

# Case introduction of a tire technical development utilizing the TRIZ technique

【The 14th Japan TRIZ Symposium 2018】  
2018/09/13 (Thursday)  
J04 (16 : 45~17 : 25, Room A)

**Kazuhiro Sakakibara, Naoto Kashiwara**

**The first headquarters tire early technology development  
department of technology  
Design investigation and technological project group  
Toyo Tire & Rubber Co., Ltd.**

# Outline of presentation (contents)

1. Company introduction
2. Content of symposium announcement
3. Introduction of new technology
4. TRIZ technique adjustment explanation  
(case introduction)
  - ① Foundation cause analysis/device analysis
  - ② Evolution pattern
  - ③ Effects
  - ④ Invention principle
  - ⑤ For QCD
5. Peroration

# 1.1 Company introduction: Outline

**Trade name** The Toyo Rubber Industry Co., Ltd.  
**(English display)** Toyo Tire & Rubber Co., Ltd.

**Establishment** August 1, 1945 (1945)

**The capital** 30,484,627,991 yen

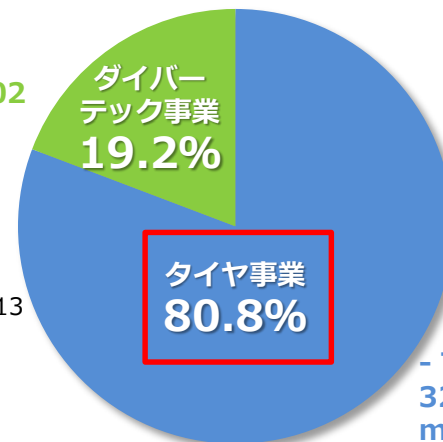
**The stocks total** 127,179,073 stocks

**Number of employees** (connection) As of December 31, \*2017 every 11,759 people

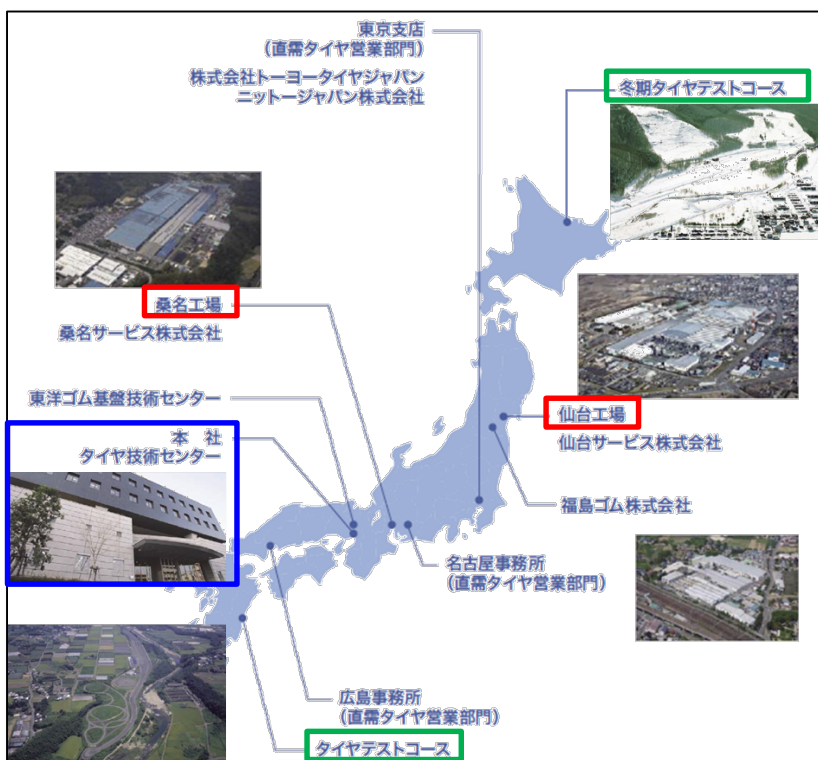
**Headquarters** 〒664-0847 Hyogo Prefecture Itami City wistaria tree 2 chome second No.13

Sales ratio according to business (period on December, 2017)

- Diver Tec  
77 billion 902  
million yen



- Tire  
327 billion 97  
million yen



**It centers on parts for the tire and the car, and the global expansion from a domestic technological base.**

# 1.2 Company introduction: About the tire business

**TOYO TIRES**  
driven to perform

- Three branding strategies



- Technological concept



In the tire, is there a surprise?

- Example of commodity lineup

Minivan exclusive use



トランパス・エムエル  
**TRANPATH ML**

Sporty



プロクセス・スポーツ  
**PROXES Sport**

Low fuel cost



ナノエナジー・スリー・プラス  
**NANOENERGY 3 PLUS**

Pickup truck



**RIDGE GRAPPLER**

[Sutaddoresu]



Winter  
**TRANPATH TX**

Track bus



ナノエナジー エムイチロクロク  
**NANOENERGY M166**

- Business form

CS ⇒ CD (customer satisfaction)(customer impression)

It is unique conception power and an innovation.

・Goods on the market tire

⇒ B to C

・Tire for new car

⇒ B to B

An approach (innovation) different from the past is necessary to offer the customer "Surprise".

# 2. Content of symposium announcement

- In-house innovation promotion: System chart

Fiscal year 2016

Fiscal year 2017

Fiscal year 2018

<div>Application list</div> <div>Problem solution Scene</div>	Mechanism (solution tool)					Software effective use (thinking time an increase)	
	Theme Setting	Problem Setting	Cause Analysis	Idea Conception	Idea Summary	Knowledge retrieval GF	Patent analysis BC
Needs search	(QFD)	-	-	-	-	-	-
Product planning	(QFD)	-	-	-	-	-	-
Trend survey	-	-	-	-	-	-	-
Technological project	-	-	-	-	-	-	-
Pure research (long term)	-	-	-	-	-	-	-
Early development (middle term)	-	-	-	-	-	-	-
Product development (short term)	-	-	-	-	-	-	-
Patent application	-	-	-	-	-	-	-
Quality improvement	-	-	-	-	-	-	-
VE	-	-	-	-	-	-	-

Up to now, it has reported on the mechanism of the system for innovation promotion of in-house.  
⇒I introduce the case with the tire technology development that uses these mechanisms at current year.

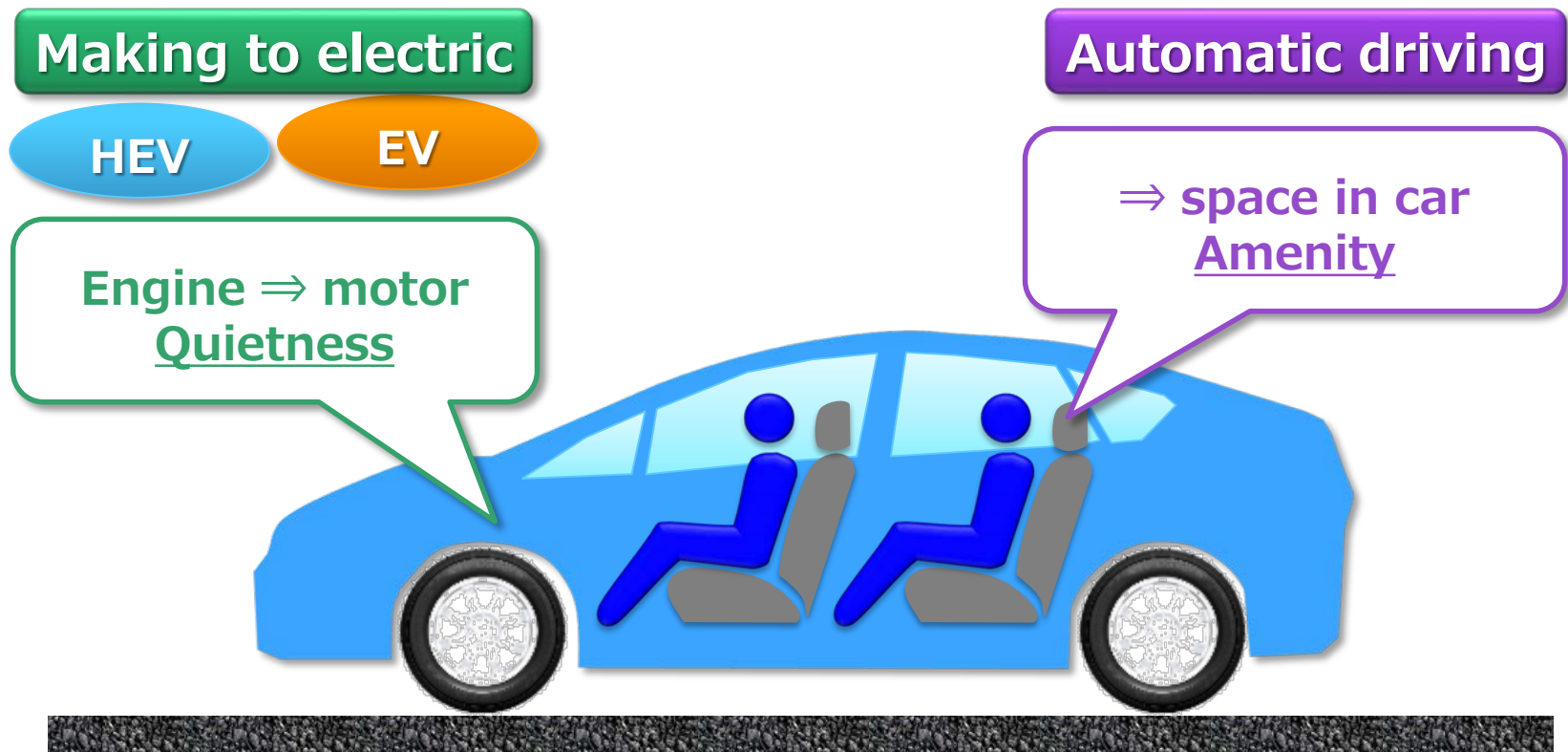


# 3.1 Introduction of new technology: Background ①

■ What is the situation in which the car industry is put?

➤ It faces at the revolution period once every 100 years.

(\* It is a business in those of making to electric and an automatic driving, the communication, and sharing, etc. for the string. )



Needs from which the environment in the car is requested have changed by the change in the mobility environment.

## 3.2 Introduction of new technology: Background ②

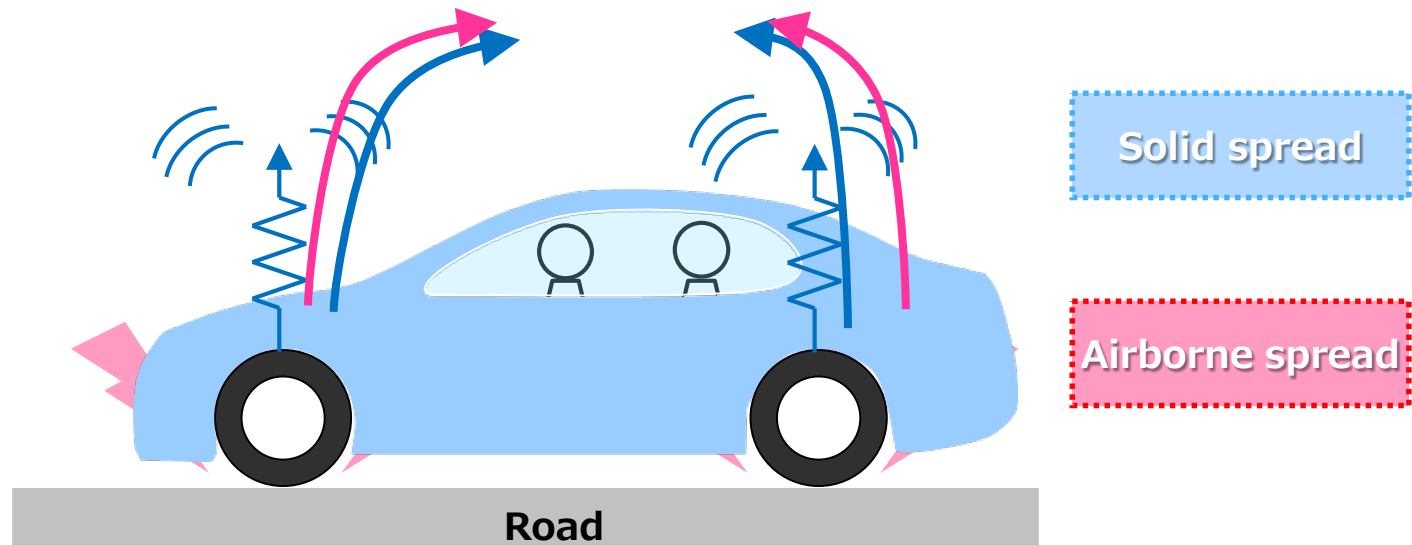
- What is the noise of the car?

### Noise in car: Loading noise

- The vibration of the tire by the road becomes a vibration of the body and the floor through the wheel axle suspension, and it transmits in the car.

### Vehicle exterior noise: Pattern noise

- The sound generated from the road and the tire spreads and is transmitted in air.



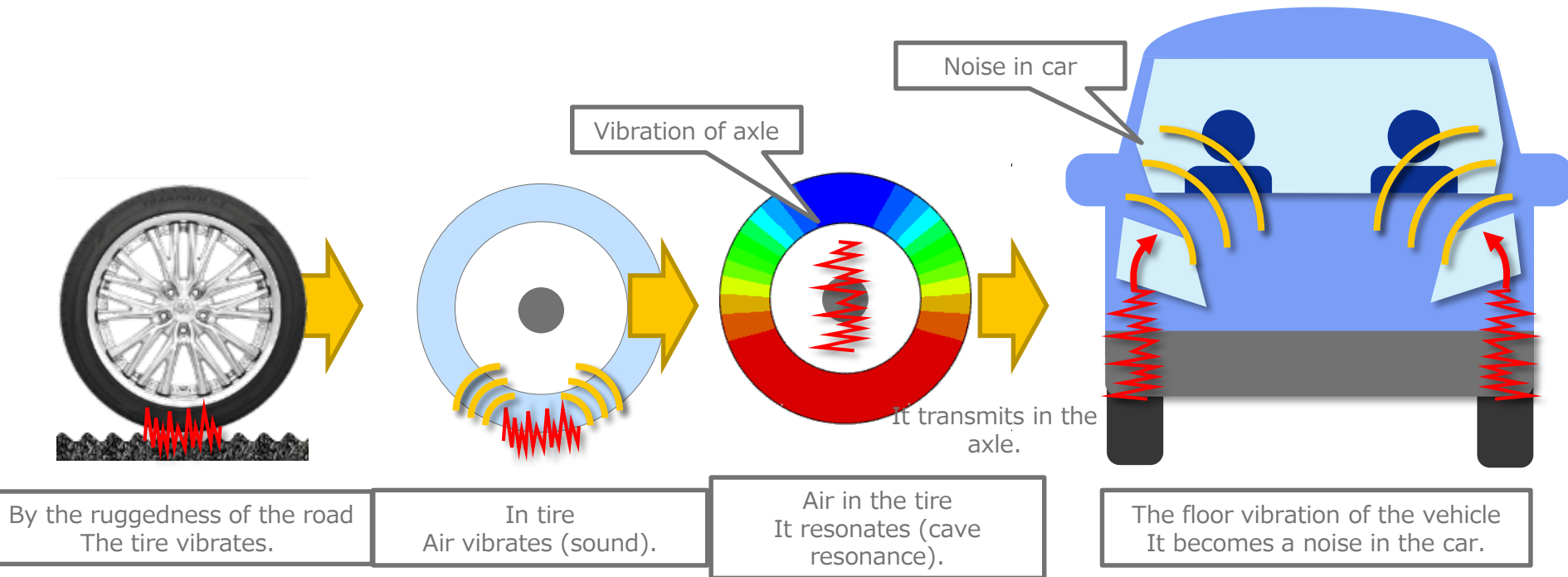
The noise of the car includes the noise heard by noise heard by 'Outside the car' and 'In the car'.

# 3.3 Introduction of new technology: Background ③

■ What is the noise of the car that originates in the tire?

➤ **Tire cave resonance sound**

➤ It is a noise that transmits resonance phenomena of air in the tire in the car, and generates.

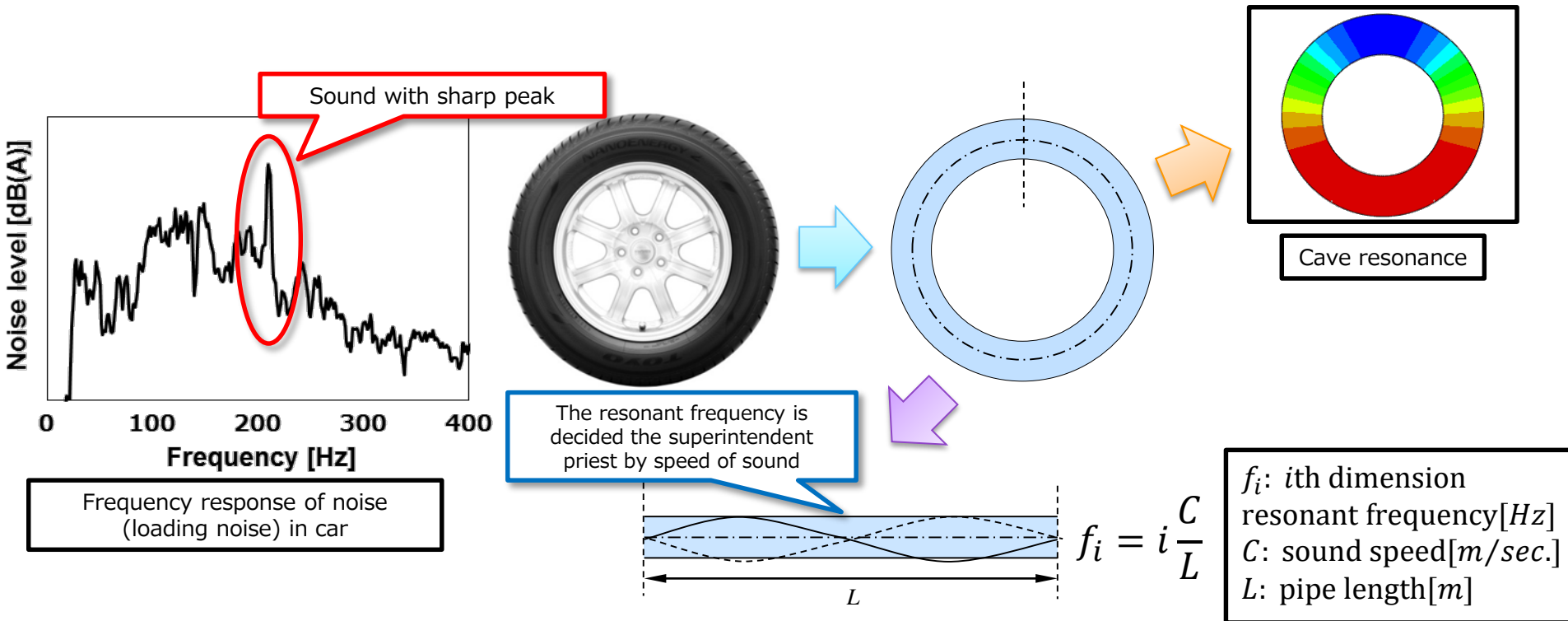


**There is a cavernous resonance to be generated because it is a cave where the tire was filled with air.**



# 3.4 Introduction of new technology: Background ④

- 'Tire cavity resonance sound', a noise in the car that originates from the tire
  - Noise to be generated in band of about 200~250Hz



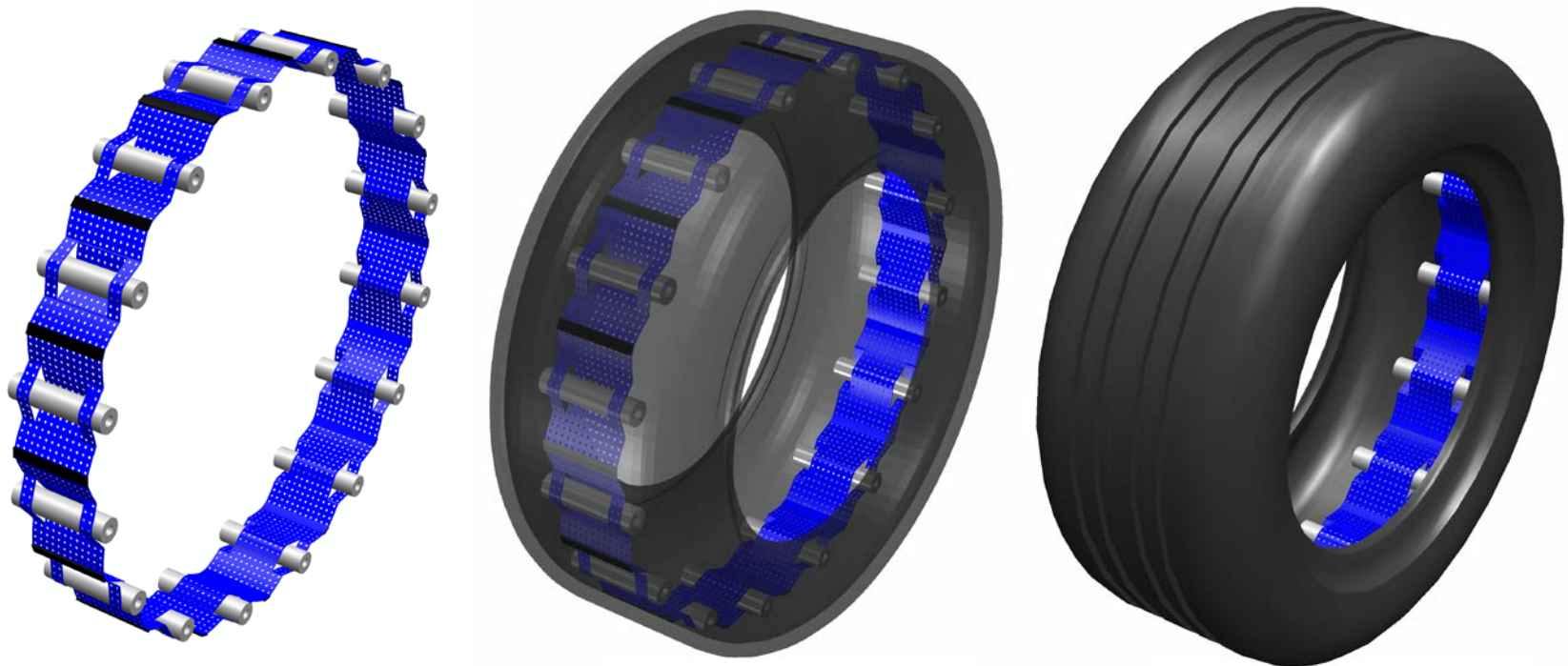
- It is a sound 'paka-n' when passing over the seam in the sound, the expressway, and the groaning bridge 'cau' when running on the road that gets rough, etc.

- The difference is a sound in how to feel it according to compatibility with the vehicle that always hears though it is.

**Jarring noise that depends on size of tire of generation in decided band**

## 3.5 Introduction of new technology: Development goods

- What are the development goods that plan the tire cave resonance sound?
  - **Device by form that differs from the early other companies and is original**



# Toyo Silent Technology

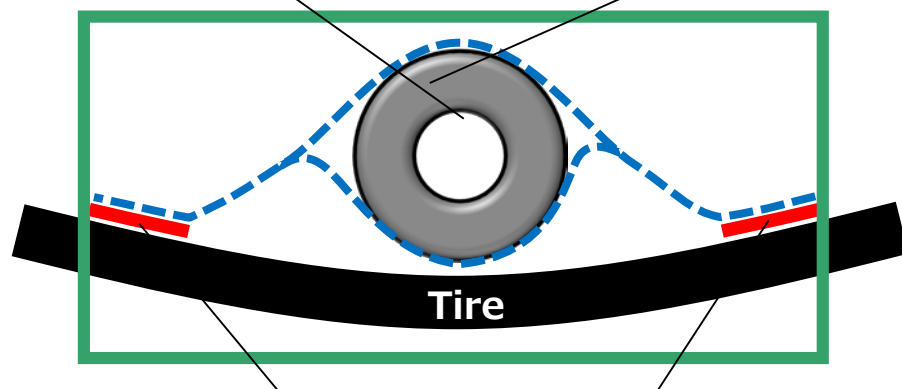
- June 29, 2018 press release

The device that effectively decreases the cavernous resonance by arranging it in the tire is developed.

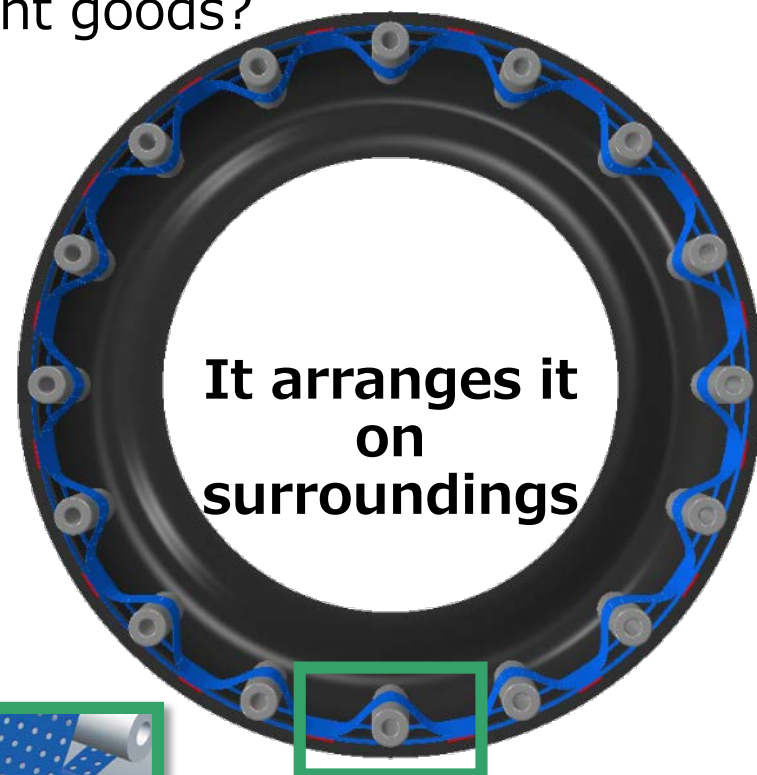
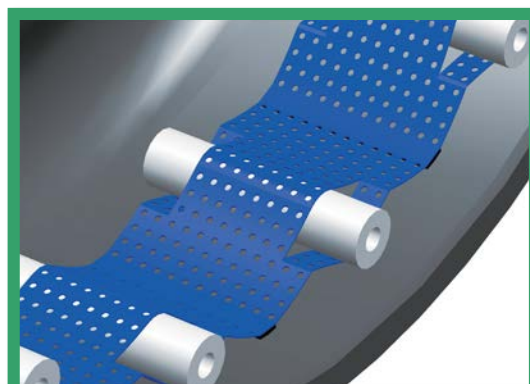
## 3.6 Introduction of new technology: Technological explanation ①

- What is the structure of the development goods?

Cylinder sponge      Porous film



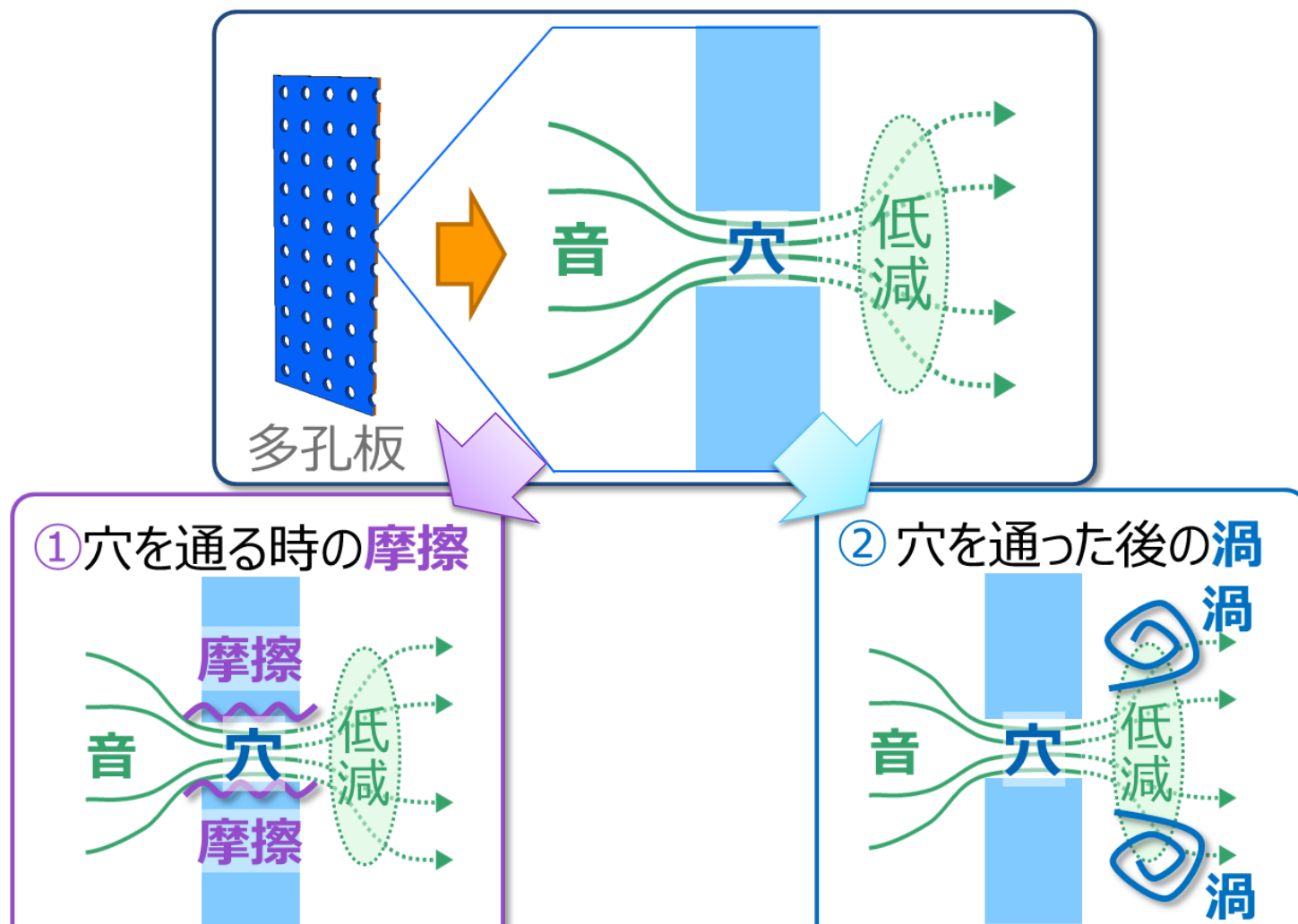
Cushion material + double-faced tape



Structure to combine porous film arranged in mountain with cylinder sponge

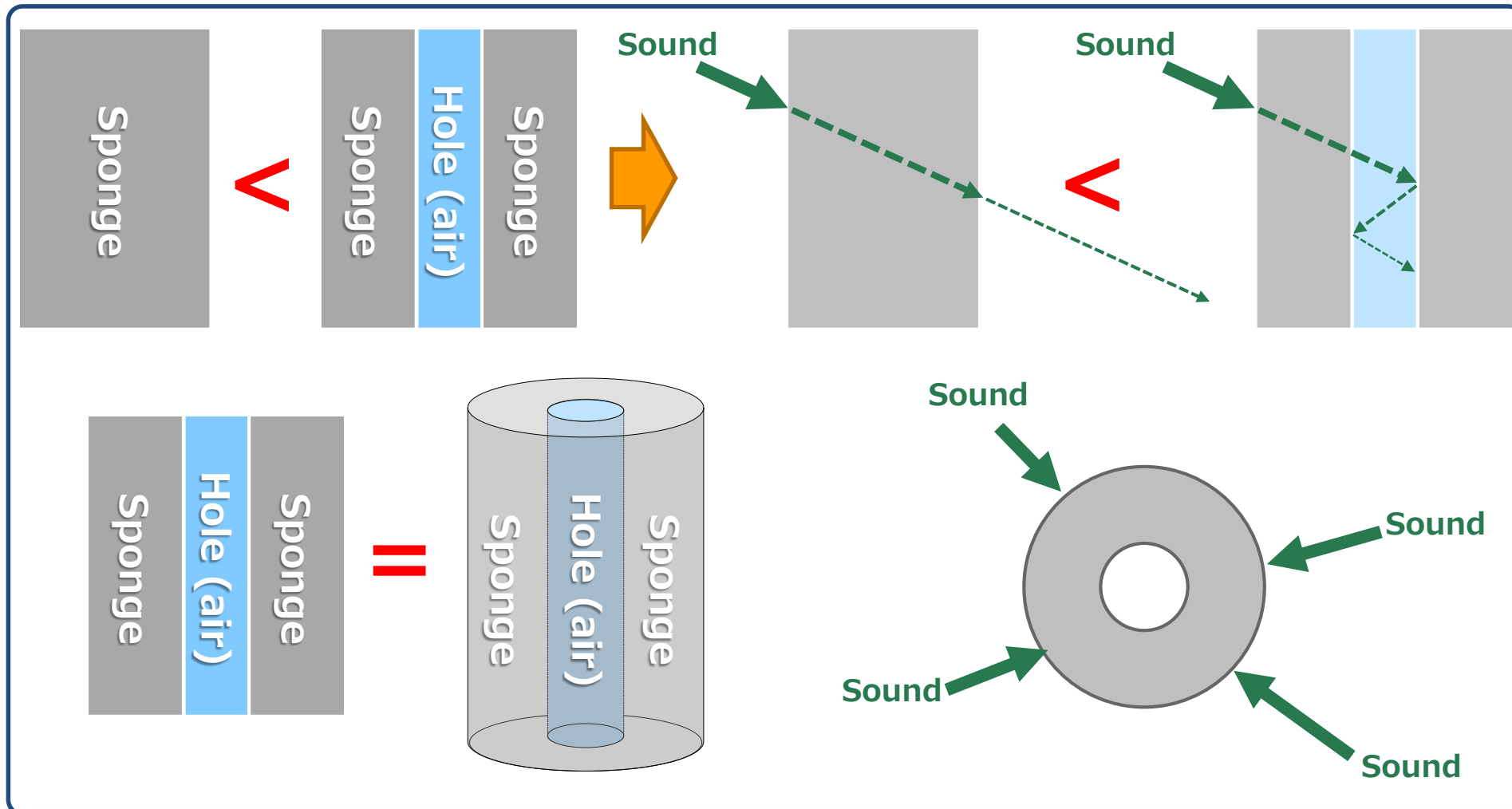
# 3.7 Introduction of new technology: Technological explanation ②

- What is the effect of the perforated plate (film)?



The energy of the sound can be decreased by hole of making for the board (film) passing the sound.

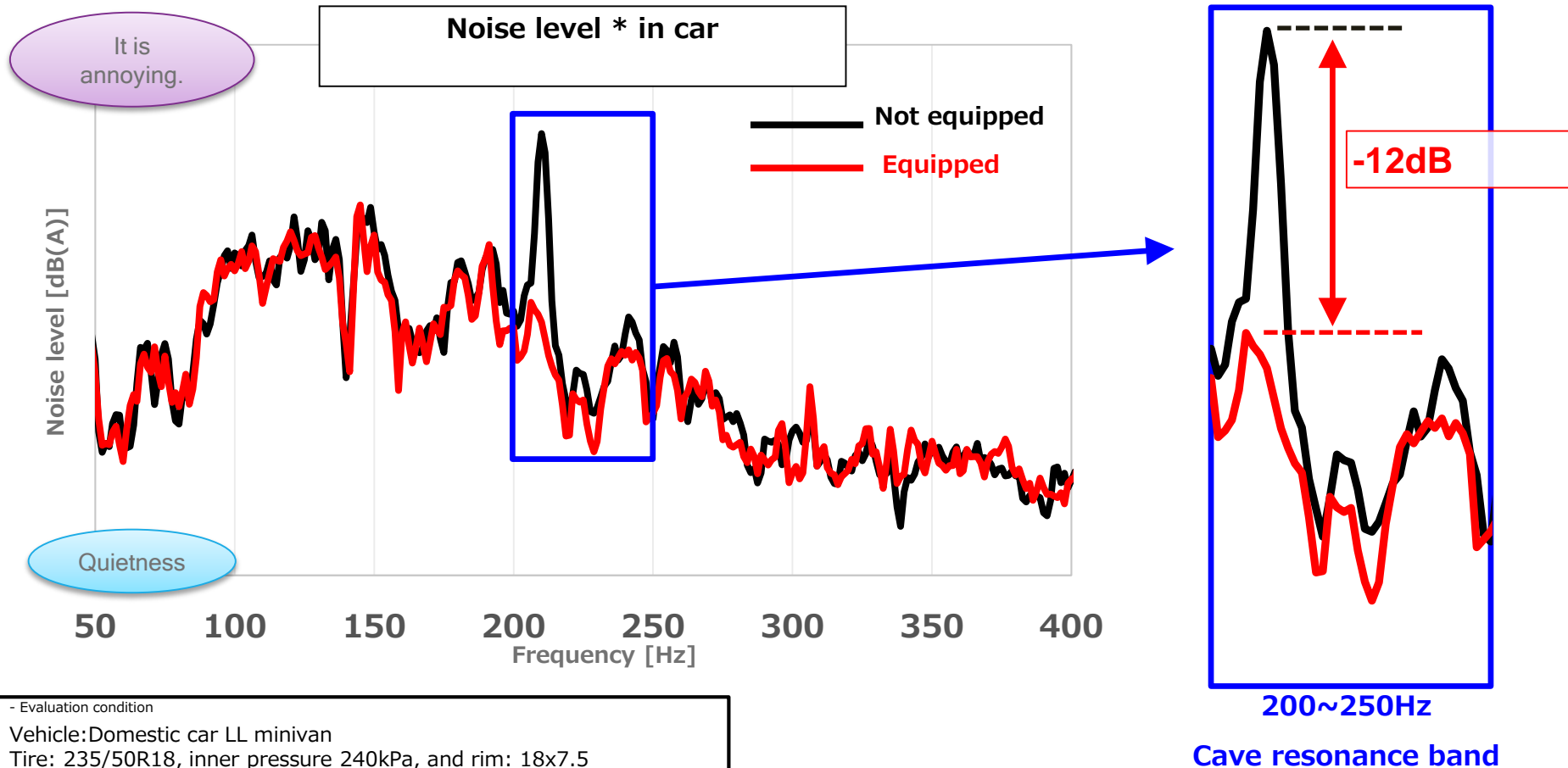
## ■ What is the effect of a cylinder sponge?



**Sound can be effectively absorbed also with a little amount of sponge according to the hole and the shape made for the sponge.**

# 3.9 Introduction of new technology: Technological explanation ④

- What is the effect of the decrease of the development goods?



- Evaluation condition

Vehicle: Domestic car LL minivan

Tire: 235/50R18, inner pressure 240kPa, and rim: 18x7.5

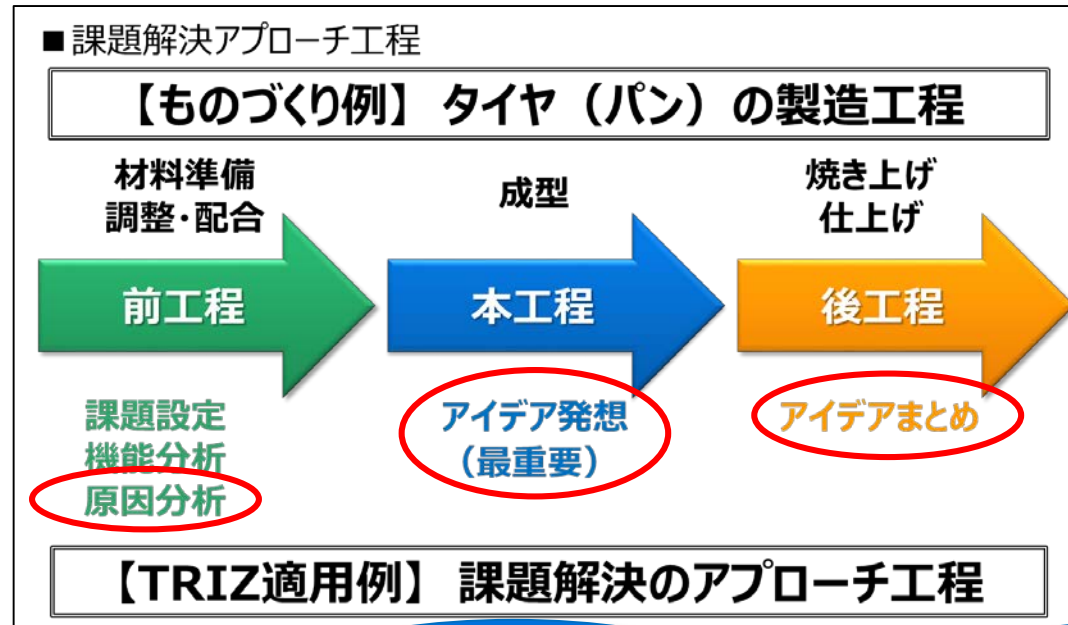
Measurement position: Crew ear position and place: Our examination room

The peak of the cavernous resonance of the target is greatly decreased according to an original form/composition.



# 4. TRIZ technique adjustment explanation (case introduction)

## ■ Approach in development goods



Approach ①  
The phenomenon of  
the target is caught.

Approach ②  
How is the hint used?

Approach ③  
How is the idea achieved?

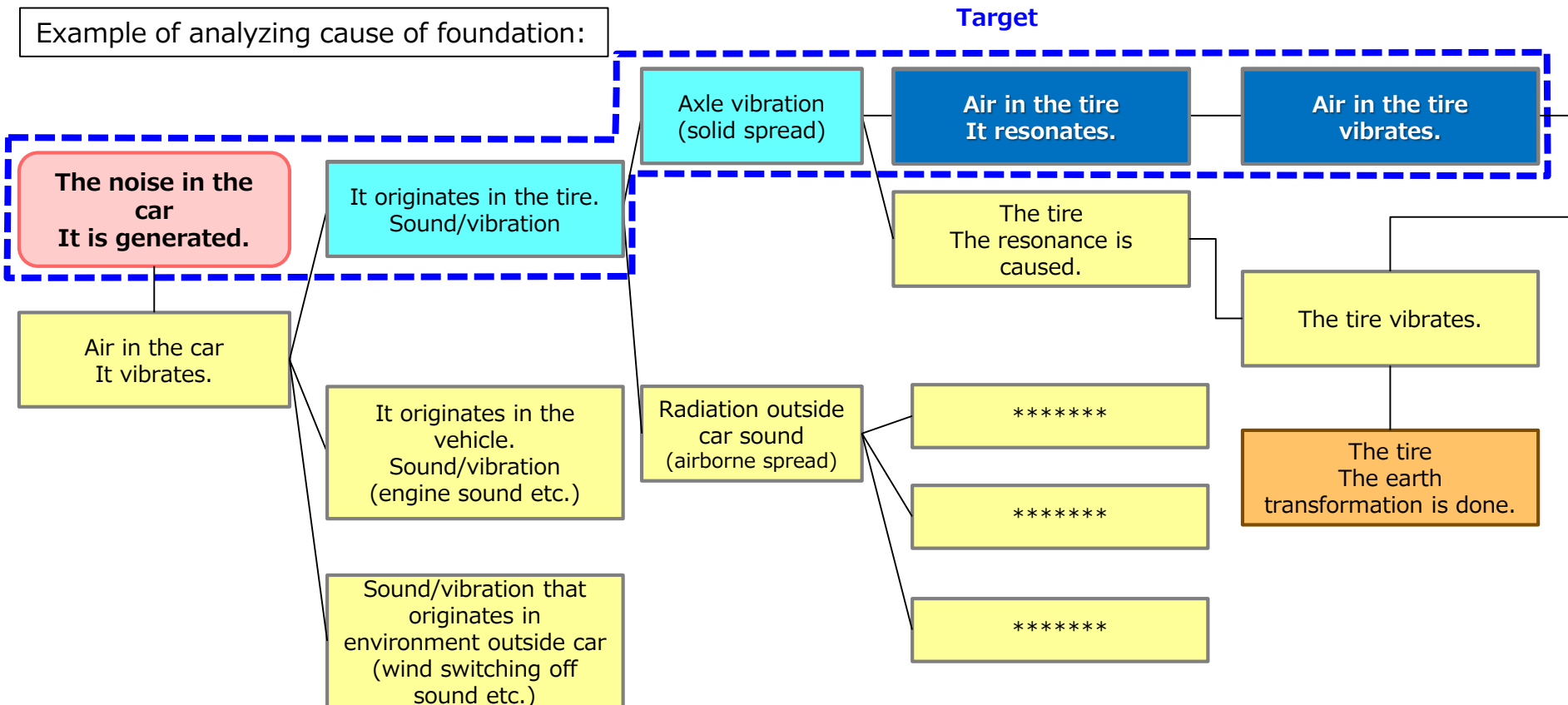
Approach ④  
Action on real problem

Approach ⑤  
For QCD balance

I introduce five approaches that use the TRIZ technique in development.

# 4.1 Approach ①: Phenomenon grasp of target

- Making of noise problem in car essence: 'Foundation cause analysis', 'Device analysis'
  - It pays attention to 'Air' in the tire by the foundation cause analysis.



It catches, and it pays attention to 'Air' in the tire , saying that 'Phenomenon of air' the cause 'Sound' of the target.

## 4.1.1 Grasp and observation of phenomenon: Making to visible ①

- How is air in the tire going?
  - ✓ How is air in the tire going?
  - ✓ Do you turn with the tire?
  - ✓ Is there a flow of air?

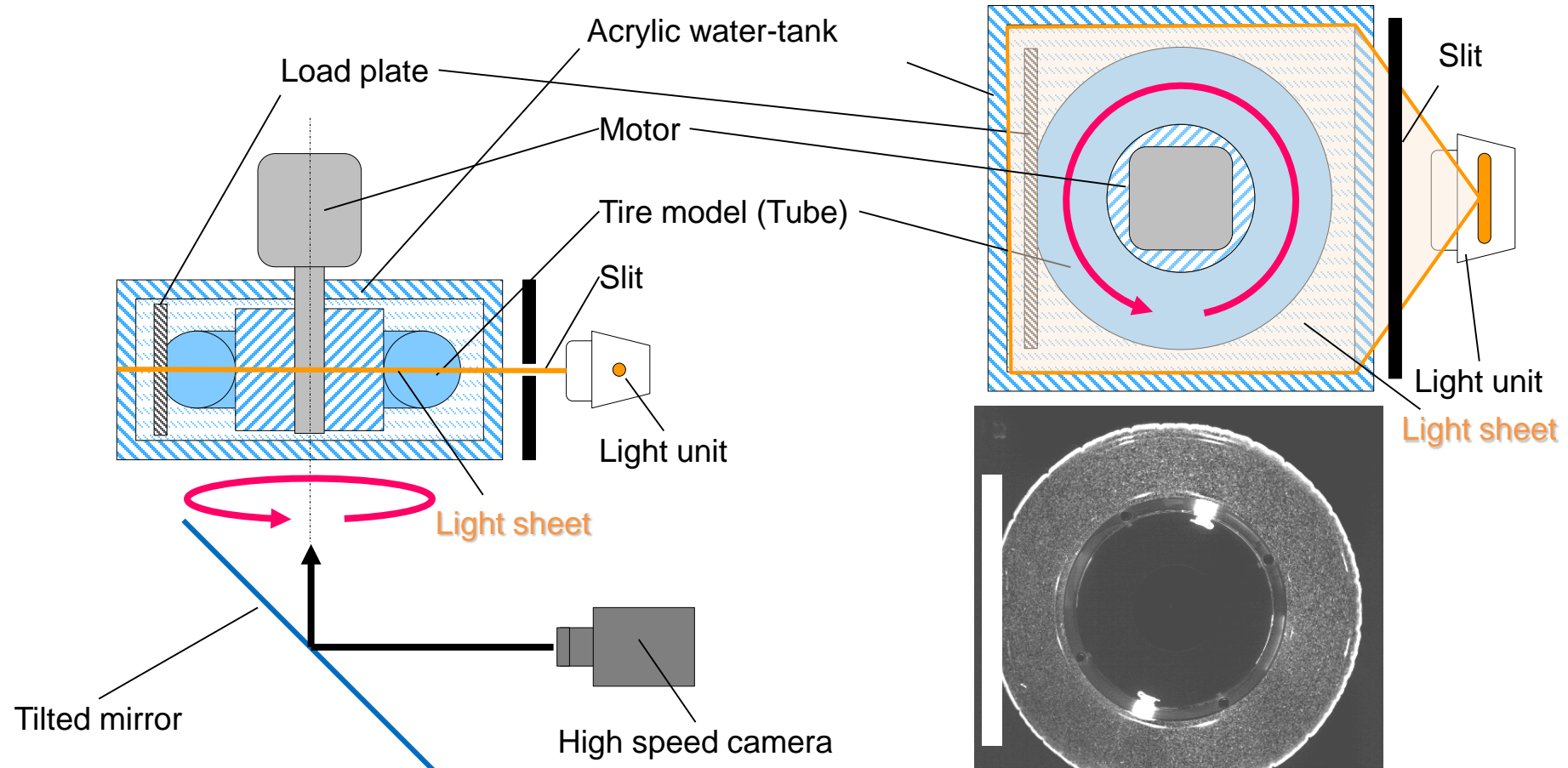


**It was tried to pay attention to air in the tire, and to make to visible, and to confirm the state of air in the nutation.**

## 4.1.2 Grasp and observation of phenomenon: Making to visible ②

### ■ How is air in the tire made visible?

- Particle image flow velocity measurement method: PIV(Particle Imaging Velocimetry)



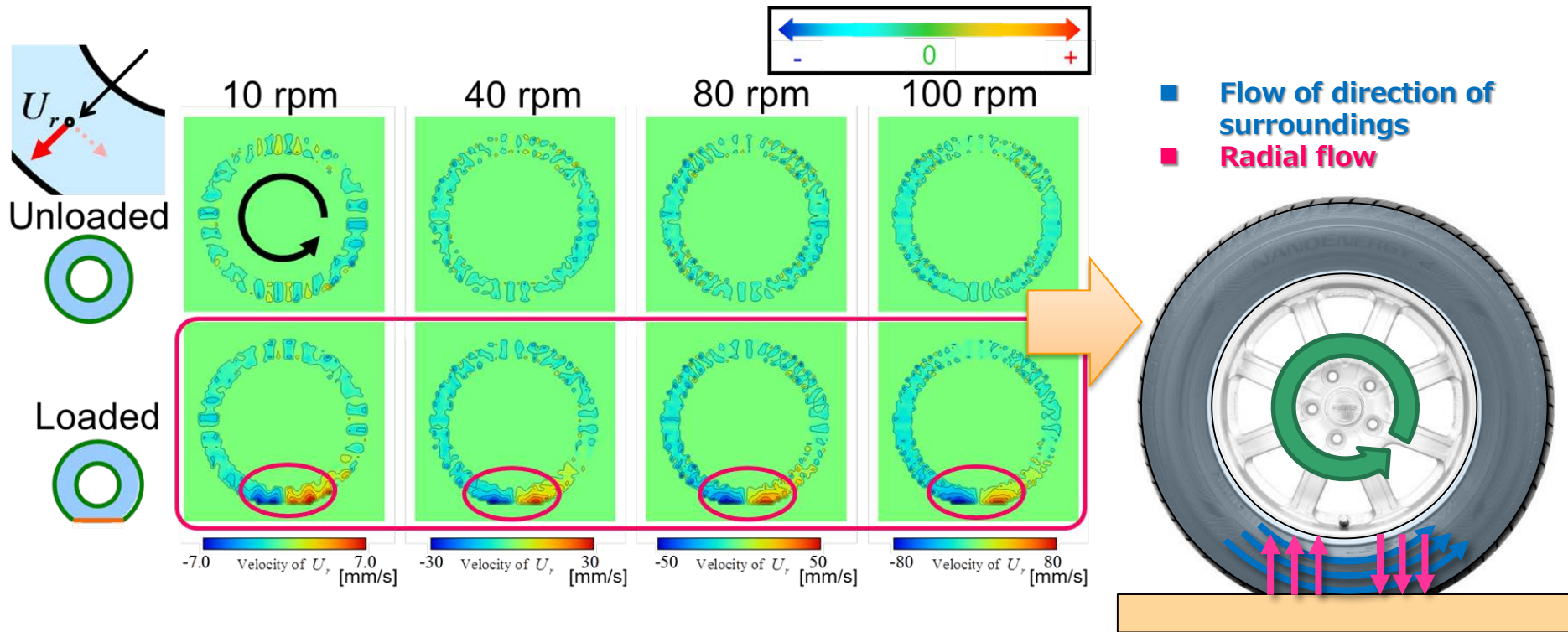
**It confirmed it by replacing air with water and using a water tank and a transparent floatage circle.**

# 4.1.3 Grasp and observation of phenomenon: Making to visible ③

■ How is air in the tire going?

▣ 'It moves by transforming the tire the earth, and the flow exists' has been understood.

- Air turns together if there is no earth transformation, and the flow is not generated.



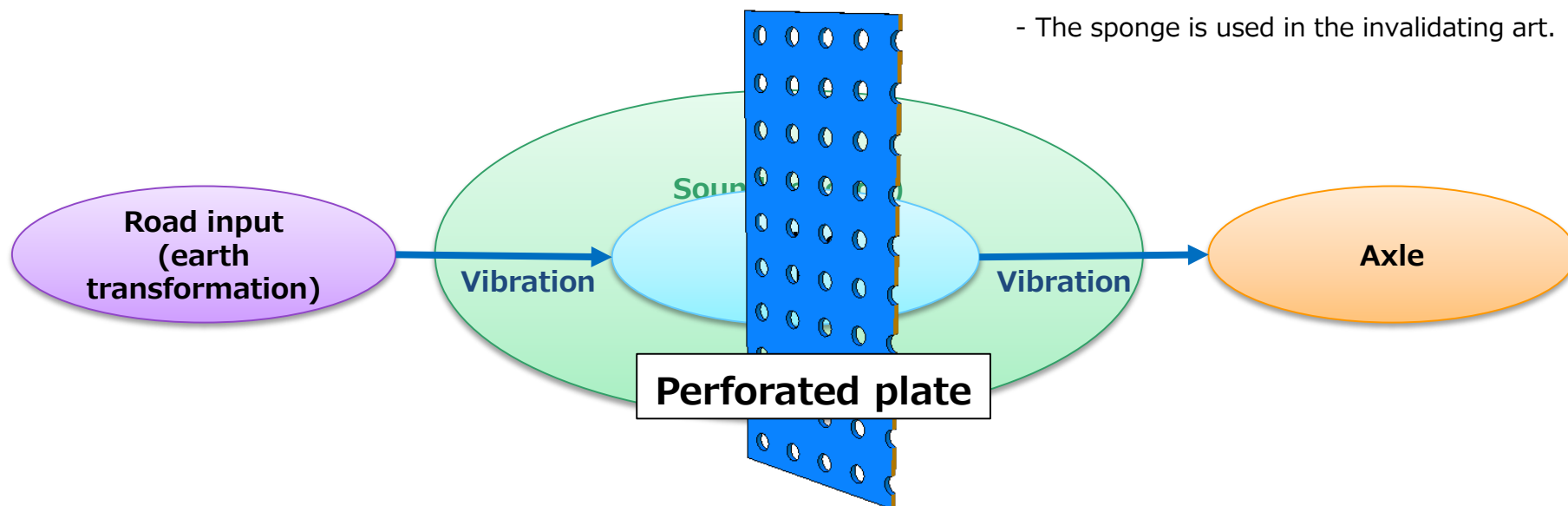
It was confirmed to air in the tire the generation of the flow by the earth transformation of the tire.

## 4.2 Approach ②

### ■ Do to decrease the sound in the tire?

#### ➤ Reinforced ⇒ evolution pattern 'Material-place' of main function and Effects (sound field)

- A useful action: The sound is decreased for the amenity (The acoustic pressure is lowered).
- Approach that decreases sound energy in tire as well as invalidating art



- ✓ Field of architectural sound: Wall etc. of music room and concert hall
- ✓ Field of road noise measures: Soundproof wall etc. of expressway

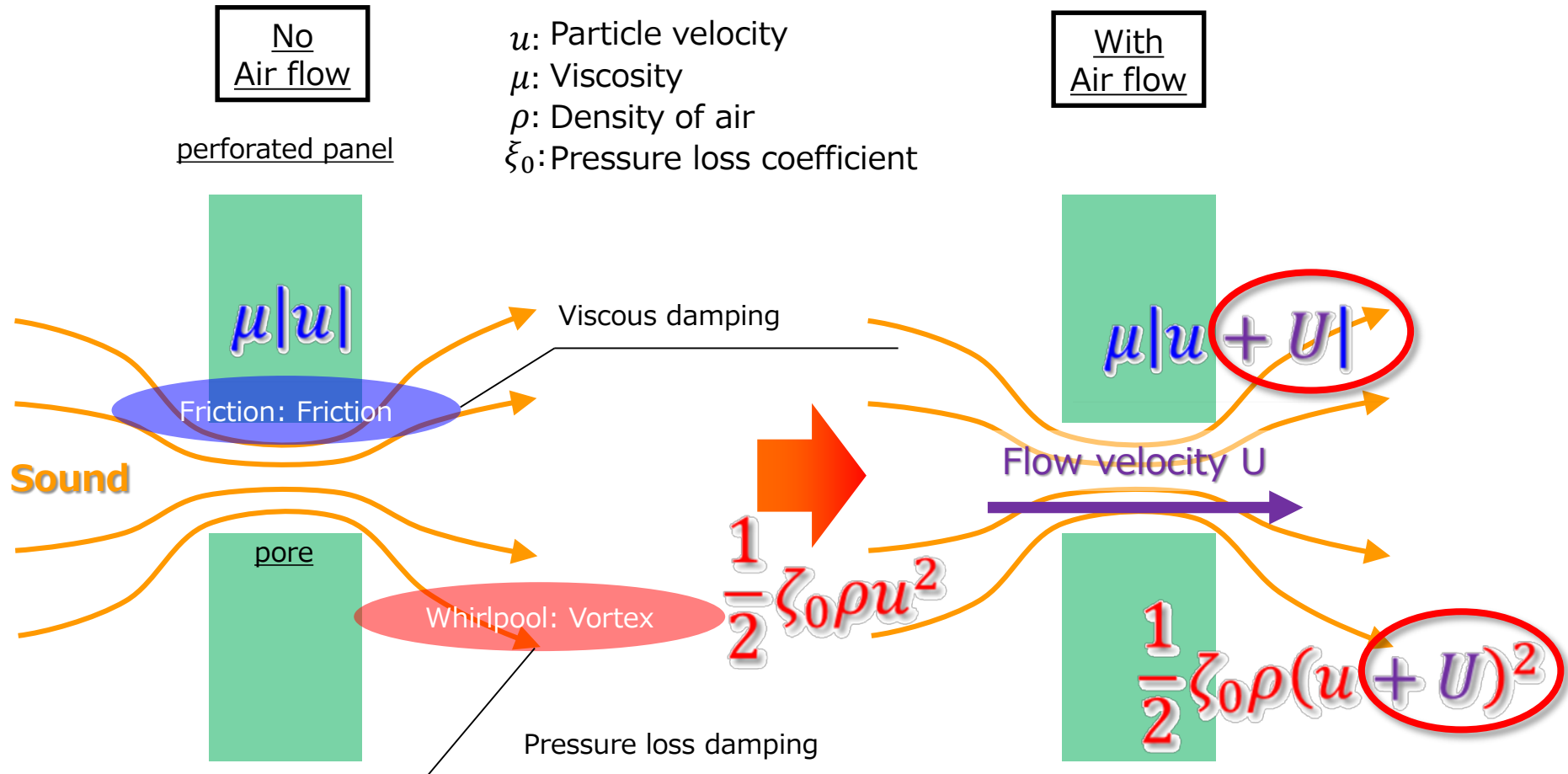
**It paid attention to 'Perforated plate' used for an architectural sound and a road traffic noise measures.**



# 4.2.1 Feature of perforated plate

■ Cannot the flow of air in the tire be used?

➤ As for the perforated plate, the effect is improved by the flow of air.



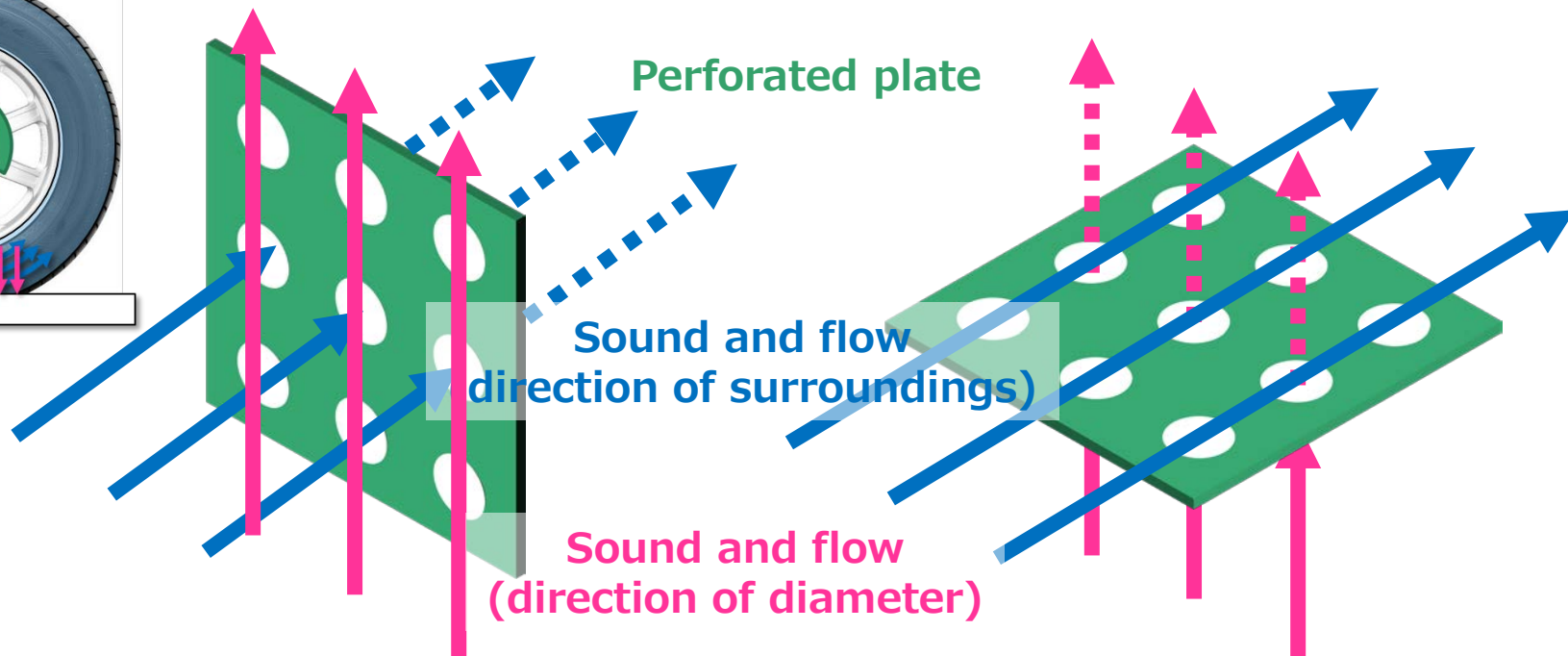
The effect of the decrease is improved to the effect of the perforated plate by the flow of the air of the place.

## 4.3 Approach ③

- Cause 'Sound'
- It uses it. 'Flow of air'

How is the perforated plate arranged for these?

- 半径方向の流れ
- 周方向の流れ



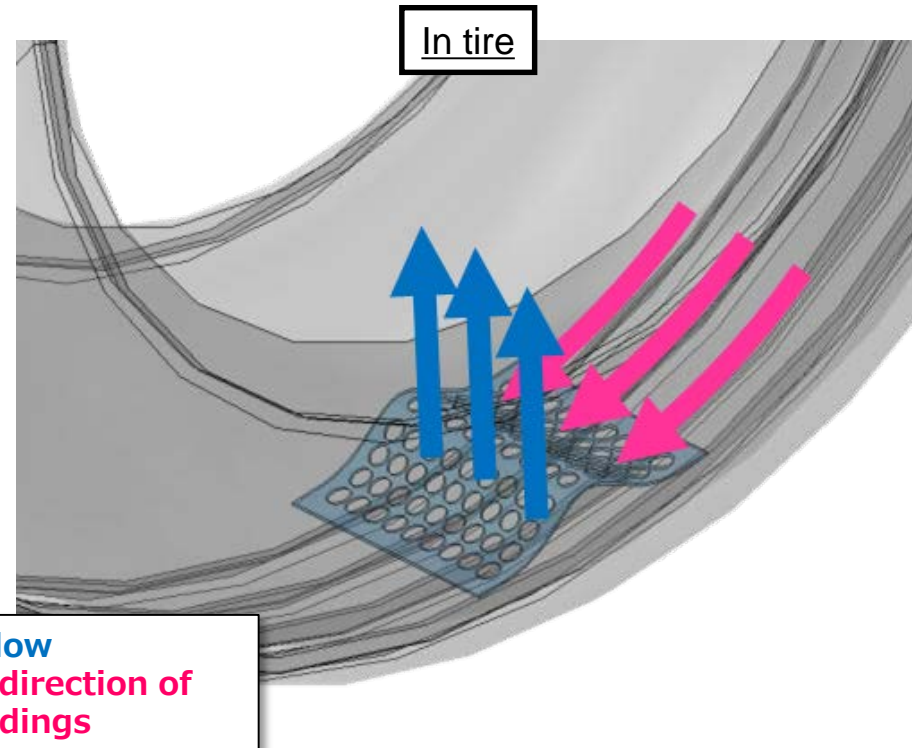
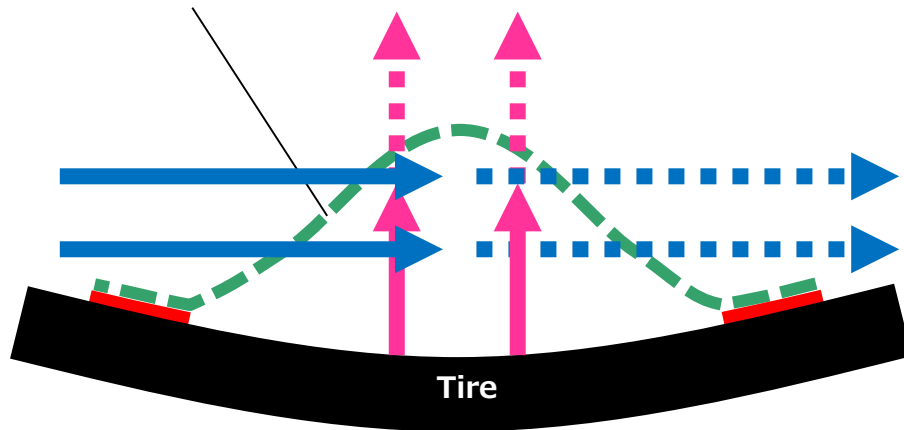
**It is necessary to arrange it to appropriate it to a radial sound, the flow, the sound in the direction of surroundings, and the flow.**

# 4.3.1 Arrangement of perforated plate

- Cause 'Sound'
- It uses it. 'Flow of air'
- Evolution pattern 'Geometrical evolution'

How is the perforated plate arranged for these?

Perforated plate ..mountain it.. (film)

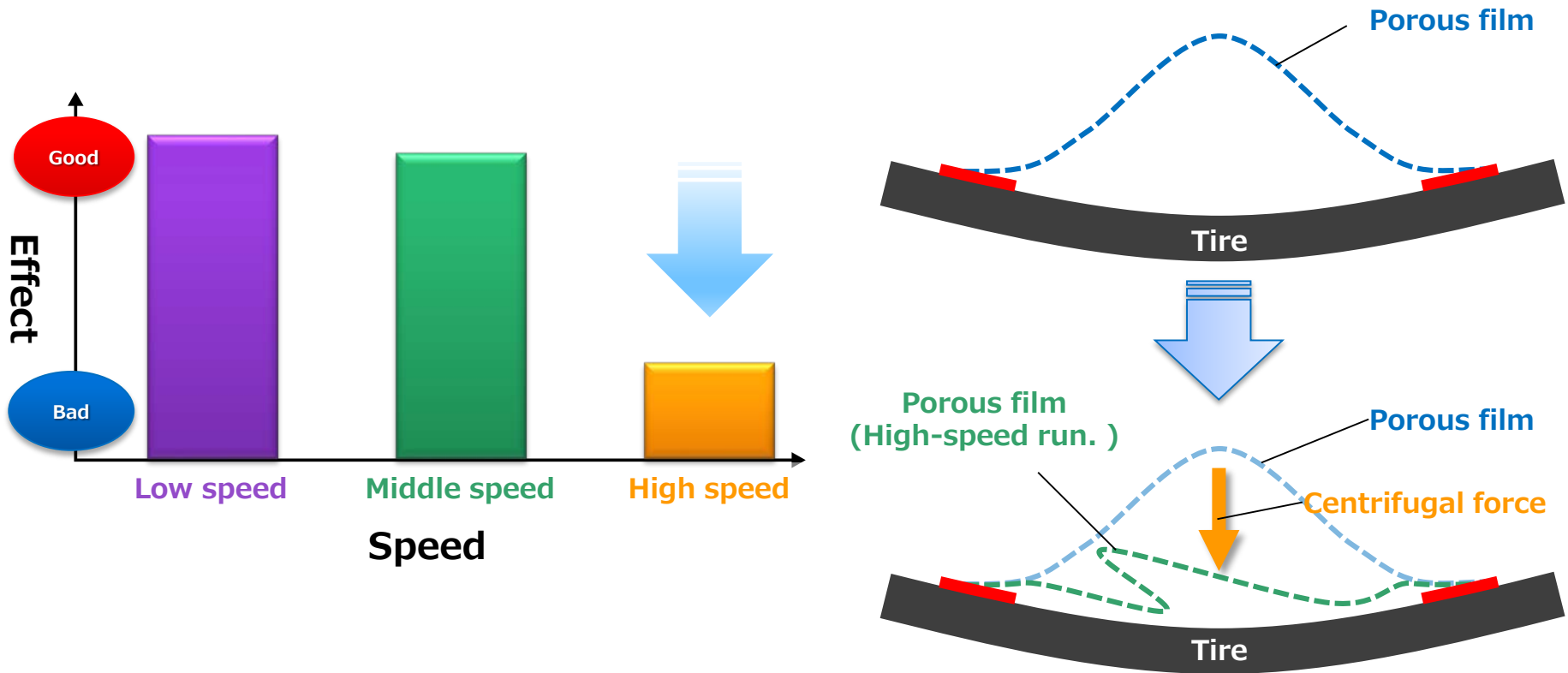


- Radial flow
- Flow of direction of surroundings

It corresponded to the sound in two directions and the flows by arranging the porous film in the mountain.

# 4.4 Approach ④: Problem generation

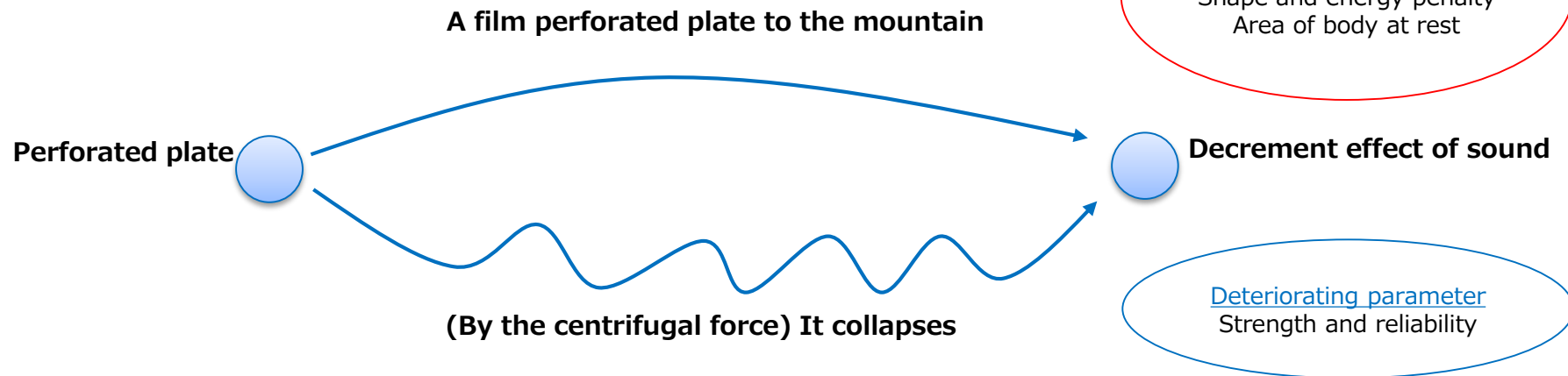
- What is the problem that occurs in the effect confirmation to be obtained for the tire?
  - The tendency to which the effect lowered was confirmed to the effect in the speed region in a high-speed region while it was low speed-.



**The porous film arranged in shape collapses by the centrifugal force when high-speed running the mountain.**

# 4.4.1 Contradiction model ①

- Contradiction model ⇒ Inventive Principle



	Idea ①	Idea ②	Idea ③
<b>Improving parameter</b>	Shape	Energy loss	Area of non-moving object
<b>Deteriorating parameter</b>	Strength	Reliability	Strength
<b>Recommended Inventive Principle</b>	<b>30 thin film use principle</b> <b>14 curved surface principle</b> <b>10 advance action principle</b> <b>40 composite materials principle</b>	<b>11 prior protection principle</b> <b>10 advance action principle</b> 35 parameter change principle	<b>40 composite materials principle</b>

Two or more invention principles by the idea are examined overall.

# 4.4.2 Adjustment of Invention Principle

- To prevent the porous film from collapsing by the centrifugal force
  - **Inventive Principles: advance action, prior protection, composite materials**

It is a problem of the porous film of shape the mountain.

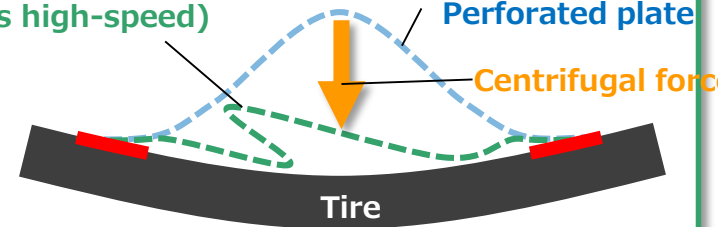
**It doesn't get good results when high-speed running.**

⇒Collapsing by centrifugal force.

Perforated plate  
(It is high-speed)

Perforated plate

Centrifugal force



The sponge is arranged between the films.

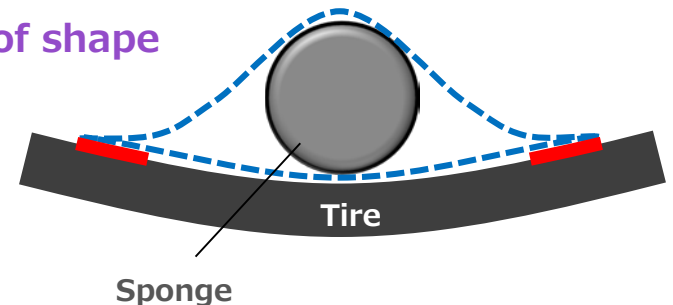
**Collapsing of the porous film is controlled. - Maintenance of shape**

⇒So as not to collapse, it reinforces it.

**Effect of decrease of sponge**

⇒Effect of absorbing sound of sponge.

⇒Effect of combination with porous film (acoustic material arrangement in the back air layer)

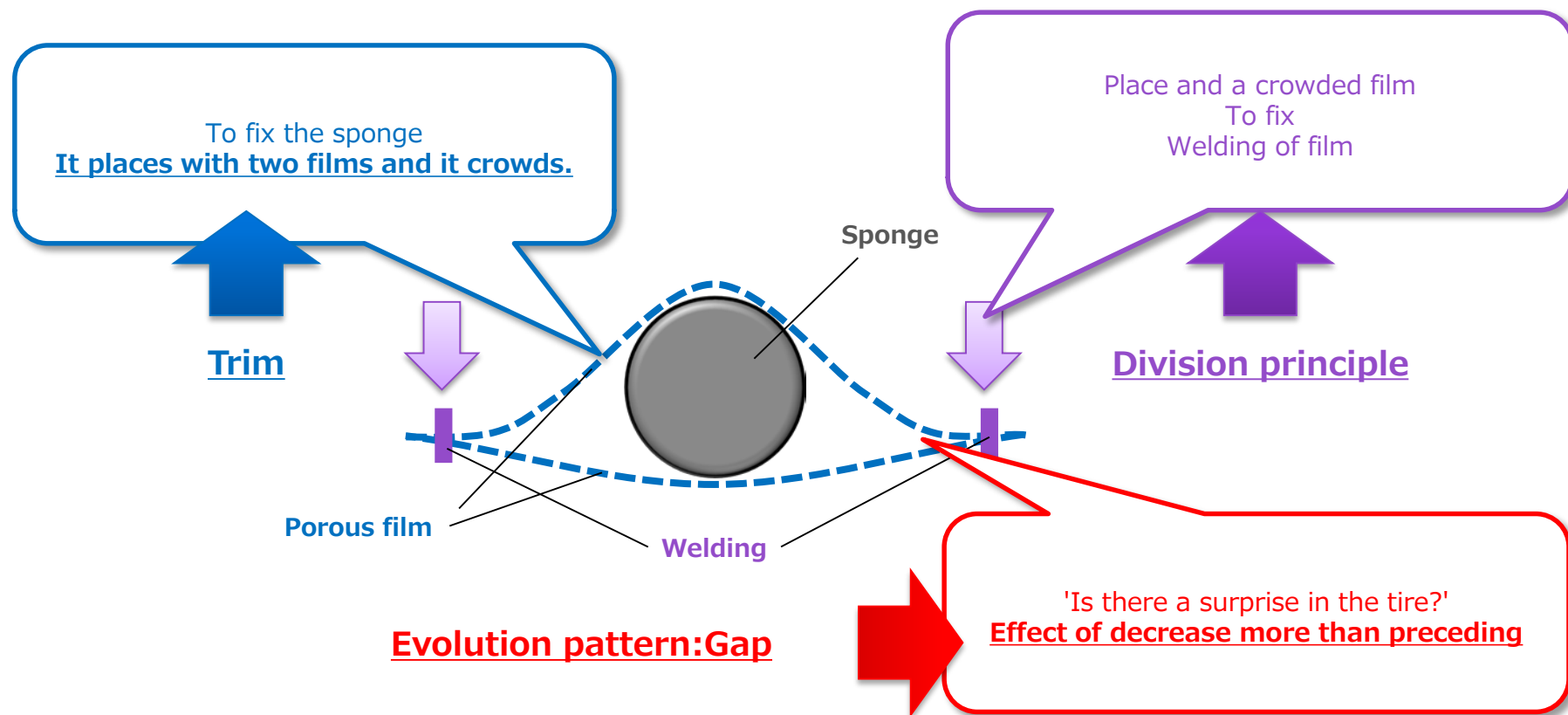


**The sponge is arranged between the porous films, and shape is maintained ..the mountain it...**



# 4.5 Approach ⑤

- For QCD: Reduction in material and processing man-hour and improvements of effect
  - ✓ The material and the processing man-hour increase the sponge of the shape maintenance because it adjusts.
  - ✓ Can the effect of the decrease more than preceding be shown?

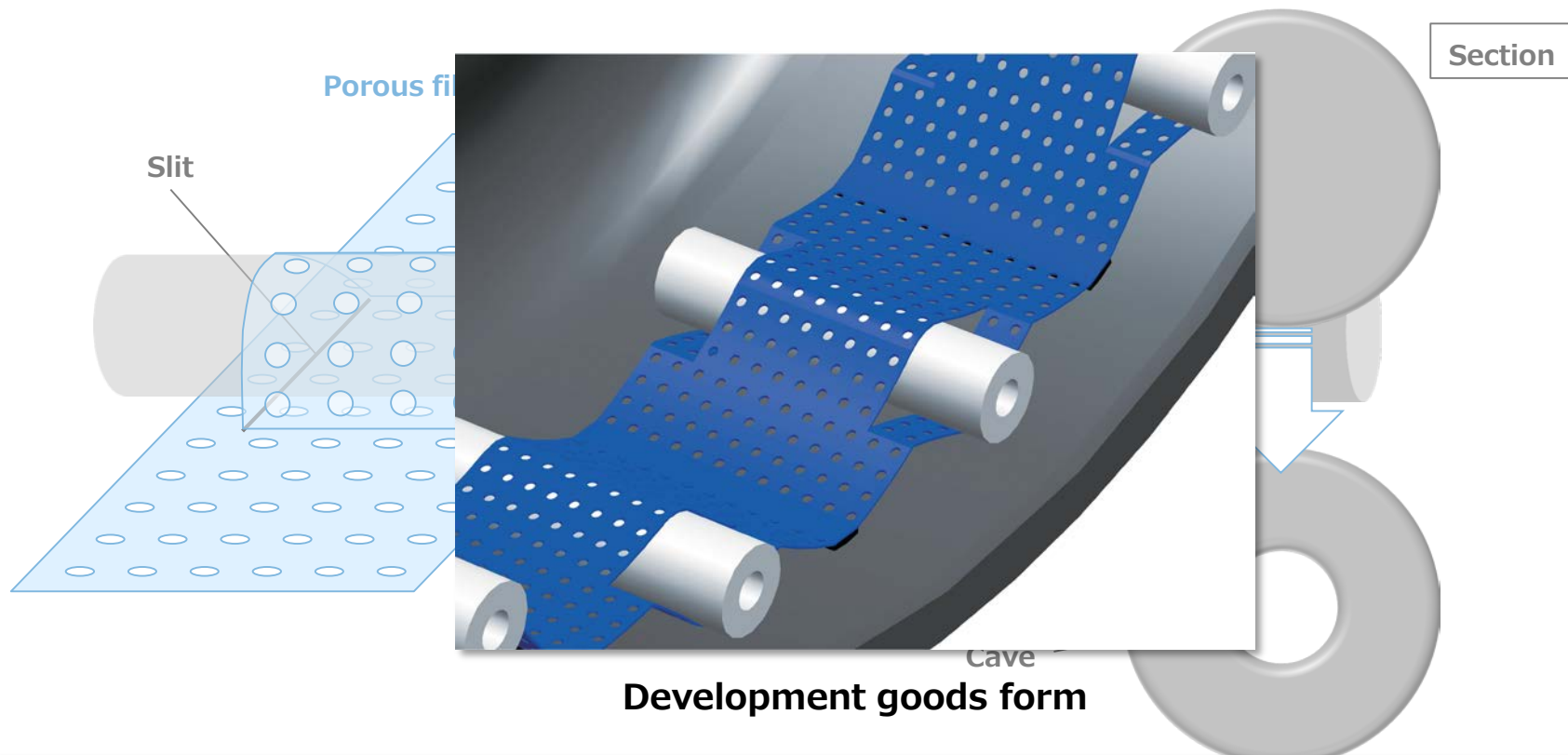


It ..various technique.. adjusts to the improvement of the material, the processing man-hour reduction in the QCD correspondence, and the performance.

# 4.5.1 Composition for QCD

## ■ For QCD: Reduction in material and processing man-hour and improvements of effect

- It is a slit, and two piece  $\Rightarrow$  1 piece in the film: The material decrease and man-hour decrease.
- It is a cave in the sponge: Material decrease, lightening, and effect improvement



**It arrived at composition/form of the development goods by QCD measures.**

# 5. Peroration

- I introduce 'Five approaches' in a new technology that develops.

Approach ①  
**The phenomenon of  
the target is caught.**

Cause analysis and device analysis  
⇒ Grasp/observation of phenomenon

Approach ②  
**How is the hint used?**

Evolution pattern and Effects

Approach ③  
**How is the idea achieved?**

Evolution pattern

Approach ④  
**Action on real problem**

Contradiction model ⇒ invention principle

Approach ⑤  
**For QCD balance**

Trim, invention principle, and evolution pattern

- It is thought that the approach that uses the TRIZ technique is effective for various problem solutions in technological development.
- In the future, it ..technological development that can offer impression and the surprise to the unique bonito guest.. will try.

***TOYO TIRES***  
*driven to perform*