Application of DMU(Decision Making Under Uncertainty) on Korean Transport Infrastructure Feasibility Study

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Contents

Ⅰ Introduction

Ⅱ On-going Study Result

Ⅲ Unfolding The Future

I Introduction

1. Future Changes in Investment Environment

4th Industrial Revolution

Criteria Quantity — GDP, Congestion, etc.

Data with Hassle — User equilibrium, Monitoring, etc.

Conflict Hidden — Decision Maker behind Table, etc.

Correlation Linear — Importance Element, etc.

Abrupt Change

Technology
(IOT, AI, Autonomous Car, Dron, etc.)

Social Economic Change
(Population, Political Power, etc.)

Priority Competition
(Development, Conservation, etc.)

Concept Evolution
(Car Sharing, etc.)

Paradigm Shift

Criteria Quality — Employment, Income, Happiness, etc.

Big Data without any Hassle — Social Optimum, Direction, etc.

Conflict Open — Decision Maker on Table, etc.

Correlation Non-Linear — Vulnerability, etc.

1. Future Changes in Investment Environment

Long-term

National·Global

Government Role, Global System, Global Security

Economy

Growth capacity, Labor Risk, Labor Essential

The individual

Identity, Ethics, Human Connection, Information

Business

Paradigm shift, Expectation of customer, Big data

Society

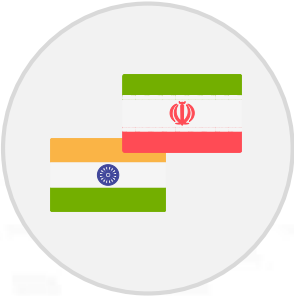
Inequality, Middle Class, Political Power

Short-term

Liberalism VS Anti-globalization, Nationalism, Protectionism

7th M&A Flow Change

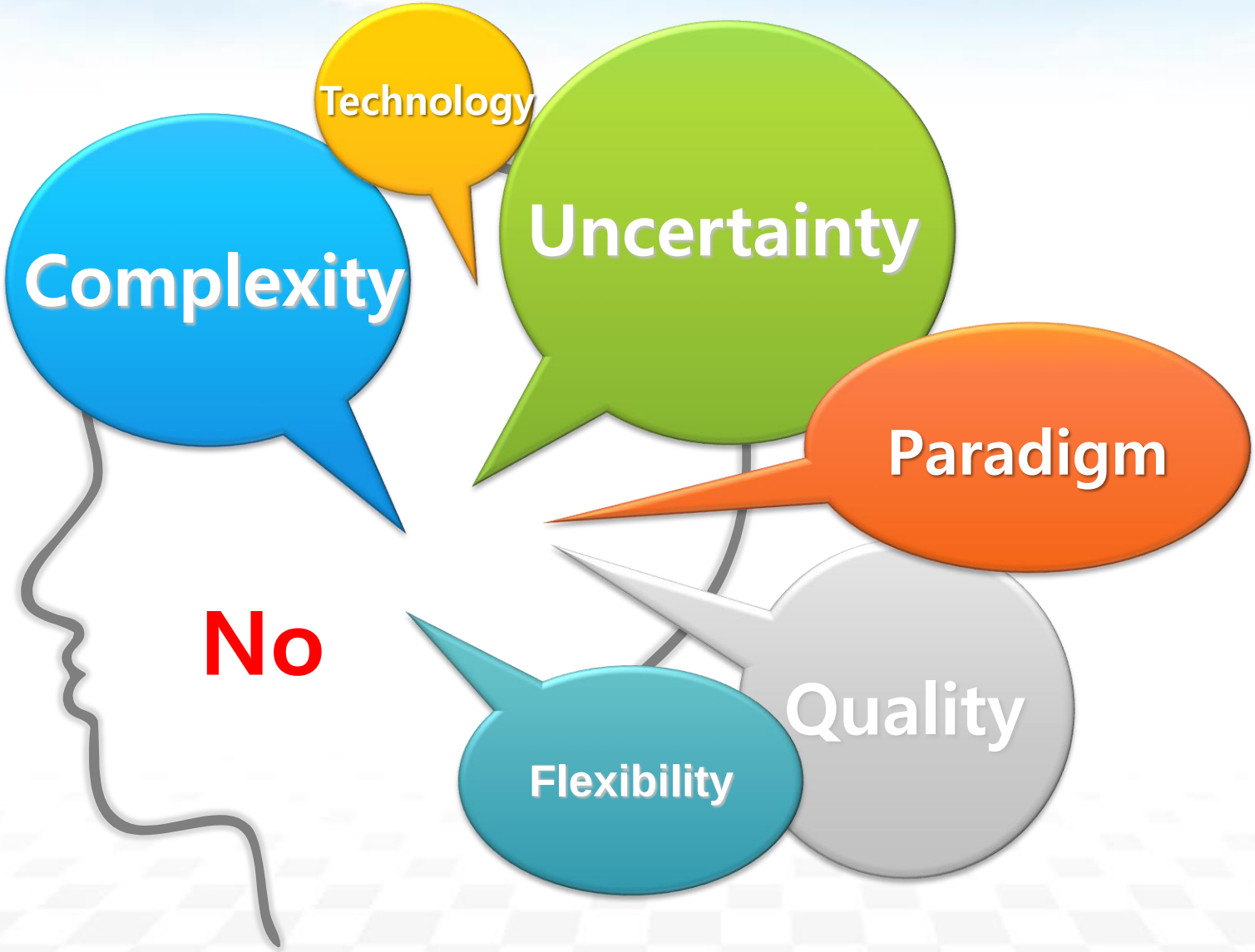
Long-term low interest, Slow growth



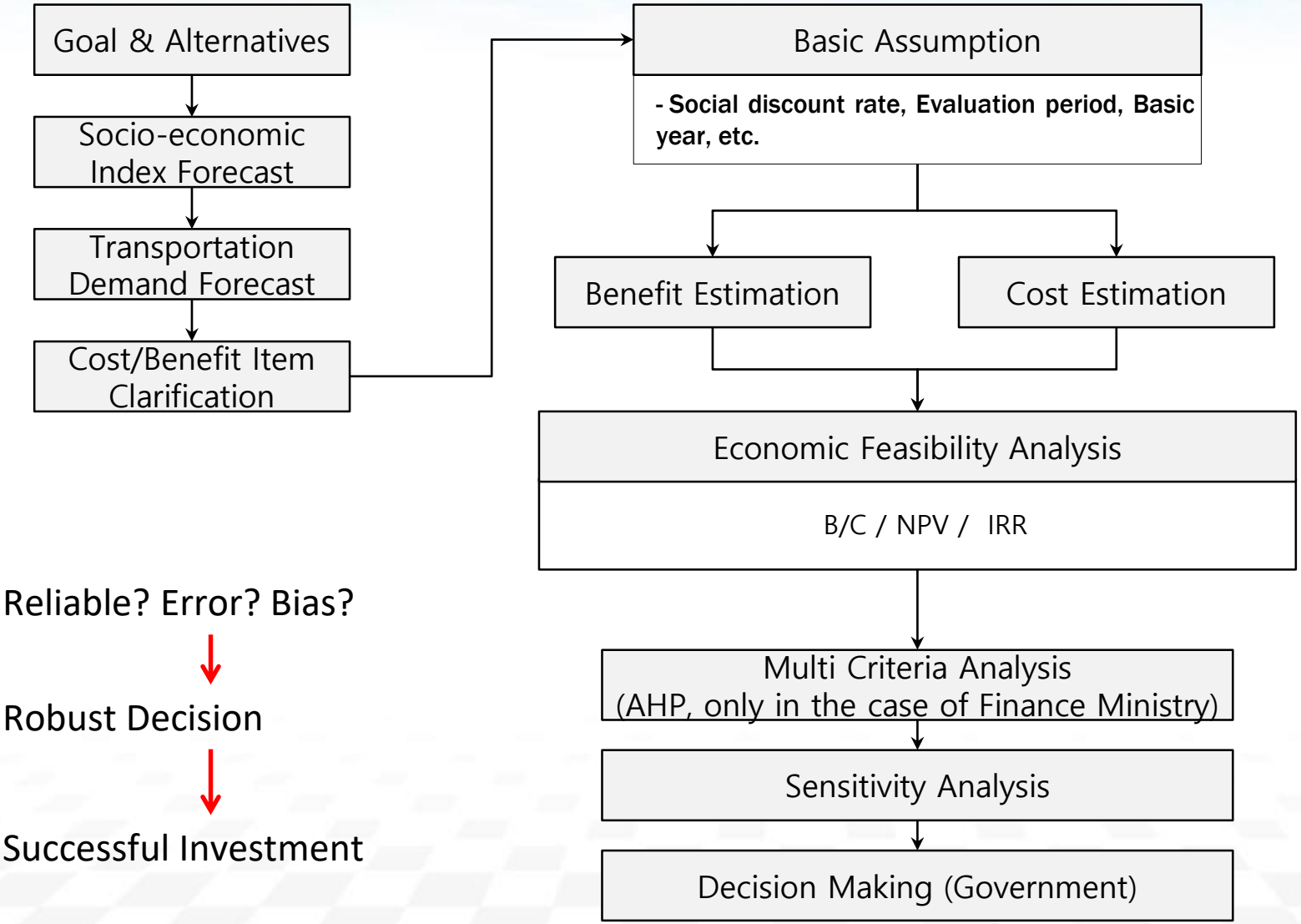
New Global Economic Power

Traditional Economic Assumption Change

2. Is Traditional Method viable in the future?



3. Current Feasibility Study in Korea(1/2)



Reliable? Error? Bias?

↓

Robust Decision

↓

Successful Investment

3. Current Feasibility Study in Korea(2/2)

DMU Method

Considering uncertainty

Applied to the whole process

Decision makers on the table

Minimizing the negative impact

Finding the best strategy

Present Decision Making

Feasibility Study

↓

Planning & Design

↓

Construction

↓

Evaluation

↓

Countermeasure Performing

Demand : 19,976pcu/day

Estimated Cost : +38%

Cost : +18.4%
Period : +10%

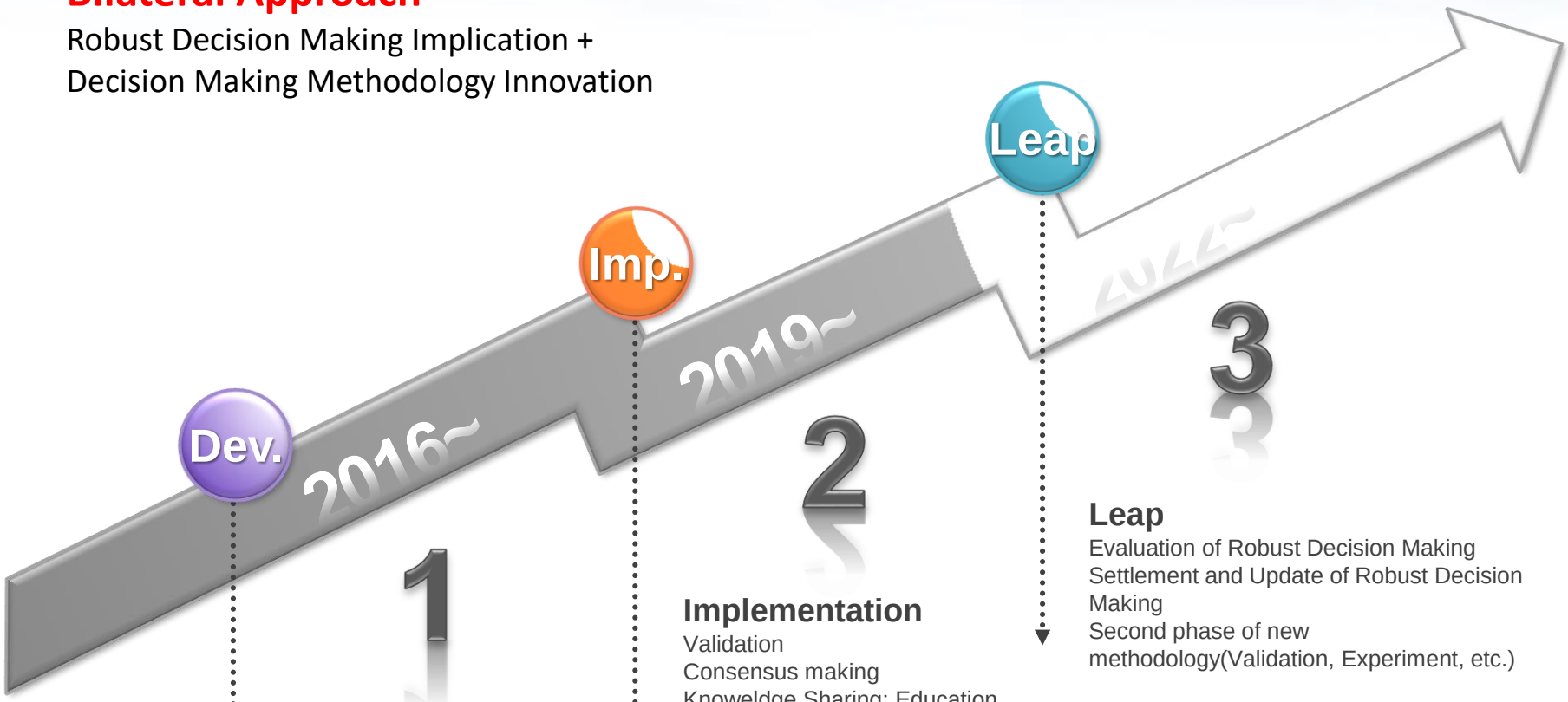
Demand : 9,750pcu/day
B/C : 0.81

Assumption Change!!

4. Research Plans of KOTI: Big Picture

Bilateral Approach

Robust Decision Making Implication +
Decision Making Methodology Innovation



Development

Definition of Future Transport
Robust Decision Making Method
Based on Traditional Method
Implicaiton Strategy
Experiment: Real Cases
New concept for Decision
Making Process

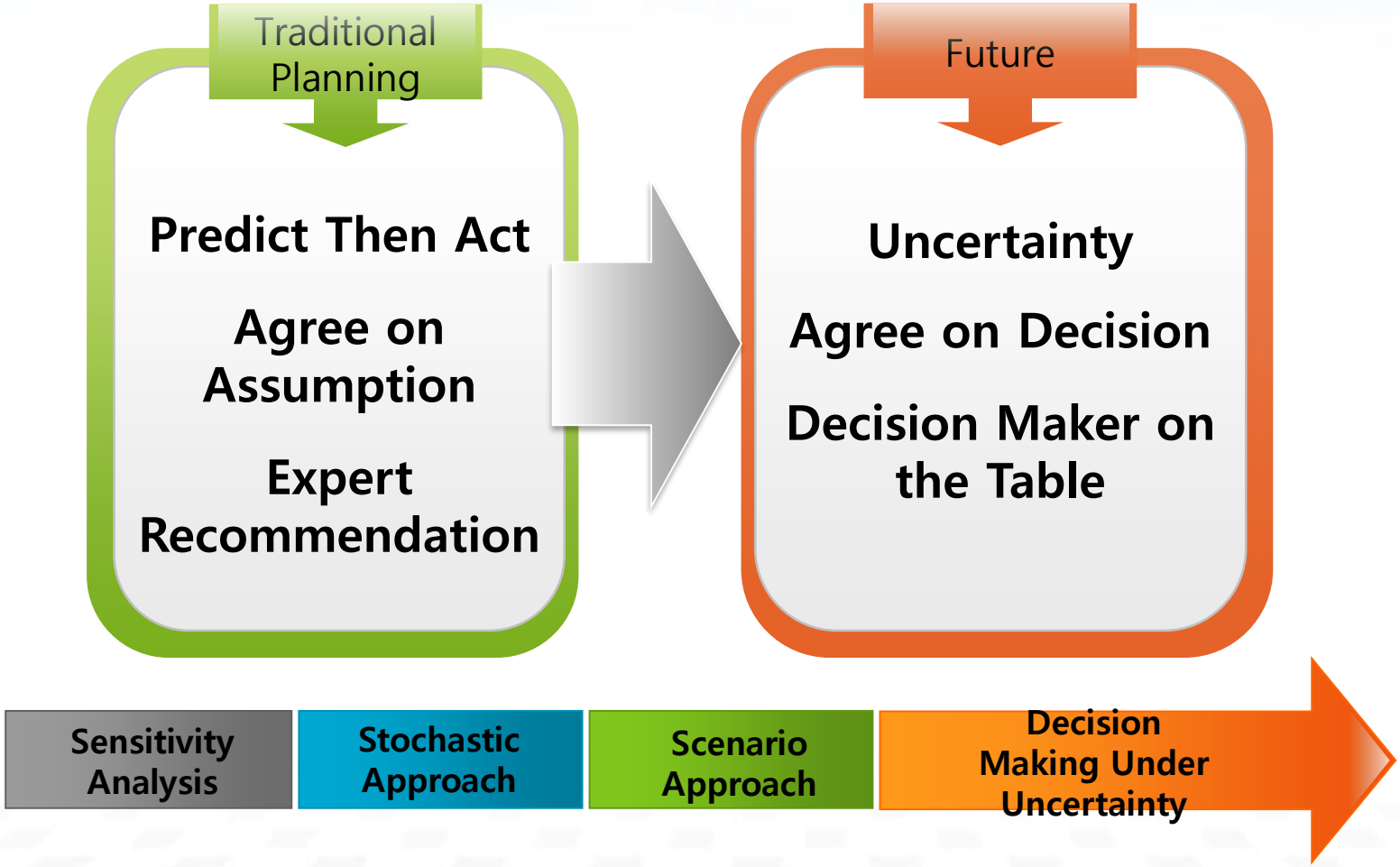
Implementation

Validation
Consensus making
Knoweldge Sharing: Education,
Conference, etc.
System renovation for
Governance Structure
New methodology development
to replace traditional method

Leap

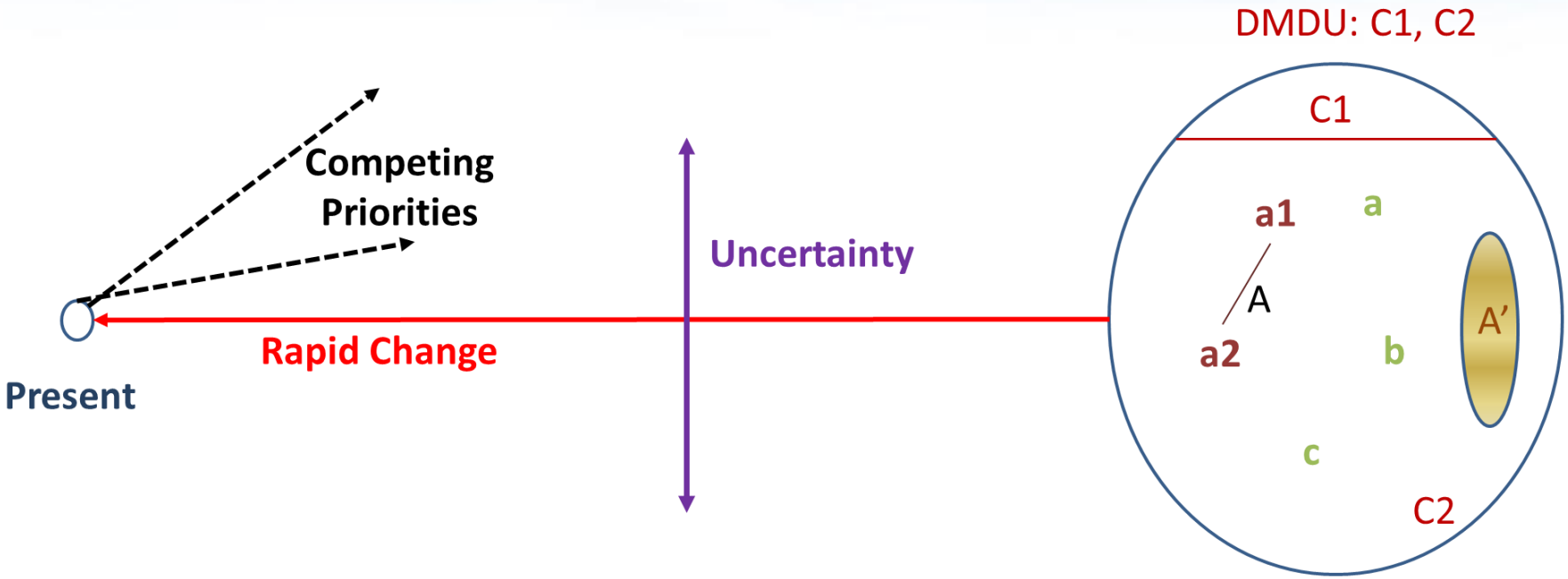
Evaluation of Robust Decision Making
Settlement and Update of Robust Decision
Making
Second phase of new
methodology(Validation, Experiment, etc.)

5. First Step


Traditional Planning
Predict Then Act
Agree on Assumption
Expert Recommendation
Future
Uncertainty
Agree on Decision
Decision Maker on the Table
Sensitivity Analysis
Stochastic Approach
Scenario Approach
Decision Making Under Uncertainty

Ⅱ On-going Study Result

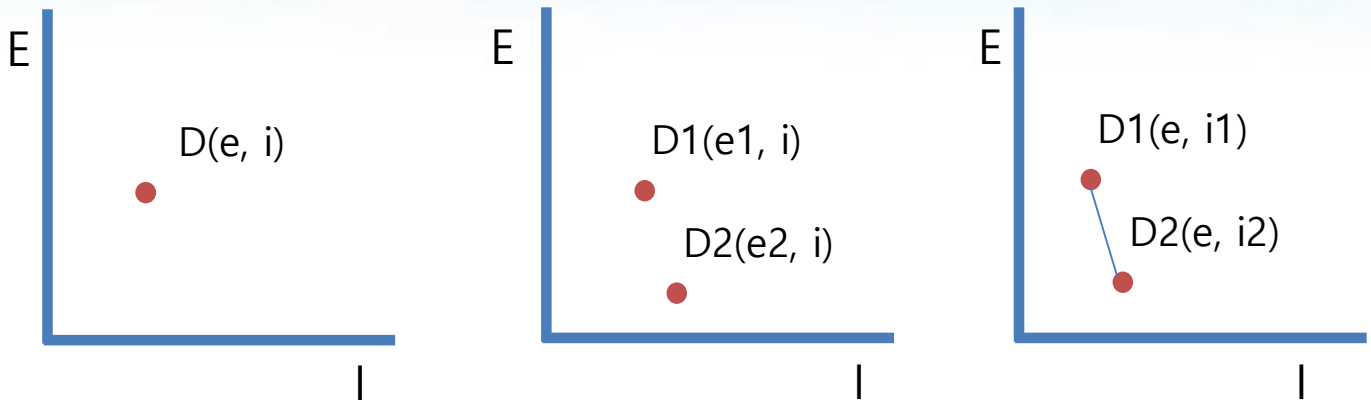
1. Understanding of The DMU Concept(1/2)



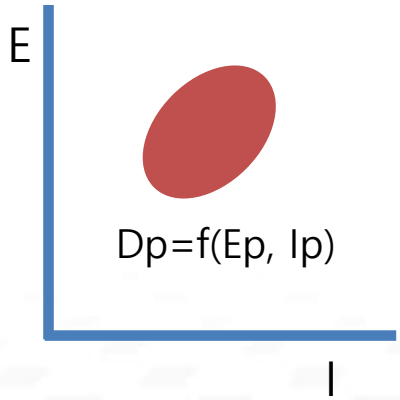
Methodology	Assumption	Future	Decision	Stakeholders	Application Flexibility
Current	Before Evaluation	One	Deterministic	Decision Maker	Fixed
Sensitivity	Before Evaluation	One	Risk Finding	Decision Maker	Fixed
Scenario	Before Evaluation	Several	Deterministic	Decision Maker	Fixed
Stochastic	Before Evaluation	Weighted	Risk Finding	Decision Maker	Partially Strategic
DMU	After Evaluation	Discovery	Negotiation	Flexible	Fully Strategic

Current: A
Stochastic: A'
Scenario: a, b, c
Sensitivity: a1, a2

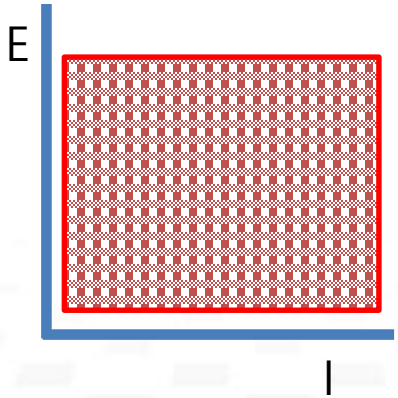
1. Understanding of The DMU Concept(2/2)



Traditional **Scenario** **Sensitivity**



Stochastic



Best Strategy: D1 is optimal, but when E<e, I<I, D1=Vulnerable, D2=trade-off, so prepare something

DMU

E: Condition, I: Variable

2. DMU in Transportation Infrastructure

DMDU in Transportation Infrastructure

To here

Transportation Infrastructure
- Transportation Mode
- Maximize Benefit

Decision Making
- Benefit/Cost

Not Perfect, but Tolerable Result

Climate Change, Information technology, Social Paradigm Shift, Rapidly emerging transport technologies(autonomous car, dron, …), etc. → **Investment Failure**

No Longer Effective

To the Future

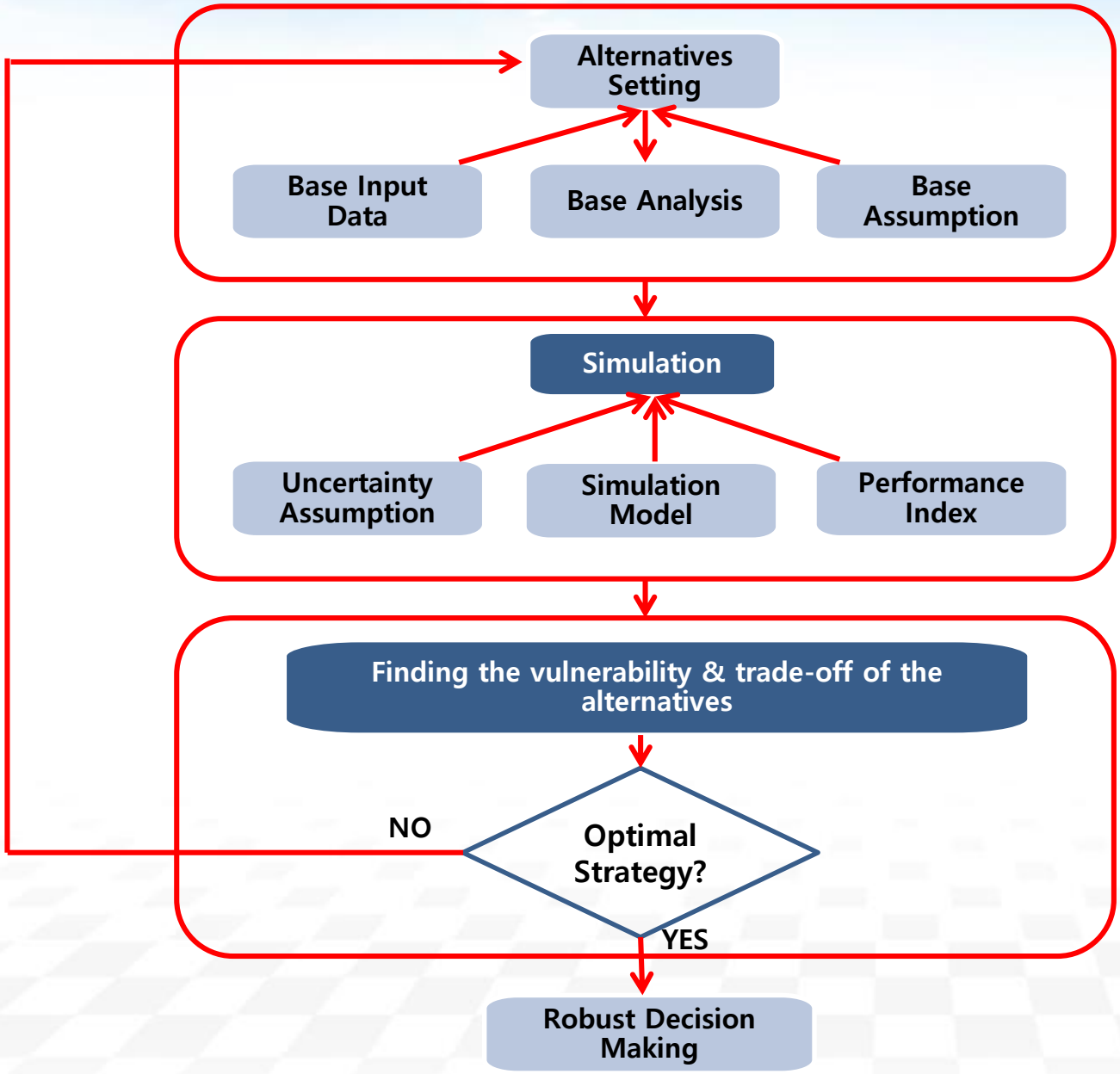
Transportation Infrastructure

Too many parameters
- Transportation Mode Change
- Social Economic Change
- Innovative Technology
- Paradigm Competition

Decision Making
- Beyond B/C
- Negotiation
- Collective Wisdom
- Prepared for Rainy Days

Robust Decision Making, but need for the decision making process change first

3. Study Framework(1/2)



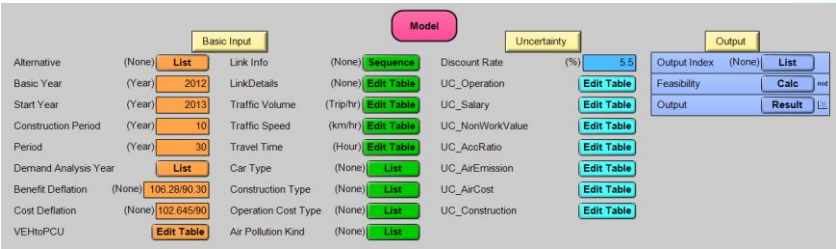
STEP1: Making Strategy
(Feasibility Scheme)

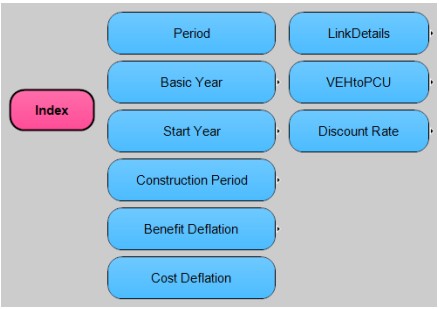
STEP2: Simulation
(Analytica 4.0)

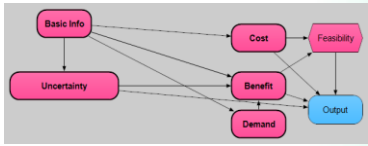
STEP3: Scenario Discovery
(R package, PRIM Model)

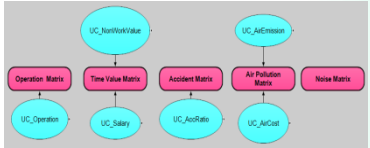
3. Study Framework(2/2)

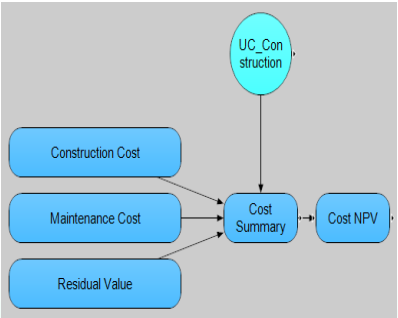
Analysis Tool

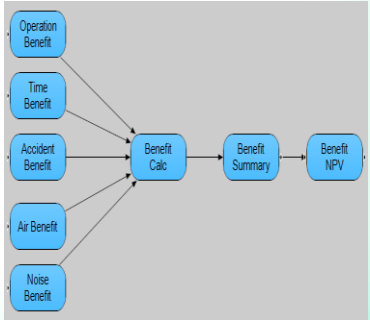




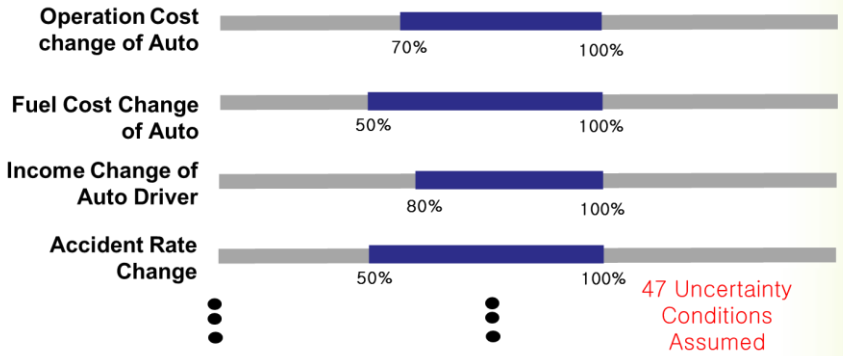








Uncertainty Factors



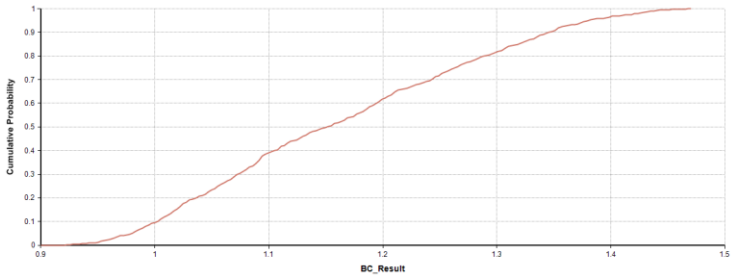
- Uncertainty: Operation Cost, Income Change, PCU, Discount Rate, Accident Cost, Accident Rate, Air emission Cost, Noise Cost, etc.
- Application: Uniform Distribution, LHS, 1,000 iterations

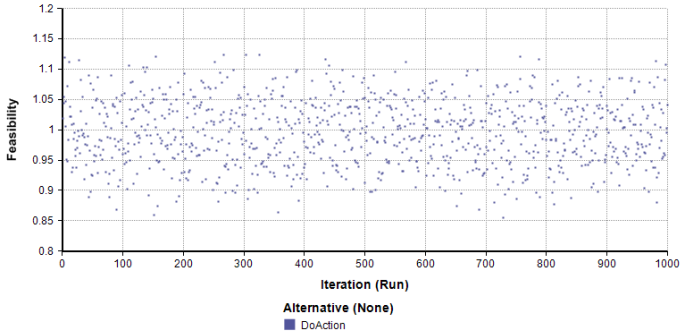
4. Case Study(1/3)

Target Case

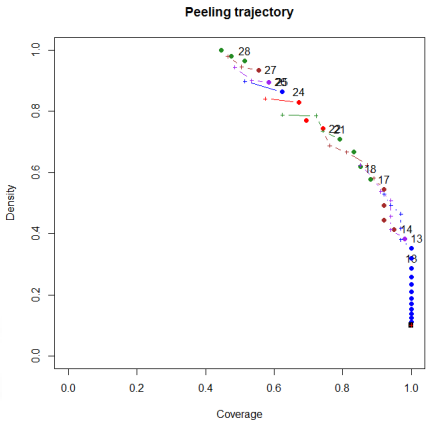
- A Newly-organized local road project, 7.36km, KRW 200 billion subsidized by the government, 10 year project
- Project Objective: Resolving chronic traffic congestion

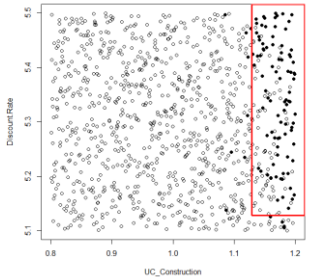
Simulation

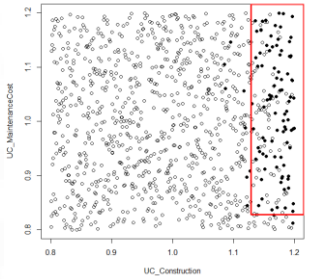




Searching







4. Case Study(2/3)

Dataset Statistics					
Total number of points					1000
Total number of interesting points					101
Global mean					0.101
Total input dimensions					47
Ensemble box sequence statistics					
Total number of boxes	1				
Ensemble coverage	0.7921	80 out of 101interesting points captured			
Ensemble density	0.7080	80 out of 113 captured points are interesting			
Ensemble support	0.113	113 out of 1000 total points are captured			
Report on individual boxes					
Box 1					
Density					0.7080
Coverage					0.7921
Support					0.113
Box definition	Dimension name	Bound	Density	Coverage	Support
	Construction cost (baseline proportion)	> 1.1294	0.1010	1.0000	1.000
	Value of transit time (Truck) (baseline proportion)	< 1.0521	0.5284	0.9208	0.176
	Discount rate (%)	> 5.1282	0.6232	0.8515	0.138
	Maintenance cost (baseline proportion)	> 0.8286	0.6667	0.8119	0.123

4. Case Study(3/3)

Recommendation

- **The given alternative is not profitable unless the value of transit time of truck drivers does not exceed 5%, the discount rate does not go below 5.12%, the construction cost increase to 12%, and the maintenance cost does not drop below 82.8%**

Interpretation

Categories	Possibilities	Discussion
Value of transit time of truck drivers	The value of transit time of truck drivers will not exceed 5% with the advent of autonomous trucks.	Given alternative is profitable based on the current assumptions, but is fragile if future uncertainty is included. An alternative to resolve construction costs and maintenance costs needs to be examined.
Discount rate	There might be a drop in discount rates but it seems unreasonable to go below 5.12%	
Construction cost	An increase in construction costs more than 12% is prevalent, so there is a high chance of this occurring	
Maintenance cost	Even with the advent of new technology to deal with maintenance costs, it is very unlikely that the cost will go below 82.8%	

5. Limitations and Suggestions

Linear Scale Effect of current structure	- **Limitation: Existing validity structure is a linear structure that is sensitive to baseline parameters such as social discounts.** - **Solution: Identify both positive and negative sides of uncertainties in terms of cost and benefit, then promote studies on how to adjust the scale on main factors.**
Inconvenience on uncertainties	- Limitation: During the process of selecting or considering uncertainties, it might develop into a convenience of policy. - Solution: Each year, establish guidelines on the scope or variables of uncertainties through research facilities with public confidence.
Detailed plan to promote participation of interested parties	- Limitation: Concrete plan to promote the participation of interested parties is not in the scope of KDMU. - Solution: Establish a method to promote the participation of decision makers on the basis of KDMU.
Activation of initial application	- Limitation: Activation of an initial application and expansion is limited as it implements a different paradigm to an existing one. - Solution: Through institutions with public confidence, provide regular training, seminars and informational packages that can be used immediately.

6. 2nd Year Plan(1/2)

Study Period : 2017.05 ~ 2018.04

Research Objectives

- Improvement of 1st year Research
- Completion of KDMU

Basic Concept

- More consideration of Uncertainties

1st year

- Based on measurable component included in B/C Analysis (Demand, Cost, Benefit …)

2nd year

- Based on future circumstance change (climate, technology, Investment)

6. 2nd Year Plan(2/2)

Basic Concept

- Improvement of Analysis methodology

1st year	2nd year
• B/C Analysis	• Multi criteria Decision Making Method

- Expansion of Analysis mode

1st year	2nd year
• Construction of transport facility (Road, Railroads…)	• Improvement of facilities • New transport system • Policy assessment

III Unfolding The Future

1. Current Obstacles

Expert Bias	Misunderstanding DMU is one of previous methodology Resist to get the negotiation system involved in analysis
Political Consensus	Concerned on the Impact in decision making in terms of political power
Administrative System	Legal system for investment decision making is complicated Newly decision making process is needed
Cultural Context	Negotiation between stakeholders is difficult in Korea Culture based on the quantitative analysis

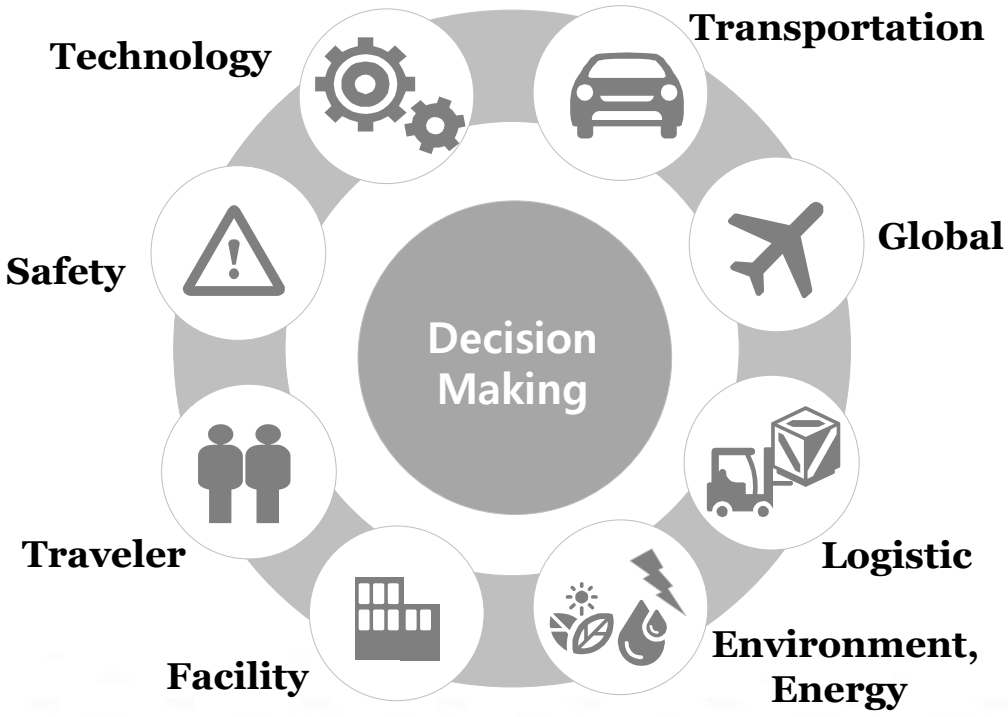
2. Strategy for Realization

Deterministic, Linear, Local

Base Researches + Infra System + Feedback

- Education
- Consensus
- Examples
- Proof
- Enhancement

Uncertain, Nonlinear, Global



3. Future Collaboration Agenda

Implementation

- Share the vision and future direction
- Master plan establishment
- Experiment on real cases jointly
- Application to on-going projects

Consensus

- Collaboration on joint seminar, international conference, etc.
- Joint research paper
- Spread the methodology to stakeholders

Model Development

- Share the research knowledge & Experience
- Enhancement of theoretical basis
- Joint research team organization

Future?

Without Strategy

Nobody Knows

Together

Everybody Enjoys

THANK YOU

감사합니다

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