# TECHNOLOGY FORECASTING FOR MEDIUM TERM USING FUNCTION ORIENTED MODEL BASED ON TRIZ

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# 1. Back ground research

## 1. Define of technology forecasting

| Person | Define | Reference |
|--------|--------|-----------|
| **Lenz** (1961) | Invention for social benefit and forecasting for technology characteristic and dimension or performance | Lenz, R.C "A Heuristic Approach to Technology Measurement" Technology forecasting and Social change Vo;27(1985) pp.249-264 |
| **Jantsch** (1967) | Probabilistic verification about future happening technology process | Jantch, E., Technology Forecasting in Perfective. Paris : OECD Publication, 1967 |
| **Bright** (1978) | The quantitative prospect of technology happening, technology characteristic, change speed of performance | Bright, J.R., Practical Technology Forecasting : Concepts and Exercise. Austin, TX : Industrial Management Center, 1978. |
| **Martino** (1993) | The prospect about useful mechanic, process, technique for future characteristic | Martino, J.P., Technological forecasting for Decision Making(3rd ed.). New york : Mc-Graw Hill, 1983 |

Historical define about technology forecasting

- **Technology Foresight** (Qualitative meaning)

  : Assume about possibility of various future situation, focus on increasing crisis management based on qualitative analysis

- **Technology Forecasting** (Quantitative meaning)

  : Forecast detail future situation using quantitative method and focus on best decision making

# 1. Back ground research

## 2. Process of technology forecasting

- 1ˢᵗ step – Set up of technology forecasting purpose
  - ① The purpose of technology forecasting
  - ② Correct analysis of forecasting target
  - ③ Set up about forecasting time period

- 2ⁿᵈ step – Extract technology project and needs
  - ① Needs understanding based on social and economical point of view
  - ② Find technology project which can react customer's needs

- 3ʳᵈ step - Define forecasting methodology
  - ① Prepare criteria of choice standard (purpose, characteristic, limit and so on)
  - ② Understand each forecasting methodology (Merit/demerit, possibility for application and so on)

- 4ᵗʰ step – Implement technology analysis and forecasting
  - ① Technology analysis and understanding surrounding relation technology
  - ② Care of forecasting error effect such as environment, individual, wrong define and so on

- 5ᵗʰ step – Verification of technology forecasting
  - ① Verify forecasting result and apply at management plan
  - ② Prepare uncertain effects

# 1. Back ground research

## 3. The period of technology forecasting

① Short term forecasting (within 1 year)

: Do not expect real change and check technology variation and gathering. Use simple statistic method

**② Medium term forecasting (3 ~ 5 years)**

: Need very correct and confidence forecasting.

Help to understand uncertainty regarding future business environment and big possibility to happen within near future

③ Long term forecasting (Over 5 years)

: Deal with wide range technology which has uncertainty. Value at deciding group consensus rather than decision making

# 1. Back ground research

## 4. Compare each technology forecasting method

- The 8 major technology forecasting method (Research result from 450 company)

| Method | Explain method | Application | Merit | Demerit |
|---|---|---|---|---|
| **Delphi** | • Questionnaire to expert to<br>• Result from gathering opinion | • Find and check whole judgment<br>• Area for big uncertainty | • Fast feedback (Related)<br>• Easy to conclude result<br>• Not expensive | • Possibility to lose good consensus<br>• Intuitive related with others |
| **Cross-Impact Analysis** | • Forecasting of realization<br>• Quantitative method for Delphi | • Understanding of future technology trend | • Escape from error of misunderstanding related with future interaction factors | • Difficult to verify complicated information<br>• Need clear assumption |
| **Trend extrapolation** | • Future forecasting based on historical trend<br>• Regression analysis | • Change variation from using alternative technology | • Simple method<br>• Effective cost | • Difficult to understand from historical trend<br>• Meaningless at new technology |
| **S-Curve** | • Forecasting from Logistic Curve and parameter | • Need to check time and how to apply technology at the market | • Simple method | • Difficult to find good example which having suitable trend |
| **Simulation** | • Forecasting using modeling about real model and control factors | • Major decision making analysis including enough expense | • Enough and detail result<br>• High accuracy | • High cost<br>• Need to understand complicate technology and other factors |
| **Scenario** | • Assume future circumstance based on reality and connection | • Apply specific situation which can not measure factors | • Very detail forecasting<br>• Enough analysis | • High cost<br>• Difficult to apply at complicate result |
| **Related technology Analysis** | • Research whole industrial technology and interaction of each core technology | • Forecasting about new technology, core and extend technology | • Understanding about related product and technology | • Difficult to understand other connected technology |
| **Relevance Tree** | • Forecasting logical relation using tree modeling<br>• Find alternative idea | • Check alternative R&D | • Provide wide technological factors<br>• Show how to achieve good result from forecasting | • Not enough informtion for alternative idea |

# 1. Back ground research

## 5. Summary of back ground research

- Many forecasting methods are not for the technology forecasting (From other research area)

- Forecasting result from 3 ~ 4 methods complexly

- General future forecasting methods are

  ① Literature review ② Expert panel ③ Scenarios

- Period and methodology from technology forecasting point of view

  ① Long term (over 10 years) : Scenarios, Workshop, Essays, Trend extrapolation, Modeling and simulation, Megatrend

  **② Medium term (within 5 years) : Not existed**

## 6. Research proposal

> Research Aim

  : Technology forecasting model research for medium term based on TRIZ

> Research Objective

  : Help to decide technology strategy and business from suggested forecasting model

# 2. Main research

## 1. Step#1

### ■ Analysis of technology system and development direction

① Select target technology system

② System analysis based on technology system completeness

③ Extract each factors function

④ Multi Screen Method and rough forecasting

① **Function Oriented System Analysis**
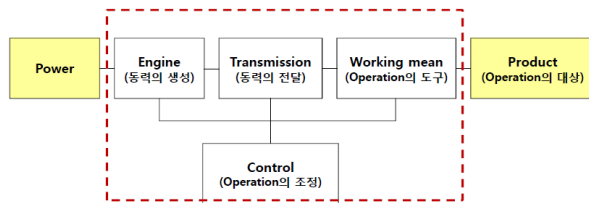
| Factor | Technology system | | | |
|--------|-------|--------------|---------|------------|
| | **Engine** | **Transmission** | **Control** | **Tool** |
| Item | Battery | Electric kit | CPU | Vision/Memory |
| Field | EL/ME | EL | EL | ME |
| Function | Give | Send | Calculation | See / Write |

② **Multi Screen Thinking**
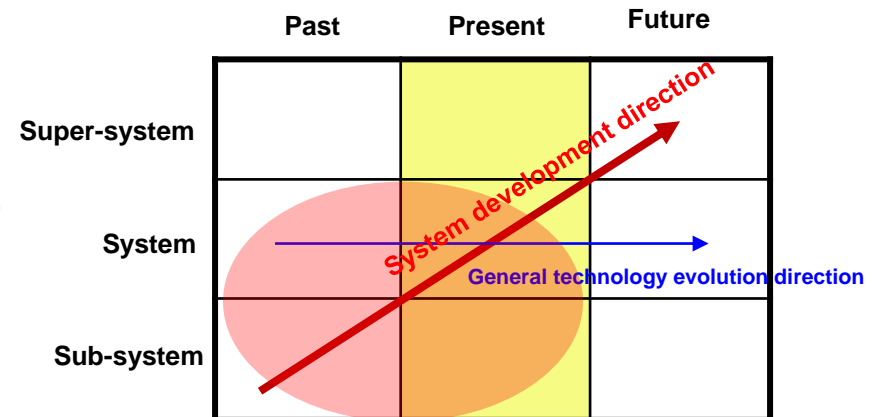
# 2. Main research

## 2. Step#2

■ **Rearrange TRIZ tool & theory for making model**

> Technology evolution theory, 39 Engineering parameter, 76 Standards solution

> Rearrange based on function oriented change of technology system

| Big class level | Medium class level (Field) | Small class level  (39 parameter / 76 solutions) | |
|---|---|---|---|
| 1. S-Curve | Mechanical | weight | Power |
| 2. Ideality | Electric | length | Waste of energy |
| 3. Completeness | Magnetic | Area | Waste and loss |
| 4. Energy Conductivity | Chemical | Volume | Waste of time |
| 5. Dynamicity | Acoustic | Speed | Amount |
| 6. MATChEm | Themal | Force | Reliability |
| 7. Macro to Micro | | Tension,Pressure,Stress | Accuracy (measurement, manufacuring) |
| 8. Transition to Super system | | Shape | Hamful factors |
| | | Stability | Manufacturability |
| | | Strength | Repairability |
| | | Durability | Adaptability |
| | | Temperature | Complexity |
| | | Brightness | Automation |
| | | Energy spend | Productivity |

# 2. Main research

## 3. Step #3

### ■ Rearrange TRIZ tool & theory for making model

> Technology evolution index from Step#1, #2

> Interview for increasing reliability (MATRIZ Level3, 3 person)

→ Technology forecasting model index for medium term (5 class, 25 items)

| Class I
Core technology development
Beginning system development | |
|---|---|
| | 1. Core technology |
| | 2 . Minimize/Simple |
| | 3 . Maximize/Duplicate |
| | 4 . Streamline (revised Design) |
| | 5 . Individual function combine |

| Class II
Enhance function, performance, convenience, Growth market | |
|---|---|
| | 6. Speed / Performance |
| | 7. Strength / Stiffness |
| | 8. Convenience |
| | 9. Stability |
| | 10. Complement function |

| Class III
System stability & Optimization | |
|---|---|
| | 11. Enhance automation |
| | 12. Enhance productivity |
| | 13. Reduce wasted energy |
| | 14. Remove side effects |
| | 15. Supplement function |

| Class IV
Enhance accuracy
Competition of 2<sup>nd</sup> market | |
|---|---|
| | 16. Measurement accuracy |
| | 17. Enhance precision degree |
| | 18. Enhance reliability |
| | 19. Enhance detection ability |
| | 20. Combination of functions |

| Class V
System complete
2<sup>nd</sup> evolution | |
|---|---|
| | 21. Technology Fusion |
| | 22. Technology Convergence |
| | 23. Innovation (New Platform) |
| | 24. ICT, BT |
| | 25. Function substitution |

# 2. Main research

## 4. Step #4

### ■ Rearrange TRIZ tool & theory for making model

> Place index (component, function) from step#1 at row of matrix model

> Place index from step#3 at column of matrix model

| Class | Index | Tool | | Transmission | | Control | | Engine | |
|---|---|---|---|---|---|---|---|---|---|
| | | Component | Function | Component | Function | Component | Function | Component | Function |
| Class I<br>Core technology development<br>Beginning system development | 1. Core technology | | | | | | | | |
| | 2 . Minimize/Simple | | | | | | | | |
| | 3 . Maximize/Duplicate | | | | | | | | |
| | 4 . Streamline (revised Design) | | | | | | | | |
| | 5 . Individual function combine | | | | | | | | |
| Class II<br>Enhance function, performance, convenience<br>Growth market | 6. Speed / Performance | | | | | | | | |
| | 7. Strength / Stiffness | | | | | | | | |
| | 8. Convenience | | | | | | | | |
| | 9. Stability | | | | | | | | |
| | 10. Complement function | | | | | | | | |
| Class III<br>System stability & Optimization | 11. Enhance automation | | | | | | | | |
| | 12. Enhance productivity | | | | | | | | |
| | 13. Reduce wasted energy | | | | | | | | |
| | 14. Remove side effects | | | | | | | | |
| | 15. Supplement function | | | | | | | | |
| Class IV<br>Enhance accuracy<br>Competition of 2nd market | 16. Measurement accuracy | | | | | | | | |
| | 17. Enhance precision degree | | | | | | | | |
| | 18. Enhance reliability | | | | | | | | |
| | 19. Enhance detection ability | | | | | | | | |
| | 20. Combination of functions | | | | | | | | |
| Class V<br>System complete<br>2nd evolution | 21. Technology Fusion | | | | | | | | |
| | 22. Technology Convergence | | | | | | | | |
| | 23. Innovation (New Platform) | | | | | | | | |
| | 24. ICT, BT | | | | | | | | |
| | 25. Function substitution | | | | | | | | |

# 2. Main research

## 5. Step #5

### ■ Rearrange TRIZ tool & theory for making model

> Component : Patent count arrangement of system for quantitative analysis

> Function : Key word arrangement for qualitative analysis

**Quantitative analysis**

**Qualitative analysis**

| Class | Index | Tool | | Transmission | | Control | | Engine | |
|---|---|---|---|---|---|---|---|---|---|
| | | Component | Function | Component | Function | Component | Function | Component | Function |
| Class I Core technology development Beginning system development | 1. Core technology | | | | | | | | |
| | 2 . Minimize/Simple | | | | | | | | |
| | 3 . Maximize/Duplicate | | | | | | | | |
| | 4 . Streamline (revised Design) | | | | | | | | |
| | 5 . Individual function combine | | | | | | | | |
| Class II Enhance function, performance, convenience Growth market | 6. Speed / Performance | | | | | | | | |
| | 7. Strength / Stiffness | | | | | | | | |
| | 8. Convenience | | | | | | | | |
| | 9. Stability | | | | | | | | |
| | 10. Complement function | | | | | | | | |
| Class III System stability & Optimization | 11. Enhance automation | | | | | | | | |
| | 12. Enhance productivity | | | | | | | | |
| | 13. Reduce wasted energy | | | | | | | | |
| | 14. Remove side effects | | | | | | | | |
| | 15. Supplement function | | | | | | | | |
| Class IV Enhance accuracy Competition of 2<sup>nd</sup> market | 16. Measurement accuracy | | | | | | | | |
| | 17. Enhance precision degree | | | | | | | | |
| | 18. Enhance reliability | | | | | | | | |
| | 19. Enhance detection ability | | | | | | | | |
| | 20. Combination of functions | | | | | | | | |
| Class V System complete 2<sup>nd</sup> evolution | 21. Technology Fusion | | | | | | | | |
| | 22. Technology Convergence | | | | | | | | |
| | 23. Innovation (New Platform) | | | | | | | | |
| | 24. ICT, BT | | | | | | | | |
| | 25. Function substitution | | | | | | | | |

# 3. Verification (Case Study)

## 1. Select case study

### 1) Case : black box for Vehicle

### 2) Select reason

> On going technology development

> Would be disappeared in the future (Remain its function on the other system)

### 3) Recent technology trend

> Will increase market around $ 0.52 B in 2014 (Korea)

> Increase penetration rate from 0.4 % in 2008 to 30 % in 2013 (Korea)

> Obligation duty of installation black box for vehicle in China and US in the near future
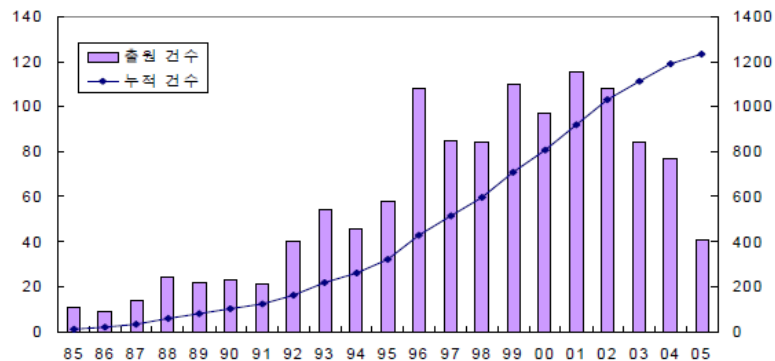


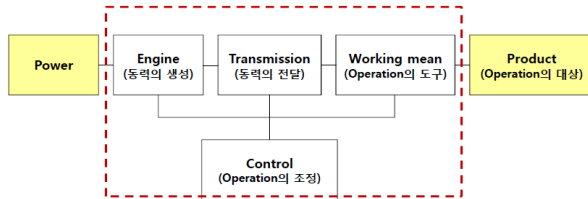**Patent trend of black box for vehicle in Korea**

# 3. Verification (Case Study)

## 2. Case analysis

1) Technology system analysis based on system completeness

　① Extract each component function

　② Multi screen method (Interview to TRIZ Level1, 30 person – 10/17/2013)

### ① **Function Oriented System Analysis**



| Factor | Technology system | | | |
|---|---|---|---|---|
| | **Engine** | **Transmission** | **Control** | **Tool** |
| Item | Battery | Electric kit | CPU | Vision/Memory |
| Field | EL/ME | EL | EL | ME |
| Function | Give | Send | Calculate | See / Write |

### ② **Multi Screen Thinking**

| Index | Past | Current | Future |
|---|---|---|---|
| **Super system_1** | Road | **GPS** | ITS(Intelligent Transportation System) |
| **Super system_2** | Electrical vehicle High power/fuel efficiency vehicle | **Hybrid vehicle** Convenience increasing vehicle | Intelligent vehicle Auto control vehicle Position tracing |
| **System** | Digital running recorder | **Black box for vehicle** **General technology evolution direction** | Intelligent parts of vehicle Multi function car 3D black box |
| **Sub system** | Recoding paper Acceleration sensor GPS receiver Digital I/O port | Detection sensor Image/ sound sensor Memory CPU Camera Battery Cable Display Speaker Bluetooth Wifi | HMI Trouble detection Auto driving unit Driver action detect Solar battery Awareness Big data analysis 3D display Infrared sensor Hologram Shock analysis Camera (360 degree) Sound detection |

*System development direction*

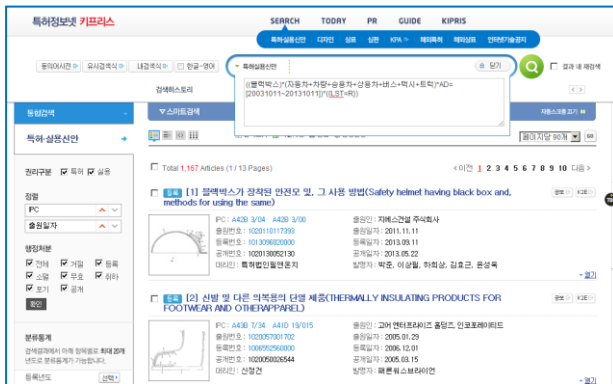# 3. Verification (Case Study)

## 2. Case analysis

2) Apply to suggested model for medium term technology forecasting

① Rearrange patent of black box (2006 ~ 2013.10)

② IPC classification analysis

> 1167 case → 683 case (1st noise elimination, Focus on component) → 313 case (2nd  noise elimination, Focus on function of system)

> Detail patent analysis based on IPC classification



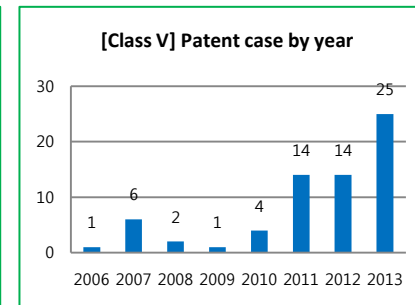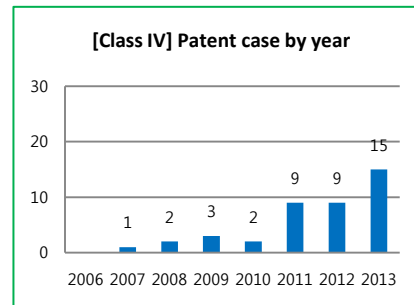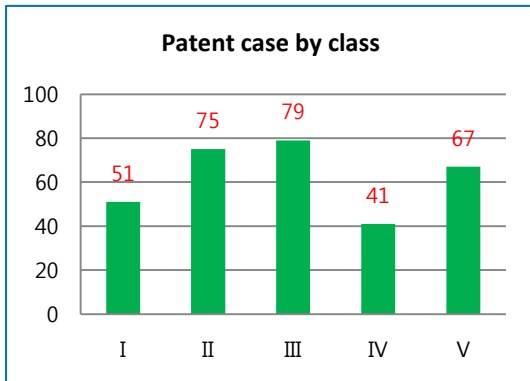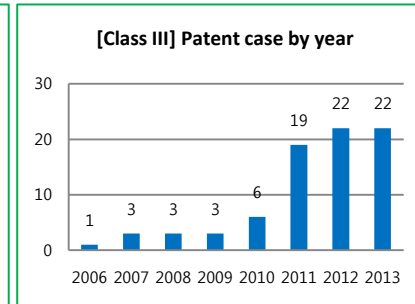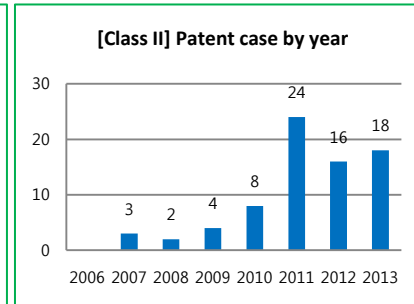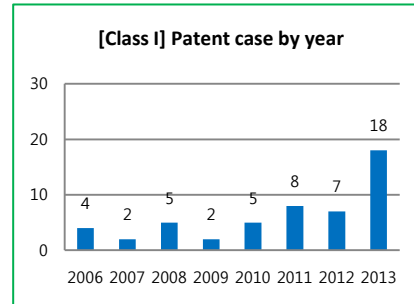| Big | Medium | Small class | Patent case | Detail explanation |
|---|---|---|---|---|
| B | 60R | 1 | 17 | Regarding general black box |
| | | 11 | 6 | Assistance system of black box |
| | | 16 | 6 | Power of black box |
| | | 19,21 | 9 | Sensing method |
| | 60W | 30,40,50 | 9 | Other Sensing method |
| | 62D | 41 | 69 | Additional function of black box |
| G | 01C | 9,21 | 3 | Black box and navigation connection |
| | 01D | 9,11,15,18 | 11 | Data saving of black box |
| | 01S | 5,13,17,19 | 5 | External system connection |
| | 02B | 3,27 | 3 | Optics, Display |
| | 06F | 1,9,15,17,21 | 11 | Data processing of black box |
| | 06Q | 50 | 7 | External communication system connection |
| | 06T | 1,3,7 | 4 | External communication system connection to super system |
| | 07C | 5 | 1 | External communication system connection (Recording) |
| | 08B | 13,21,25 | 13 | External communication system connection (Other equipment) |
| | 08C | 17 | 1 | External communication system connection (Vehicle) |
| | 08G | 1 | 21 | External communication system connection (Other system) |
| | 10L | 15 | 2 | Sound of black box |
| | 11B | 20,27 | 3 | Play of black box |
| | 11C | 16 | 2 | Memory of black box |
| H | 10Q | 1,7 | 5 | External antenna of black box |
| | 02B | 1 | 3 | Battery of black box |
| | 02J | 7 | 3 | External power of black box |
| | 04B | 1 | 8 | Additional function (External system) |
| | | 7 | 7 | Additional function (Internal system) |
| | 04L | 9,12 | 2 | Video of black box |
| | 04N | 1,5,7,9,13,17,21 | 71 | Image processing of black box |
| | 04Q | 9 | 2 | Communication system of black box |
| | 04W | 4,8,12,88 | 9 | Communication system of black box (External system) |

# 3. Verification (Case Study)

## 2. Case analysis

2) Apply to suggested model for medium term technology forecasting

③ Patent case analysis

> Rearrangement of patent based on 5 Class, 25 Item

> Time, class classification and analysis



**Patent case by year**



**[Class I] Patent case by year**



**[Class II] Patent case by year**



**[Class III] Patent case by year**



**Patent case by class**



**[Class IV] Patent case by year**



**[Class V] Patent case by year**
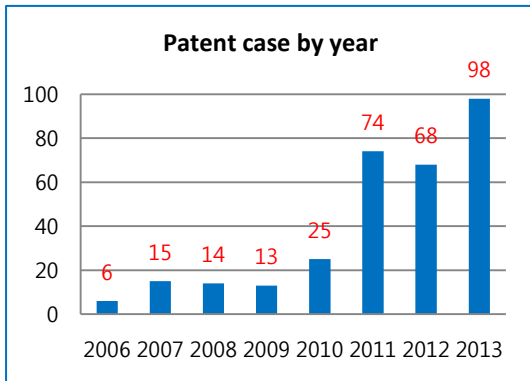
**Patent case by Class & year**

# 3. Verification (Case Study)

## 2. Case analysis

2) Apply to suggested model for medium term technology forecasting

④ Result of applying technology forecasting matrix

> Each component's patent count → Understand subdivided technology concentration (Quantitative)

> Each function's key word → Understand connected technology (Qualitative)

| Class | Index | Tool Component | Tool Function | Transmission Component | Transmission Function | Control Component | Control Function | Engine Component | Engine Function |
|---|---|---|---|---|---|---|---|---|---|
| **Class I** Core technology development Beginning system development | 1. Core technology | 1 | | | | | | | |
| | 2 . Minimize/Simple | 3 | | 3 | | | | 2 | |
| | 3 . Maximize/Duplicate | 17 | | 5 | | 1 | | 1 | |
| | 4 . Streamline (revised Design) | | | | | | | | |
| | 5 . Individual function combine | 11 | | 2 | | | | | |
| **Class II** Enhance function, performance, convenience Growth market | 6. Speed / Performance | 8 | | 17 | | 8 | | 7 | |
| | 7. Strength / Stiffness | 1 | | 5 | | | | | |
| | 8. Convenience | 3 | | 1 | | 1 | | 3 | |
| | 9. Stability | | | | | | | 1 | |
| | 10. Complement function | 5 | | 4 | | 1 | | 1 | |
| **Class III** System stability & Optimization | 11. Enhance automation | 1 | | 2 | | 2 | | 7 | |
| | 12. Enhance productivity | | | | | | | | |
| | 13. Reduce wasted energy | 1 | | 2 | | | | 1 | |
| | 14. Remove side effects | | | 4 | | | | 10 | |
| | 15. Supplement function | 19 | | 11 | | 8 | | 9 | |
| **Class IV** Enhance accuracy Competition of 2nd market | 16. Measurement accuracy | 2 | | | | | | 8 | |
| | 17. Enhance precision degree | 5 | | 1 | | | | 11 | |
| | 18. Enhance reliability | | | | | | | | |
| | 19. Enhance detection ability | 1 | | | | | | 11 | |
| | 20. Combination of functions | 2 | | 1 | | | | 1 | |
| **Class V** System complete 2nd evolution | 21. Technology Fusion | | | | | | | 2 | |
| | 22. Technology Convergence | 6 | | | | 4 | | 1 | |
| | 23. Innovation (New Platform) | | | | | 1 | | | |
| | 24. ICT, BT | 1 | | 1 | | 15 | | 1 | |
| | 25. Function substitution | 16 | | 6 | | 10 | | 2 | |

# 3. Verification (Case Study)

## 2. Case analysis

3) Rearrange index for the technology forecasting (3~5 years)

> Yellow cell : expect to launch product to the market soon

> Green cell : Not yet enrolled patent

| | Communication | Vehicle | Traffic system | Human |
|---|---|---|---|---|
| **Super System** | GPS | Functional vehicle | Traffic light | Smart phone |
| | RFID | Hybrid vehicle | General traffic agency | Tablet |
| | Radar | Electric vehicle | Police officer | |
| | Wireless frequency | Intelligent vehicle | Insurance | |
| | G sensor | | ITS | |
| | wifi | | | |
| | External network | | | |

| | Camera | Lens | Image Processing | Memory | Battery |
|---|---|---|---|---|---|
| **System** | Low resolution | High magnification | Image processing | Volatile | Vehicle power |
| | High resolution | Wide angle | Compression | Non volatile | External power |
| | Multi / All around | Fish eye | Restoration | Sound recording | Regular power |
| | High speed | Multi view (360 degree) | Prevention of copy | Regular recording | Solar power |
| | Infrared | | Encryption | Cloud server | |
| | Sound | | Shock detection | | |
| | Thermal | | Position tracing | | |
| | | | Image detection (Line) | | |
| | | | Stereo image processing | | |

| | Display | Sensor | VCR |
|---|---|---|---|
| **Sub System** | LCD | Detection | VCR |
| | OLED | Distance measuring | AVN |
| | 3D | Sound | |
| | Hologram | Air damper | |

# 4. Summary

## 1. Back ground research

- Study and identify overall technology forecasting methodology

- Select research topic → making model for technology forecasting whiting 5 years

## 2. Main research

- Study and rearrange of TRIZ tool and theory

- Focus on function of technology system and make forecasting matrix

- Interview TRIZ expert group for Increasing reliability of model

## 3. Verification

- Case study (Black box for vehicle)

- Apply to suggested forecasting matrix and analyze each result (Qualitative, Quantitative)

- Forecast system's technology development within 5 years

## 4. Future plan

- Apply other technology area and increase more reliability  (Electric vehicle, w/KAIST I&TM)