



(WW3 – 2)

# Buried Pipe Detection Technology and In-pipe Traveling Robot Technology

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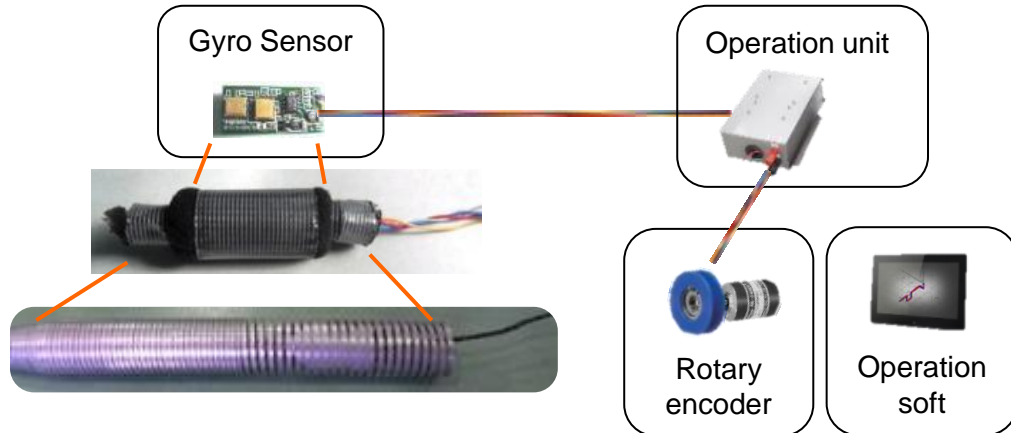
- Technology Search across the other Industries by the Japan Gas Association (JGA) to improve Next-Generation Gas Piping Safety
- MEMS Gyroscope Technology  
: Gyro-Locator for detecting three-dimensional pipe locations

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Osaka Gas

- In-pipe Traveling Robot Technology  
: Active Scope Camera for in-pipe delivery inspection
- Conclusion including Future Issues

M. Konno  
Tokyo Gas

## *Gyro Locator*



## *Active Scope Camera*

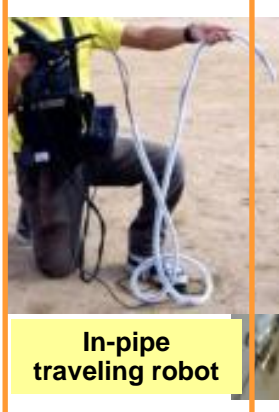
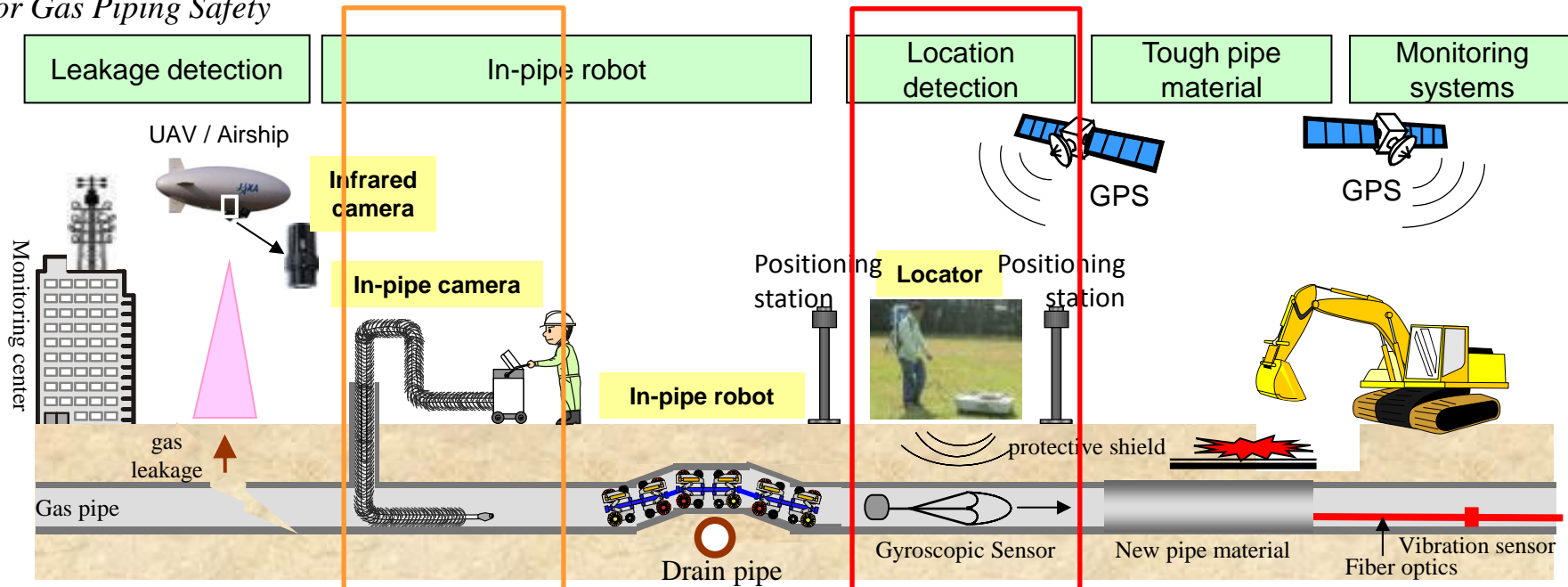


# Technology Search - Two Promising Technologies

Five Needs  
for Gas Piping Safety

*In-pipe Traveling Robot*

*MEMS Gyroscope* by JGA (2008 - 2010)



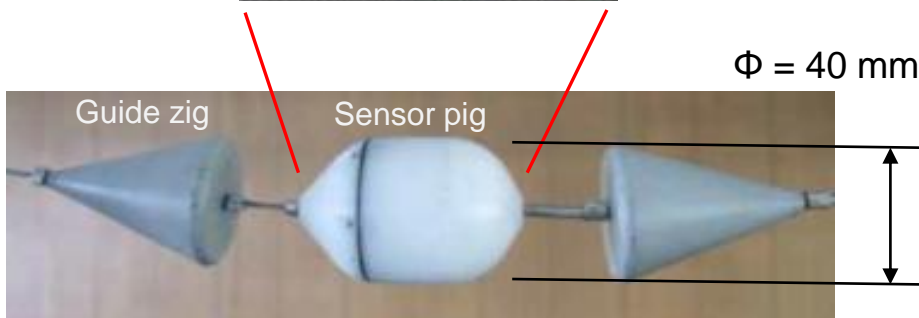
*In-pipe Traveling Robot*

*MEMS Gyroscope*

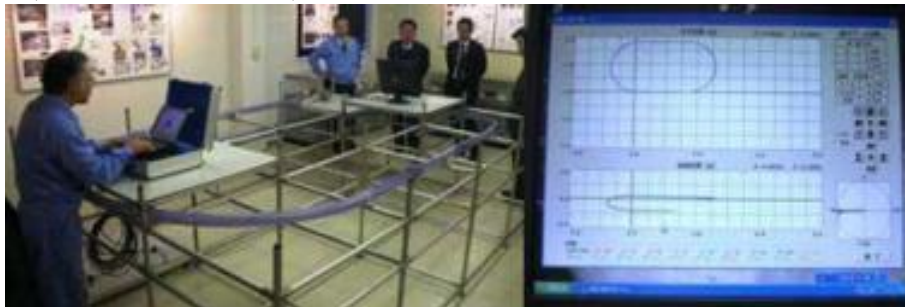
# Gyroscope Technology - MEMS Gyro Sensor

by JGA (2008 - 2010)

## Configurations of Gyro Sensor



## (Demonstration)



## (Specifications)

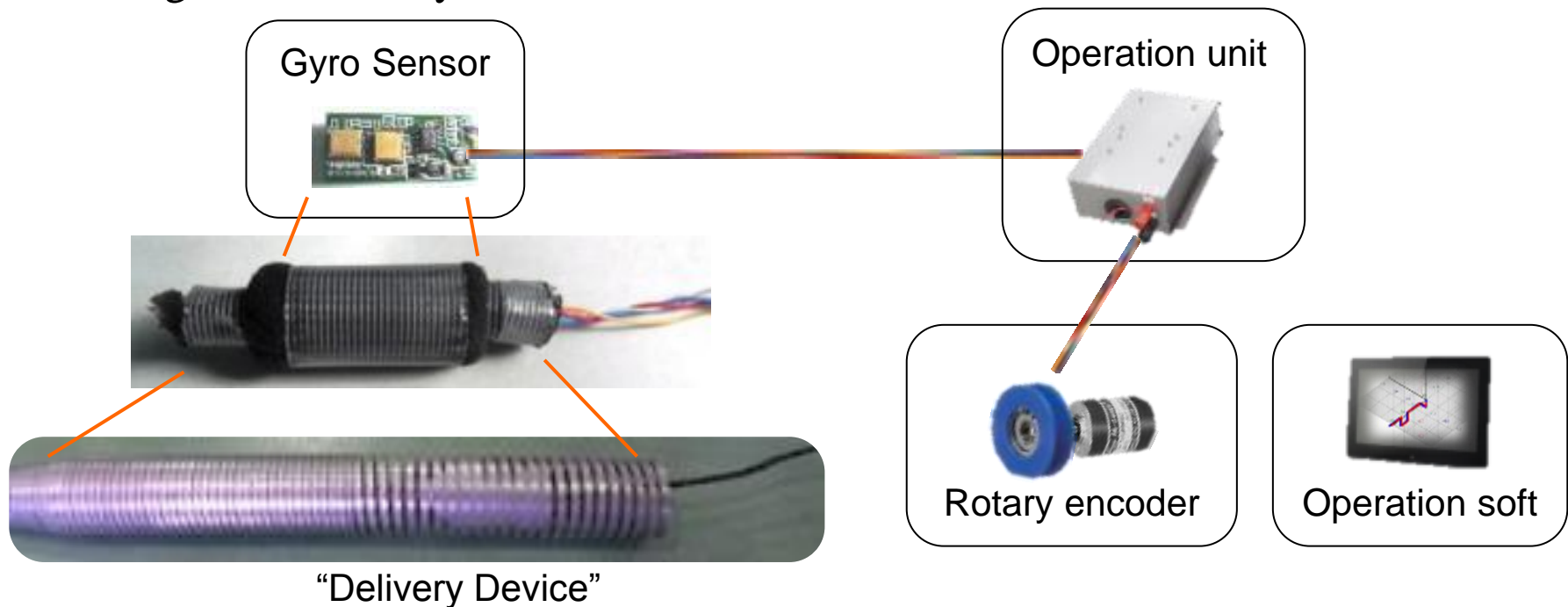
<b>Purpose</b>	Three-dimensional Pipeline Measurement
<b>Principle</b>	Gyro sensor carries through the pipeline, and gets the trace data.
<b>Measurement Items</b>	Gyro :Three axes Acceleration :Three axes Length :Encoder (ext.)
<b>Dimensions</b>	<u>Diameter 40 mm</u> × 61 mm
<b>Quality</b>	Prototype
<b>Application</b>	Construction field

# Gyro-Locator - Development

## Improvements

<b>Gyro Sensor</b>	Rotation Speed : From 300 to 900 degrees/sec Sensor Board : Compact in size 14 × 30 mm
<b>Insertion &amp; Collection</b>	Adopting “Delivery Device” made of coiled metal wire
<b>Software</b>	Adopting a formula that calculates Attitude Angles

## Configurations of Gyro-Locator





# Gyro-Locator - Test Assessment

## Simulation Pipes

(Specification)

- Total Length = 4 m (13 feet)
- Bend Pipe = Eight curves
- Diameter (2)  
= 1 inch & 1.1/4 inch
- Shapes (5)  
= Five different patterns

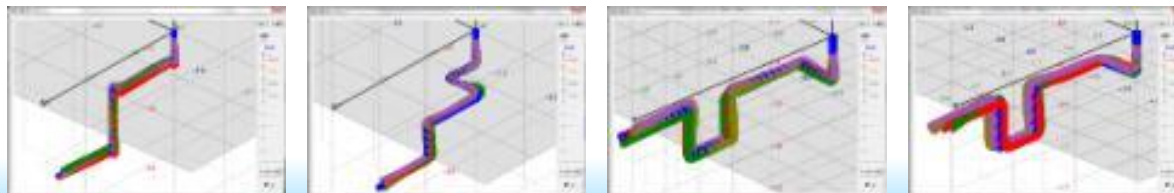
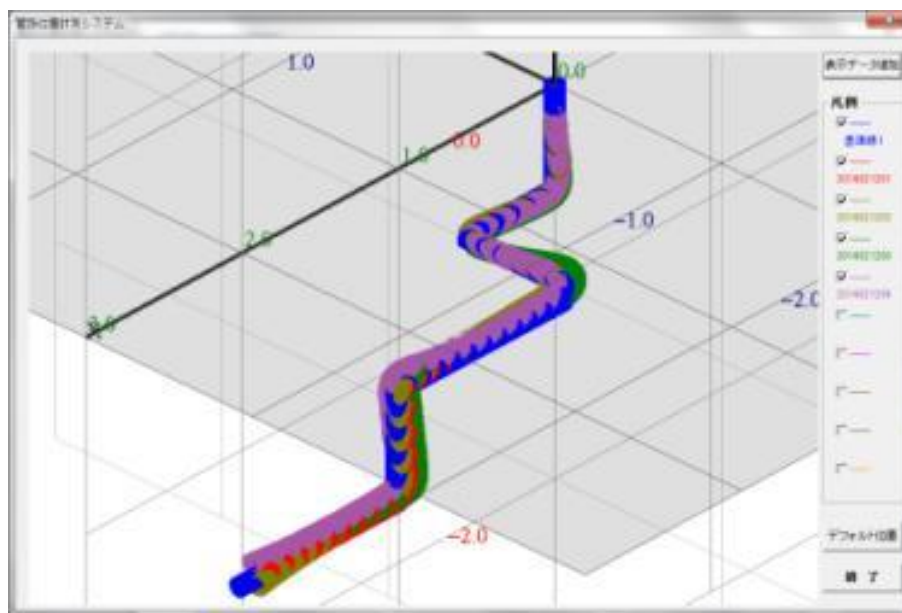
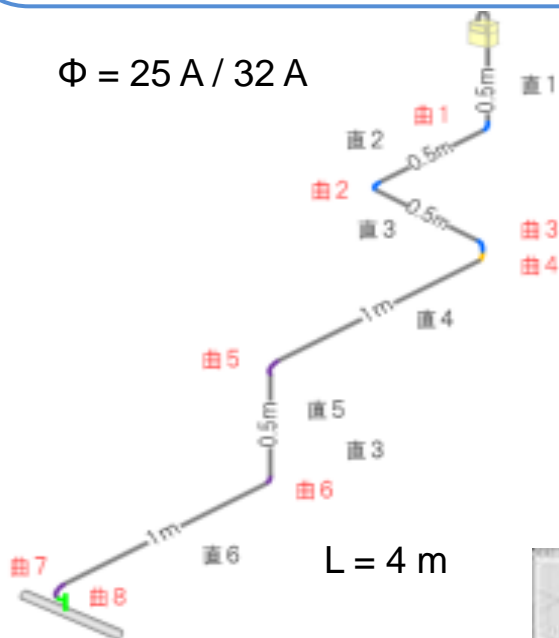
## Assessment

**Number of Tests**

2 × 5 × 3 times = 30 tests

**Three-dimensional Measurement**

All tests passed within a 10-cm (4-inch) margin of error.



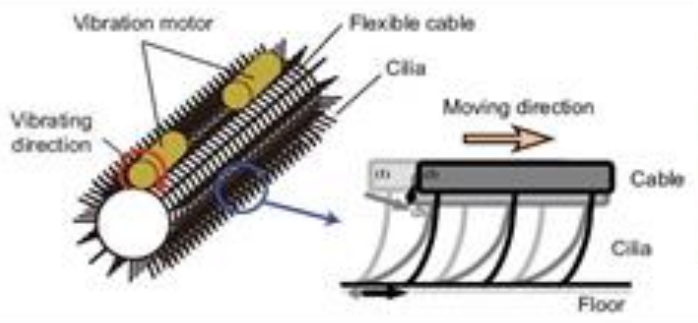
## MEMS Gyro Locator

- Development
  - A super-compact MEMS Gyro Sensor (14 × 30 mm)
  - “Delivery Device” installs the super-compact sensor.
  
- Test Assessment
  - Gyro-Locator can carry through pipe joints and pipe bends.  
(1 inch & 1·1/4 inch)
  - Accuracy of measurement is within 2.5 % margin of error.
  
- Future Issues
  - Reducing the amount of shock when passing through pipe joints
  - Correcting any margin of error in pipe measuring

# In-pipe Traveling Robot– Active Scope Camera

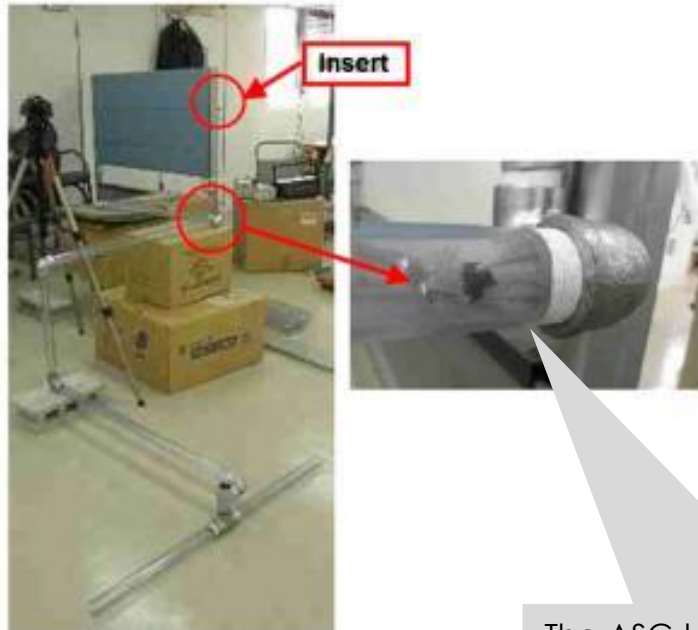
## Configurations of Active Scope Camera (ASC)

by JGA (2008 - 2010)



ASC cannot insert 1-inch pipe.

(Demonstration)



## (Specifications)

<b>Purpose</b>	Search robot for narrow space
<b>Principle</b>	ASC moves forward autonomously when the fibers attached to the surface of the camera cable respond to vibrations caused by a motor.
<b>Dimensions</b>	<u>Diameter 30mm</u>
<b>Quality</b>	Prototype
<b>Application</b>	Construction field

The ASC tends to get stuck at the curves of continuous fitting.



# Active Scope Camera - Development

## Improvements

<b>Fundamental Structure</b>	Fixed body part (including vibration motor inside) and flexible Tube
<b>Tip Rotation Mechanism</b>	Installing a tire with screw-like grooves
<b>Easy to Retract Design</b>	Tapering the metal in the tube Taking full advantage of the tube's length

**<Specifications>**

- Total length : 7m
- Diameter of the fixed body part without including the fibers : 12mm
- Diameter of the tube : 10mm
- Fiber length : 5mm

**Fixed body part including vibration motor**

**Flexible Tube**

For passing through narrow pipes in continuous



**Fundamental Structure**



**Tip Rotation Mechanism**



**Easy to Retract Design**

## Configurations of ASC

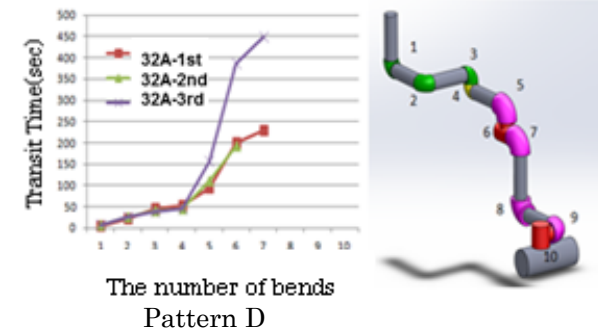
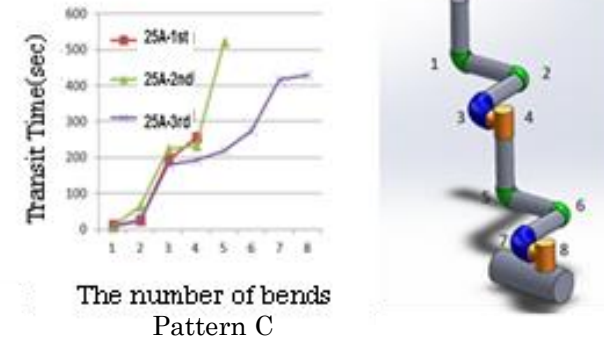
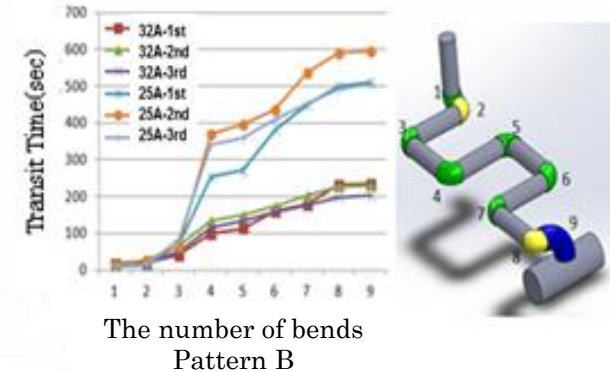
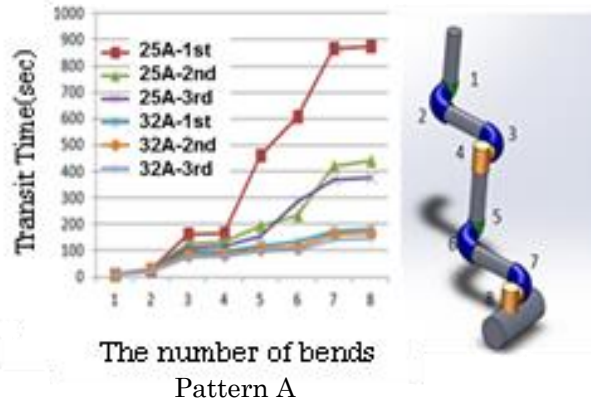


# Active Scope Camera - Test Assessment

## Simulation Pipes

### (Specification) Pattern A

- Total Length = 5.5 m (18 feet)
- Bend Pipe = Eight curves
- Diameter (2)
  - = 1 inch & 1.1/4 inch
- (Shapes (4))
  - = Four different patterns



## Assessment

	Insertion	Retraction
<b>Pattern A</b>	All bends passed.	Up to four bends retracted.
<b>Pattern B</b>	All bends passed.	Up to five bends retracted.
<b>Pattern C</b>	All bends passed. (25A-3rd)	Up to four bends retracted.
<b>Pattern D</b>	Up to six bends passed.	Up to four bends retracted.

## Active Scope Camera

- Development (for 1 inch & 1-1/4 inch diameter pipe)
  - Structural improvement of the body part and the tube
  - Installing a tip rotating mechanism
  - Easy-to-Retract design
- Test Assessment
  - Insertion: All bends passed (Pattern A,B,C).  
Up to six bends passed (Pattern D).
  - Retraction: Up to four bends retracted.
- Future Issues
  - Improving the retraction method
  - Improving the mobility through pipes with various twists and turns

# Conclusion including Future Issues

We developed these two technologies.

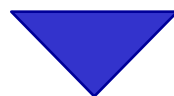
## Gyro-Locator

For detecting three-dimensional pipe locations

## Active Scope Camera

For in-pipe delivery inspection

We will develop a new technologies by combining these two technologies.



In the future,

We no longer have to dig out buried pipes to detect their location and shape.

It also allows extensive survey of the interior of the pipe.

This, in turn, contributes to safer gas pipeline maintenance.