Analysis Based on Game Theory "Frame" – Integrate with DA

What is the best competitive strategy for Bombardier?

- Use Preference Trees to:
    - Develop Uncertainties
    - Develop Scenarios
    - Inform Expert Interviews
    - Identify Critical Uncertainties
    - Develop Strategies
        - Stimulate thinking for hybrid strategy development
        - Test new strategies based on player preferences (Use preference trees to inform strategy development)
        - Focus on "owned" options

Similarities - DA and Game Theory

- Success dependent on the participation of the right individuals

- Skillful facilitation

- Good frame is critical – making decisions with imperfect information

- Structured approach – Frame/Model/Implement

- Strategy based on a selection of strategic options (each option is a disaggregated strategy element)
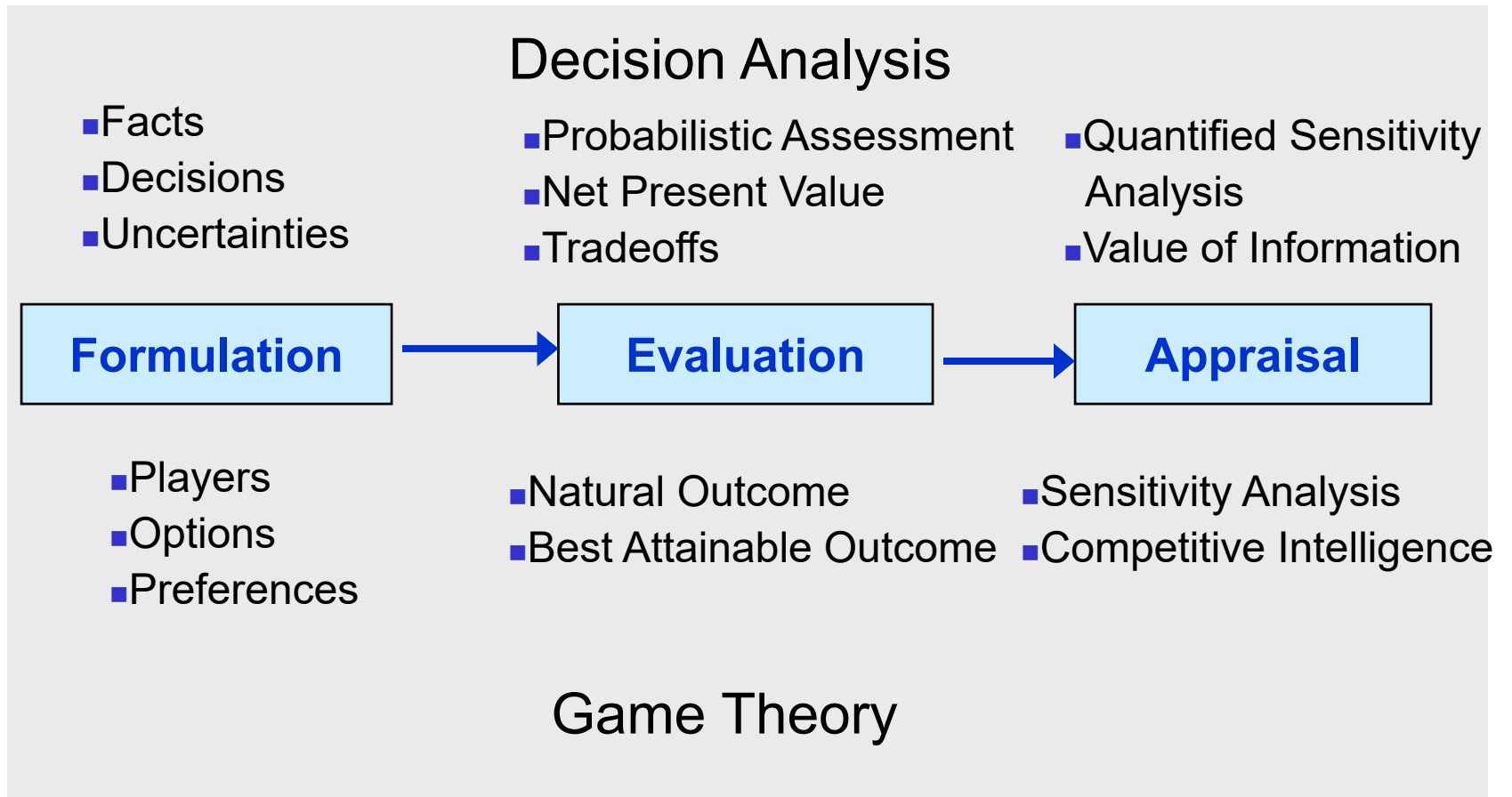
Differences – DA and Game Theory

Decision Analysis

- Critical driver – quantifiable uncertain variables
- Condense into a few outcomes to make the decision
- Financial result which informs the business case, justifies the investment
- Distinct strategies
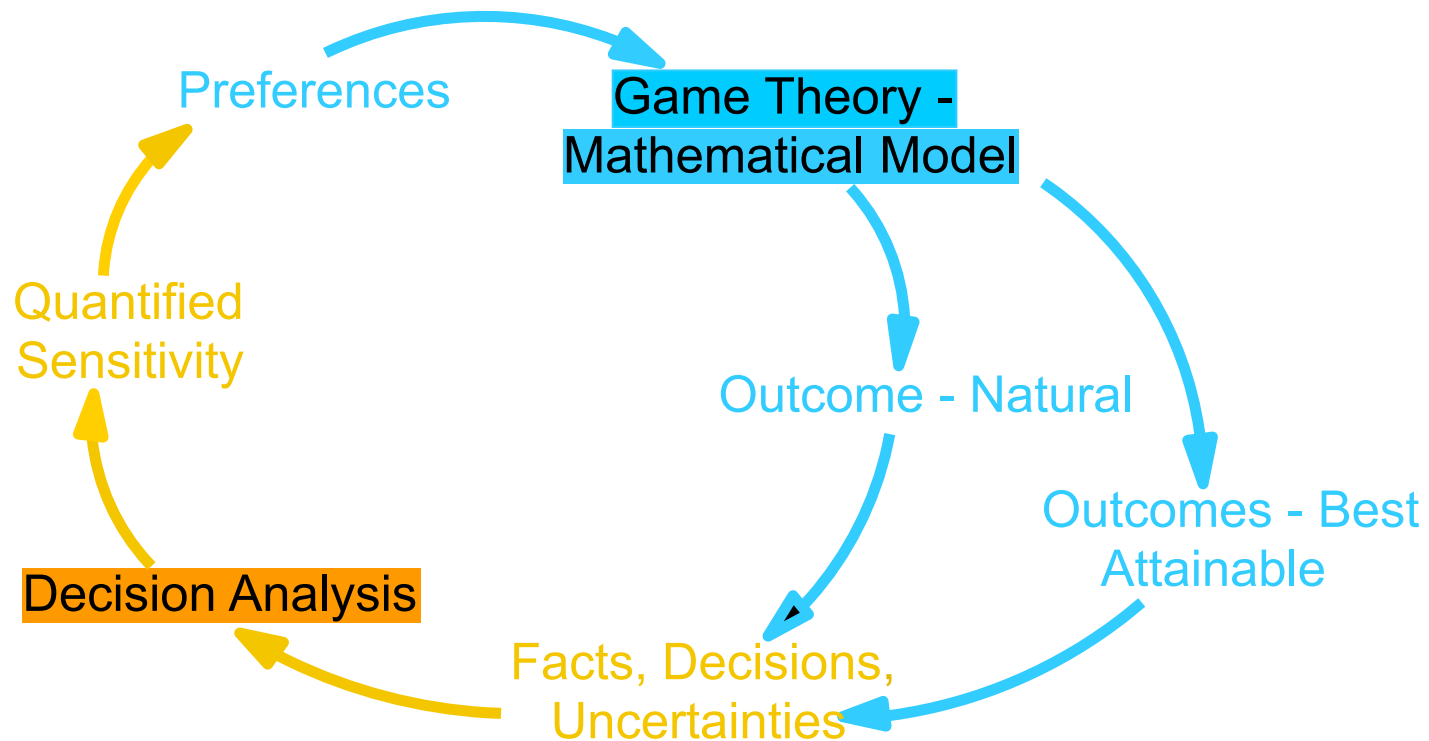- Strategies focused on "the what"

Game Theory

- Critical driver – What others can do to affect the outcome
- More outcomes than can be financially analyzed
- Multiple value measures based on preferences
- Multiple actions and outcomes
- Strategies focused on relationships and "moves" for implementation

Combining Perspectives is Powerful

Decision Analysis

- Facts
- Decisions
- Uncertainties

- Probabilistic Assessment
- Net Present Value
- Tradeoffs

- Quantified Sensitivity Analysis
- Value of Information

Formulation → **Evaluation** → **Appraisal**

- Players
- Options
- Preferences

- Natural Outcome
- Best Attainable Outcome

- Sensitivity Analysis
- Competitive Intelligence

Game Theory

Complementary at the Formulation and Implementation Stages

Preferences

Game Theory - Mathematical Model

Quantified Sensitivity

Outcome - Natural

Outcomes - Best Attainable

Decision Analysis

Facts, Decisions, Uncertainties

- Complementary decision support tool that provides a different perspective to other methods such as DA, Systems Dynamics, Scenarios, Other economic analyses.

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Integration "Signals" & Practical Combinations

- ## Signals
  - Gain new perspective/frame on the decision problem
  - Engage range of decision makers
  - Competitive landscape important to DA
  - Emotional and political element important to DA
  - Human dynamics play large role

- ## Practical Combinations
  - Mergers and Acquisitions – determine negotiating positions based on what others can do
  - Contingency Planning – identifying risks and developing alternative strategies for analysis
  - Competitive Strategy & Competitive Intelligence Initiatives
  - Strategic Planning
  - Scenario Development