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# Inner Defects Inspection for Tunnel Lining using Rapidly Scannable Non-contact Radar and Synthetic Soundness Diagnosis System



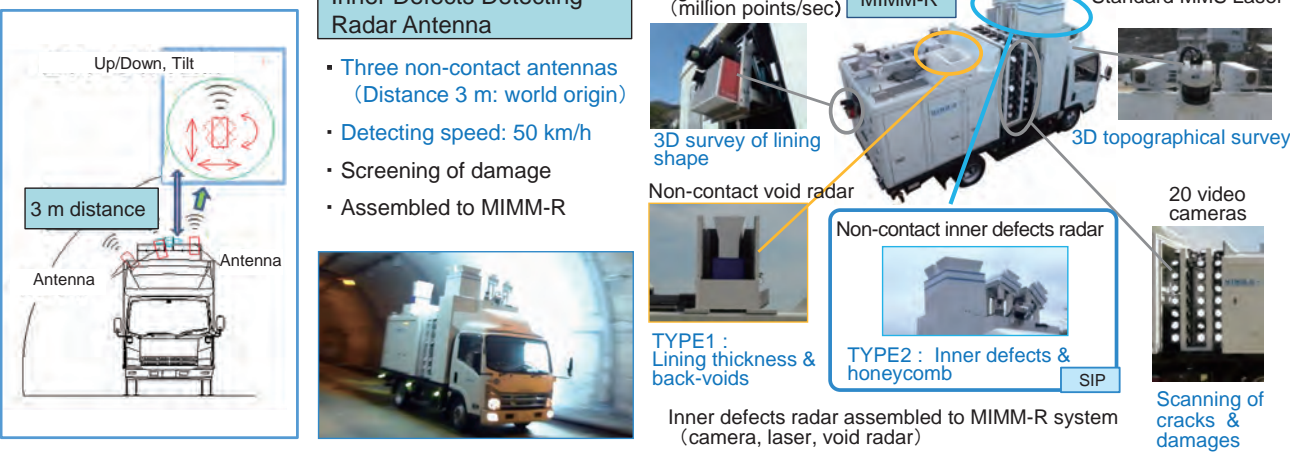
Principal Investigator Toru Yasuda (Technical Director, Pacific Consultants Co., Ltd.)  
Collaborative Research Groups Walnut, iSystem Research, Sanei, Forum8

## R&D Objectives and Subjects

### Objectives

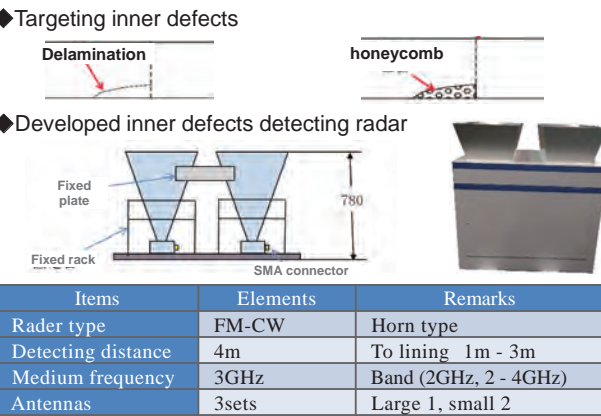
- ① The 1<sup>st</sup> Objective of this study is to develop an inspection technology detecting the inner defects for concrete lining using a rapidly scannable non-contact radar as a complement of hammering test.
- ② The 2<sup>nd</sup> Objective is to develop a synthetic diagnosis system to comprehensively assess soundness, as well as a database compilation of various conditions of unsoundness, including inner defects, by 3D visualization technology.

### Subjects

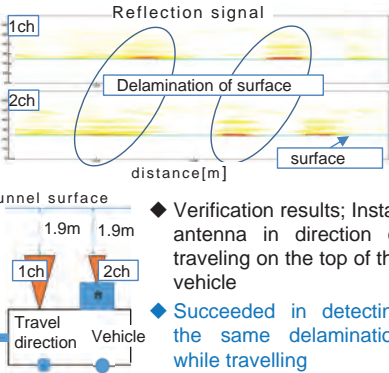


## Current Accomplishments (1/2)

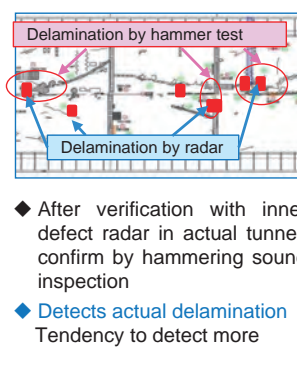
### Radar for inner defects (New developed in SIP)



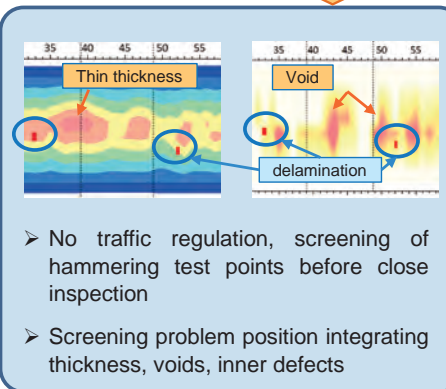
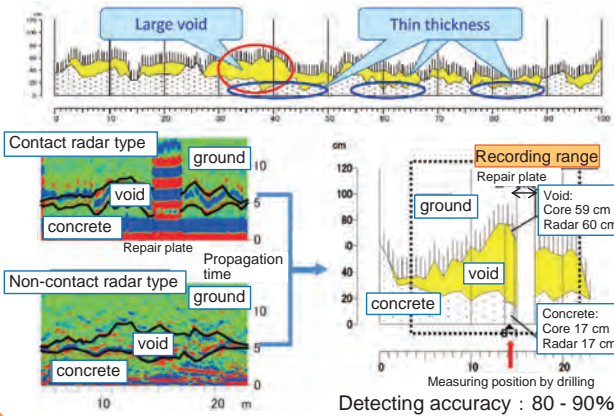
### Verification 1 Delamination



### Verification 2 Actual tunnel



### Radar for thickness & void (developed)

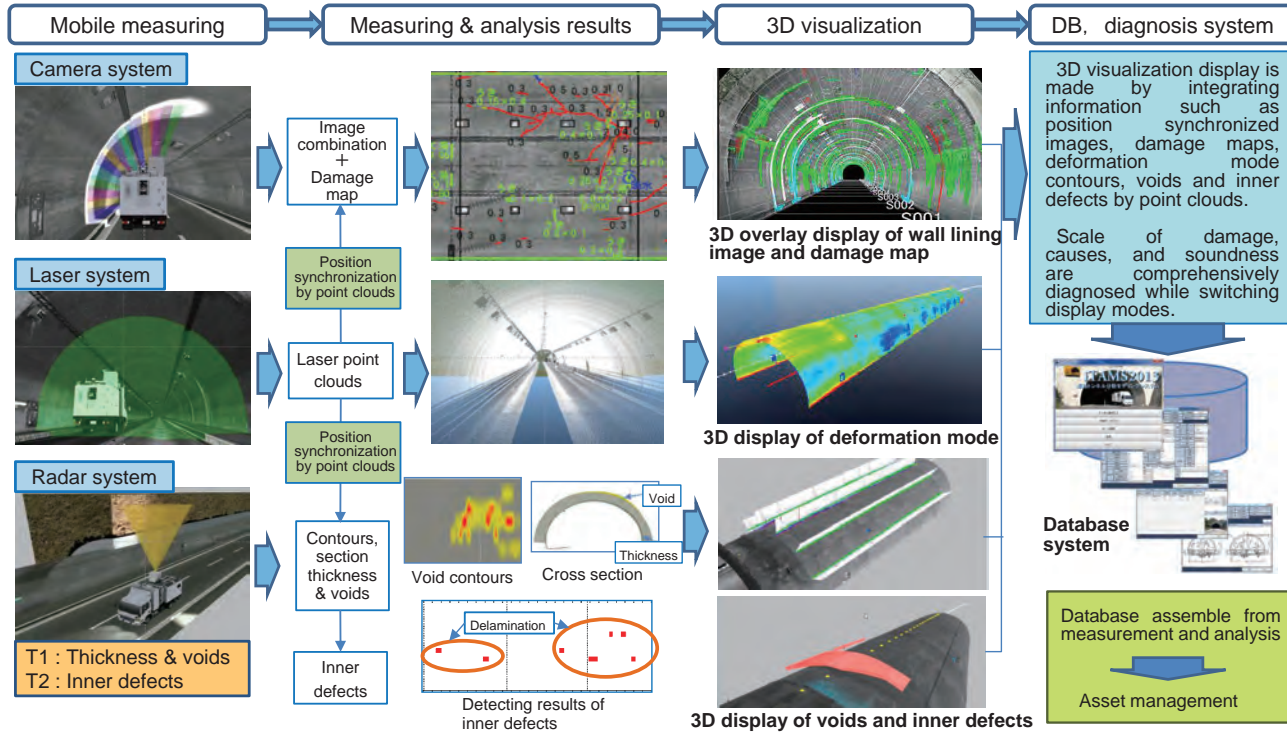


## Current Accomplishments (2/2)

### 3D visualization technology (synthetic soundness diagnosis system)

### R&D contents in SIP

- ◆Point clouds analysis functions: Automatic definition of lining joint, extraction of sectional shapes and span axis with high accuracy
- ◆Radar results visualization functions: 3D visualization, contour indicator, longitudinal and cross section with synchronized position
- ◆3D visualization and database assembly Soundness diagnosis combining image, lasers and radar is the first of its kind in Japan.



## Goals

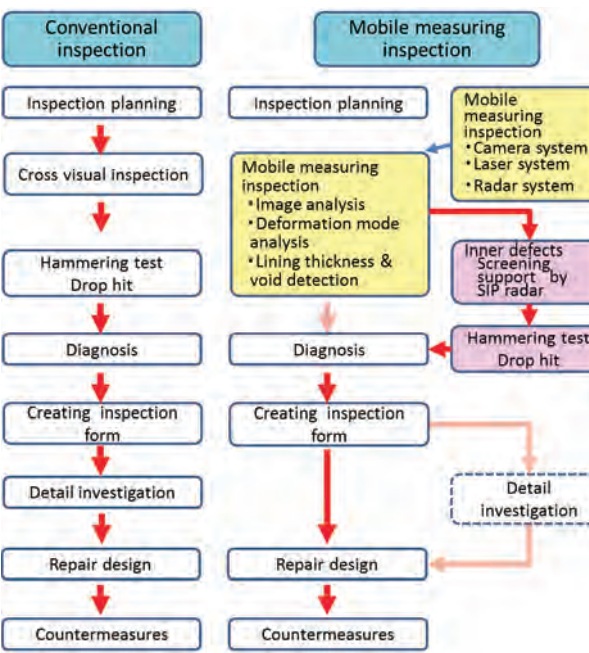
### Achieved goal and level

Items	Achieved goal	Achievement level
Radar system	System configuration • Detection accuracy : 80% • Longitudinal direction 5 cm Sectional direction 1 m • Detection depth : 20 cm	• Radar system completed • Successful reception of target inner defect signal • Detecting depth : 20 cm over
3D visualization system	• Position & lining joint synchronization, • Damage progressive evaluation S/W • 3D visualization VR S/W	• Position & lining joint synchronization completed • Progressive S/W completed • 3D visualization completed • DB ITAMS completed

### Social Implementation Image

	Exit strategy	Target	Schedule, remarks
①	Application for inspection works of radar & S/W	Own works, lending to others	Expand quickly after SIP termination We aim to increase our share to about 20% in 5 years.
②	Support and supplement for close inspection and hammering test	Ministry of Land, Infra & Transport, etc.	Linking with trial of next generation social infrastructure robot promotion, standardization by reviewing the inspection revision procedure
③	Technical guidance, consultation in the field	Municipalities	Linking with SIP program of Gifu University, etc. Promotion of diagnosis system
④	Radar & S/W sales to domestic and overseas	Consultant, inspection companies	Radar system: Sales of about 5 units per year S/W : Sales of about 10 units per year
⑤	Overseas expansion of measurement works & technical assistance	ASEAN	Overseas business model using mobile measuring vehicle Radar measurement service Application using diagnostic software

### Support for tunnel periodic inspection



We will combine cameras, lasers, radar, close visual inspection, and hammering sound tests, make appropriate judgments, support tunnel inspection, diagnose efficiency, implement work saving, and aim for low cost.