

# **One-stop Metro Tunnel Automated Inspection Solution**

**AI-based RoboCheck Exclusively Engineered for Rail Authorities**

**by Jackie Cheung 2024/10/30**

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2. Mobile scanning & imaging helps greatly with efficiency
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4. One-stop refers to 'from field to office, up to final report'
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**1.**

**How metro tunnels are now being inspected in the world**



## 1.1. Why metro tunnel inspection is a must?

Damages to metro tunnel structure and surfaces frequently occur mainly because of

- surrounding environment changes
- train-induced vibration
- human interference (eg. earthwork projects nearby)

No replay button in reality! Which will come first, Accident or Tomorrow?

construction stage – monitoring needed

operational stage – monitoring + inspection needed





## 1.2. Which headaches the inspectors might come across with?

### Headaches:

- limited time window
- dim site and dusty air
- apparent movement hazards
- stuffy environments with few vents

*Inspectors would be probably concerned about,*

- *whether we would **miss or overlook** something.*
- *how to **document the raw data** scientifically after fieldwork.*
- *how to compute the data to **obtain final report**.*
- *how to **study and detect** the variables for before&after analysis.*
- *how to **manage** the data systematically in the long run.*



### 1.3. Which contents to inspect? Which existing methodologies?

#### To inspect:

- tunnel structural deformation
- tunnel inwall defects

#### Existing Methodologies:

- visual inspection
- photography
- robotic total station monitoring
- terrestrial laser scanning

*Labor-intensive?*

*Scientific and traceable records?*

*Complete data for assessment?*

The table below presents all existing methodologies that are used by rail authorities and relevant parties involved, like contractors.

Method	Disadvantage
visual inspection + oral report	like a cursory cruise, hard to find out all problems by naked eyes only, less informative and convincing
photo-taking + summary	takes plenty of time to edit and file up then, still, easy to miss some problematic portions (like mileage info, structural info, etc.)
high-speed videography	bulk equipment and more staff to involve, high-power lighting required as well, some problematic portions (like mileage info, structural info, etc.) missing
robotic total station monitoring	big investment for a couple of units, and maintenance required for such permanently installed instruments, still, no image reference to find out defects due to point data source only
terrestrial laser scanning	low efficiency due to repeated station movements, accumulated errors to transfer, inevitable data mosaic troubles, uneven points density that affects defect detection

## 1.4. It Costs Much More for Rescue & Repair Than Inspection & Maintenance!



The construction cost of metro subway per km is around USD 72 million.

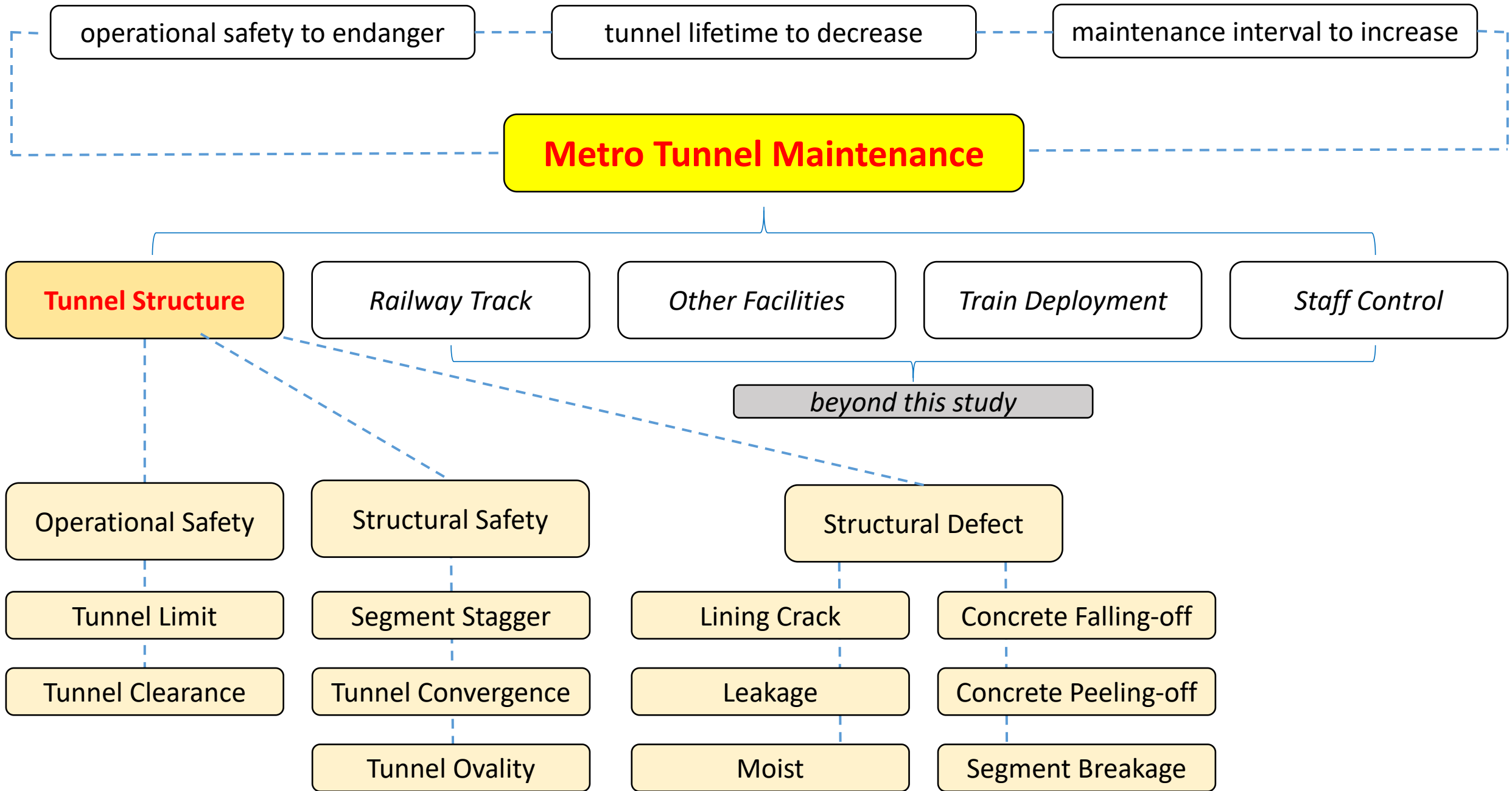


**Invest reasonable amounts** for regular “Body Check-up”. **or spend a lot more** on fatal troubles?



Any emergency response could start from hundreds of thousand US dollars.

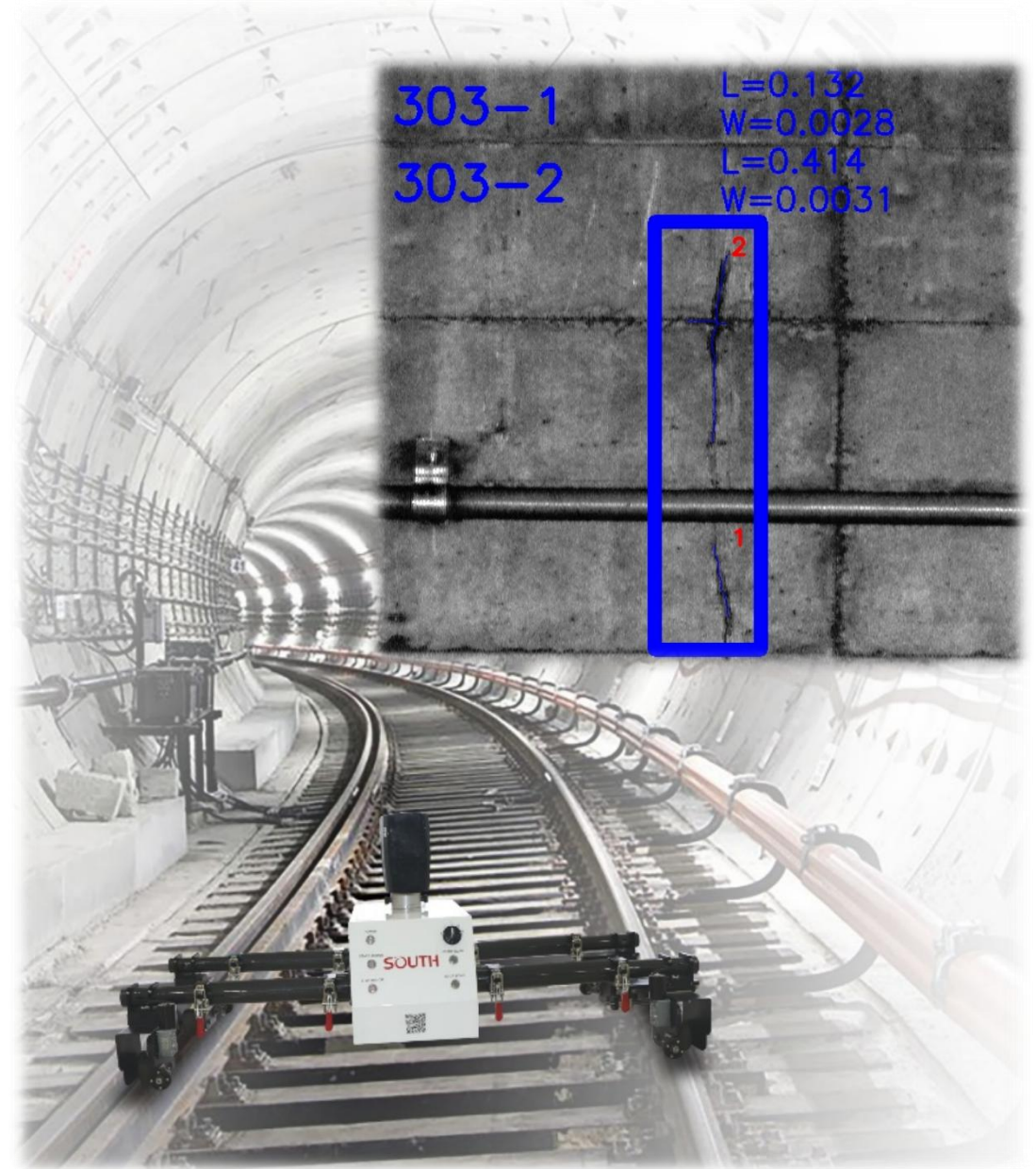






2.

Mobile scanning & imaging helps greatly with efficiency





## 2.1. **What's** the new solution and **what's** included?

### Mobile Scanning (& Imaging, if necessary):

- motorized trolley-based laser scanning
- mobile platform instead of tripod-mounted
- software-driven settings and data capture
- on-site realtime display geared by industrial computer built in trolley body

*Scientific. Traceable. Efficient.  
Visualized. Uniform. Complete.*

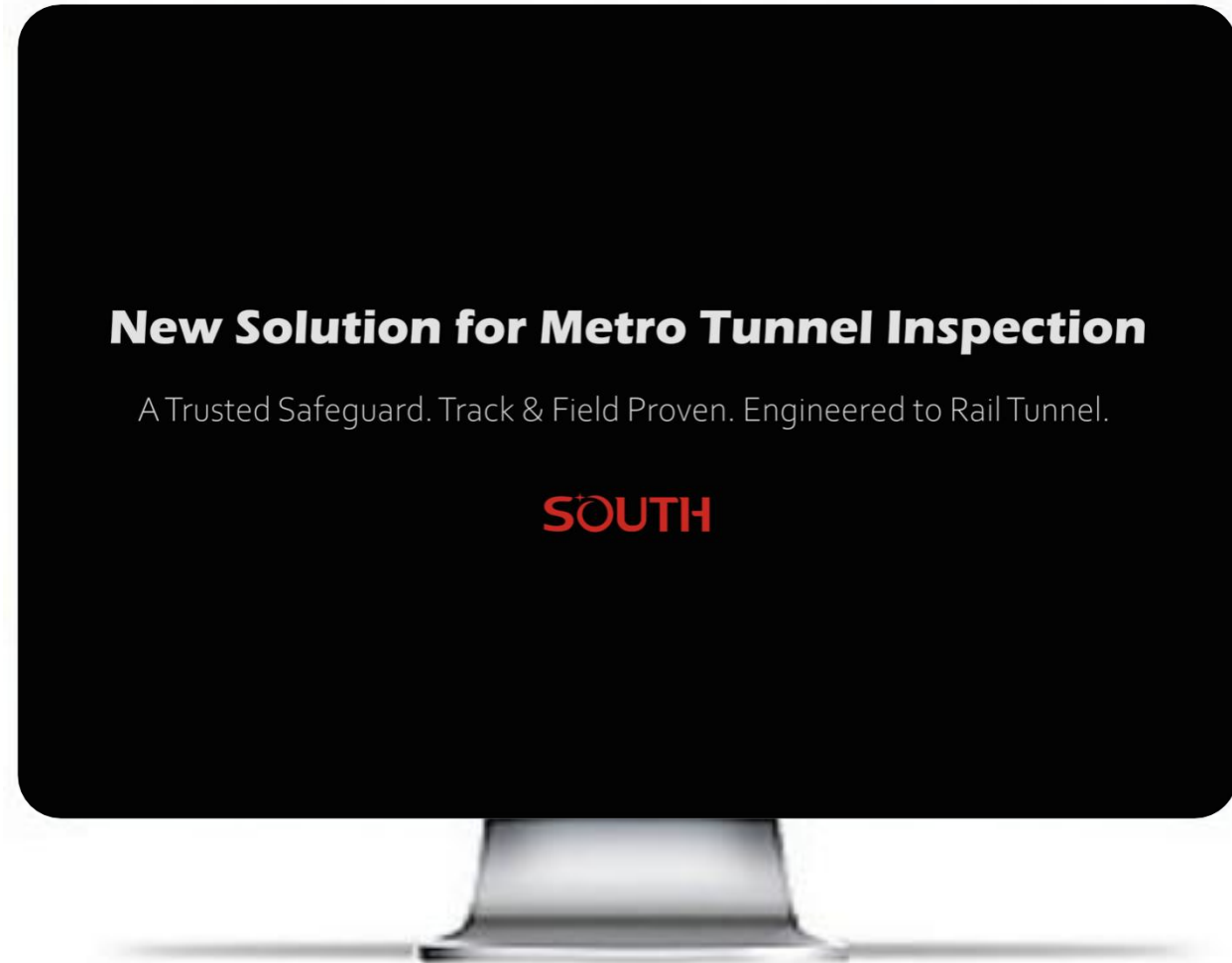
### MS100 system includes,

- all-in-one software Tunnel Scan&Go
- TrolleyAuto (with inbuilt industrial computer)
- laser scanner with Automation function
- multi-lens camera system Clover (option)
- full-life cycle control software Fulicle (option)

### **New Solution for Metro Tunnel Inspection**

A Trusted Safeguard. Track & Field Proven. Engineered to Rail Tunnel.

**SOUTH**



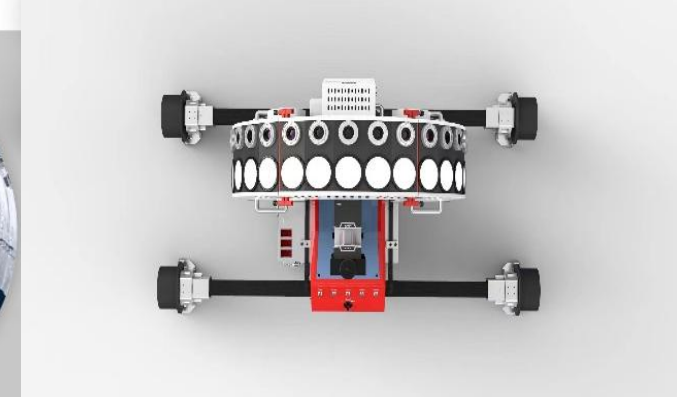
## 2.2. **When** to use this system in metro tunnel operation?

### Suited Stage:

- tracks not laid ✗ (no way to slide)
- tracks already laid ✓ (for structural monitoring)
- as-built survey ✓ (for track mid-line, by 6<sup>th</sup> gen)
- operational stage ✓ (for regular inspection)



6<sup>th</sup> generation

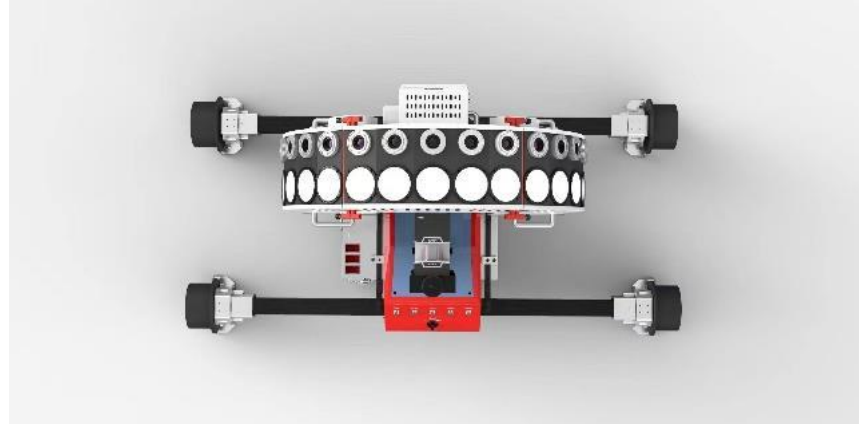


7<sup>th</sup> generation

### Suited Environment:

- ① bore tunnel
- ② shield tunnel
- ③ open-cut to shield structure session
- ④ open-cut structure station

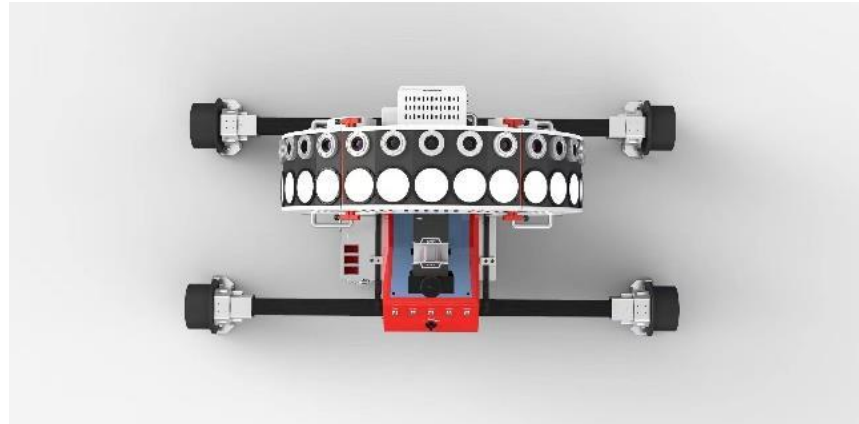




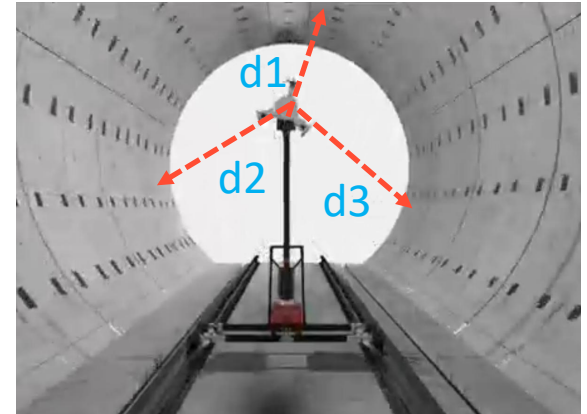
**SOUTH**

13-lens, captures vault + haunch only, suited to high-speed rail tunnels

distance:  $d1 = d2 = d3$ , then resolution:  $r1 = r2 = r3$



17-lens, captures vault + haunch + arch springing, suited to metro tunnels



## 2.3. Inspecting metro tunnels in different ways...

before



+



+



+



now



+





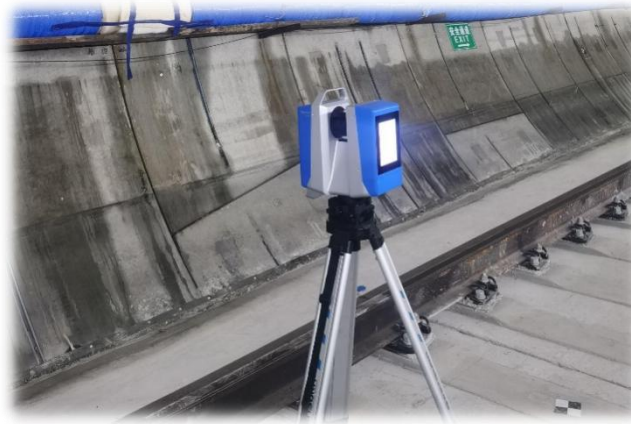
## 2.4. How long it will take to complete 1km tunnel uplink and downlink inspection?

200m per hour, 500m per job (access)

(2.5 hours max. for each tunnel access)

1km uplink and downlink = 2km in total

**2km / 500m per job = 4 jobs = 4 nights**



- repeated station movements
- apparent tripping hazards
- typically every 20m for one scan
- approx. 30 days to analyze and report

1km per hour (structure+ defects)

1 hour to cover uplink

1 hour to cover downlink

**2 hours = 1 job = 1 night fieldwork only!**



- motorized trolley running automatically
- a mobile and stable platform doing the job in one shot
- 3-4 hours to analyze and report

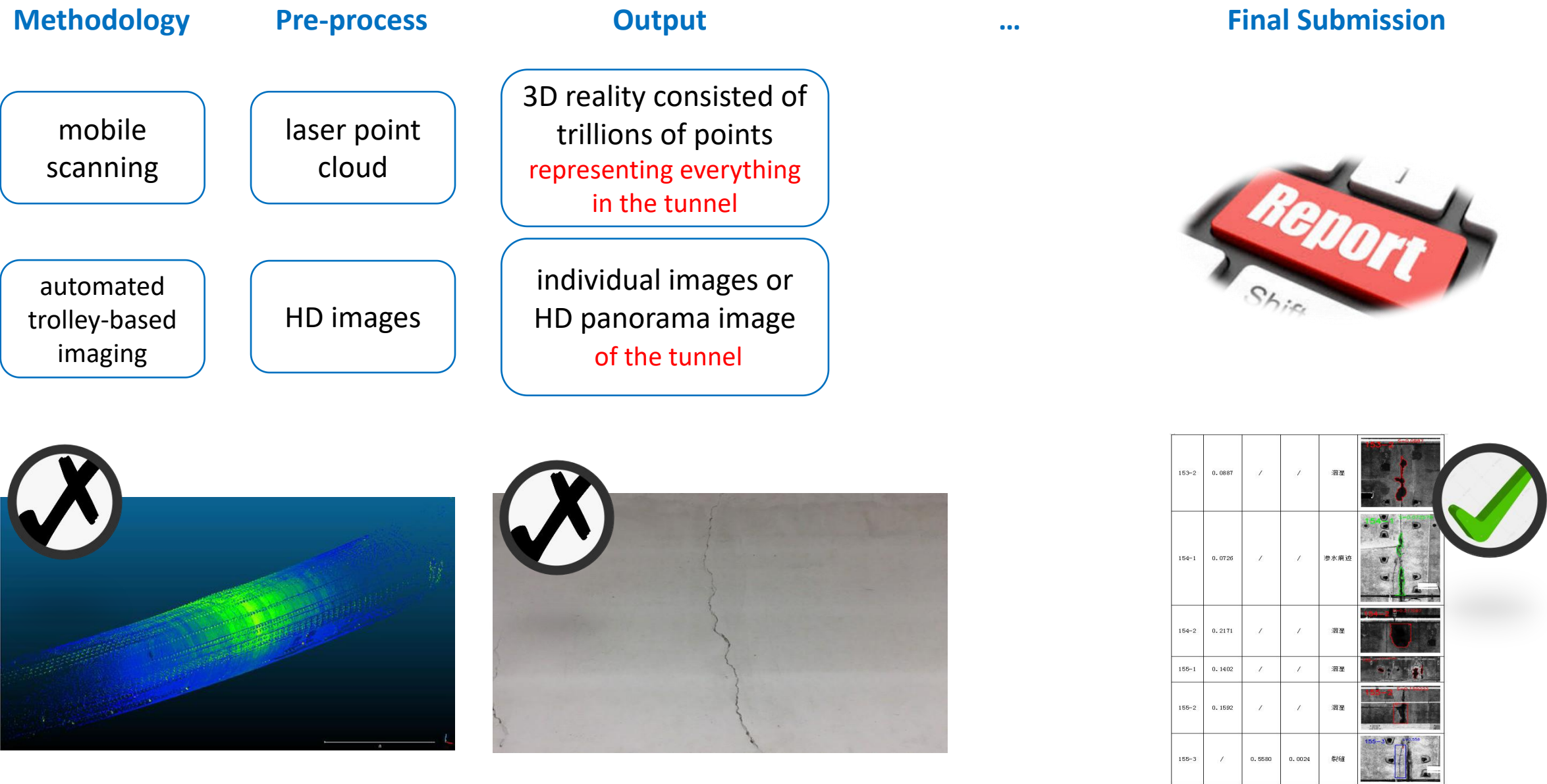


**3.**

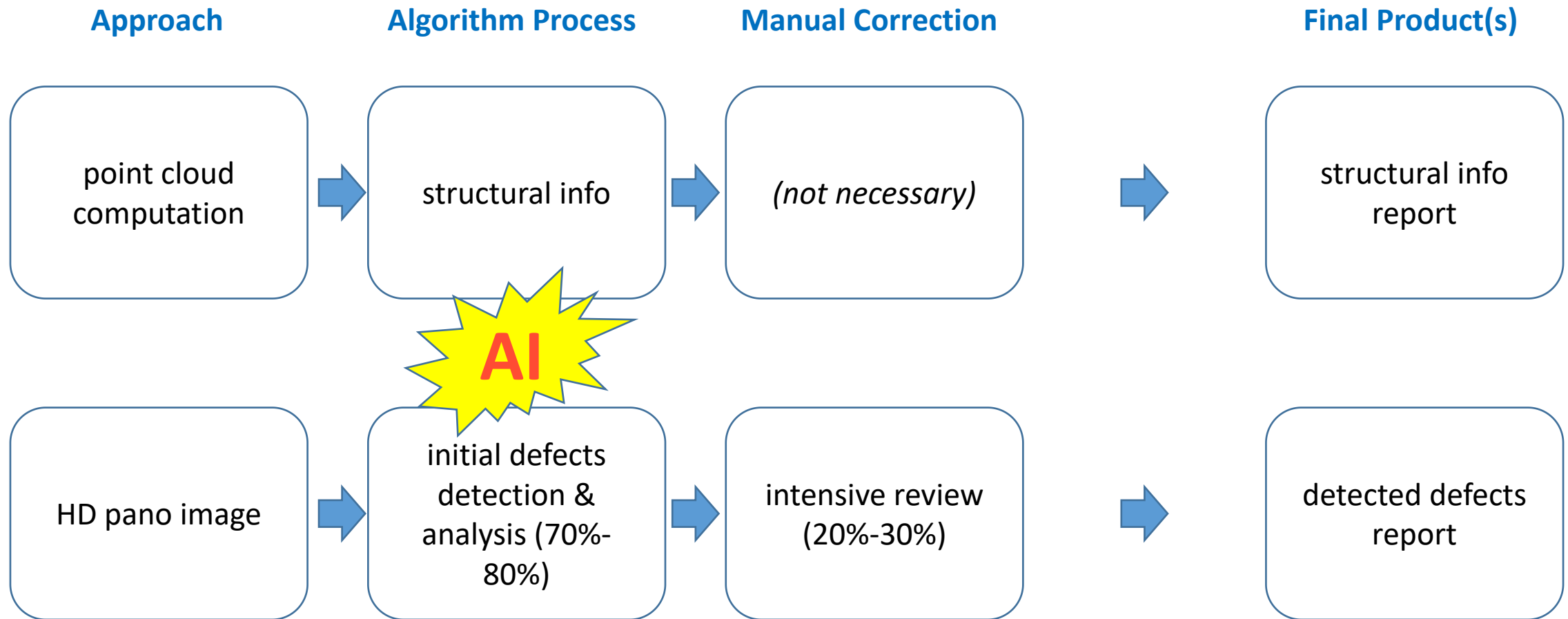
**Automated detection saves big in manpower**



### 3.1. Point Cloud & HD Image Outputs Are Not Final Products Yet



### 3.2. AI Technology Applied to Dimensional Calculation & Feature Extraction

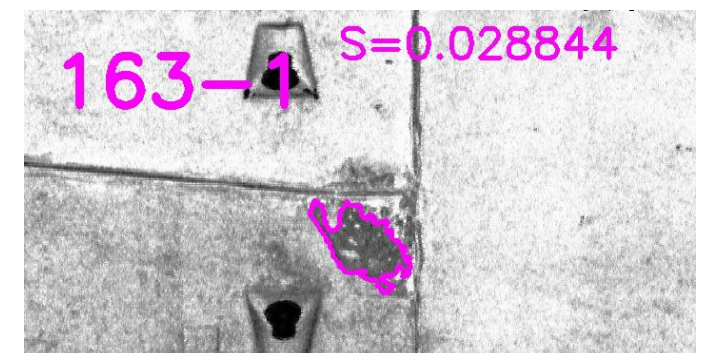
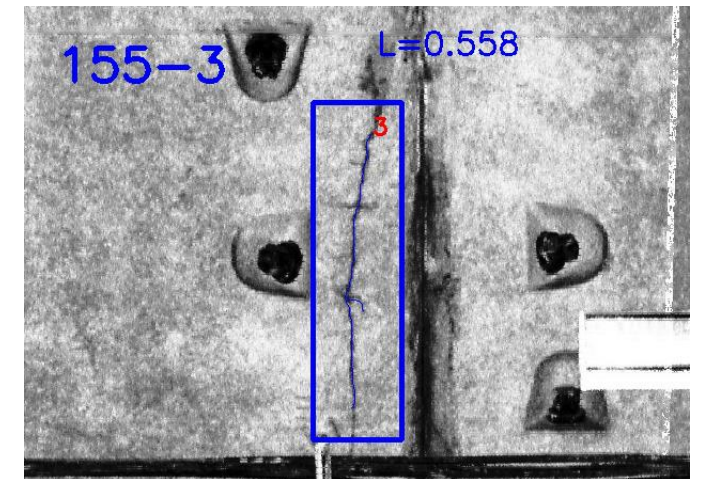
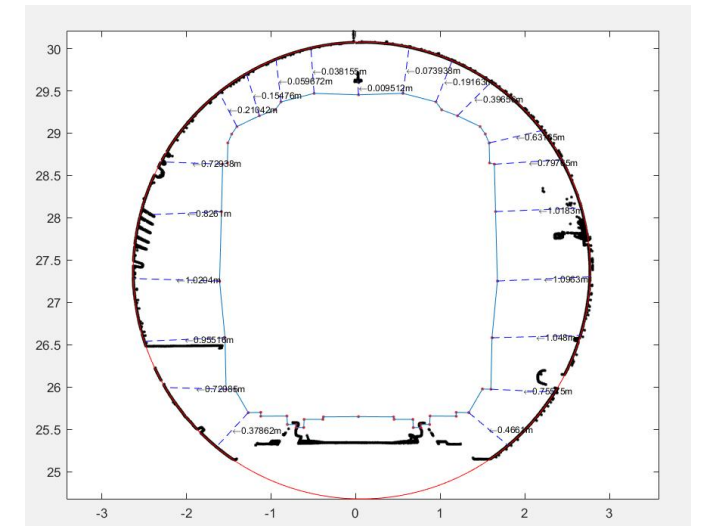


Dealing with the numerous points and images and working out the digital report is quite labor-intensive indeed.

### 3.3. Computer Vision and AI help much in...

*Generally speaking, it's supposed to find out,*

- *Are there any structural deformation portions resulting in weaker structure support, tunnel collapse, or operational safety?*
- *Are there any inwall defects resulting in rusty rail tracks, electric leakage, or lining concrete damage?*
- *Where are such defects located?*
- *What's the size of each detected defect, like length or area?*





Category	Major Content	Details to Inspect	Hidden Trouble
# 1	Tunnel Inwall Defects	moist	rusty rail tracks, electric leakage or lining concrete damage, etc.
		leakage (water seepage)	rusty rail tracks, electric leakage or lining concrete damage, etc.
		lining crack	weaker structure support, tunnel collapse, etc.
		segment breakage	weaker structure support, tunnel collapse, operational safety, etc.
		concrete peeling-off	weaker structure support, tunnel collapse, operational safety, etc.
		concrete falling-off	tunnel collapse, etc.
# 2	Tunnel Structural Information	tunnel limit	operational safety
		tunnel clearance	operational safety
		tunnel convergence	tunnel collapse, operational safety, etc.
		sectional data	operational safety
		segment ovality	weaker structure support, operational safety
		segment stagger	tunnel collapse, operational safety, etc.



### 3.4. AI Computation VS Manual Analysis

*Though structural data could be computed via point cloud,*

*Is it possible to search the inwall defects one by one?*

*How long will it take to search carefully and find all?*

*All such defects would not be missed by manual checking?*

*How to digitize the defects scientifically and come out with a logical report?*



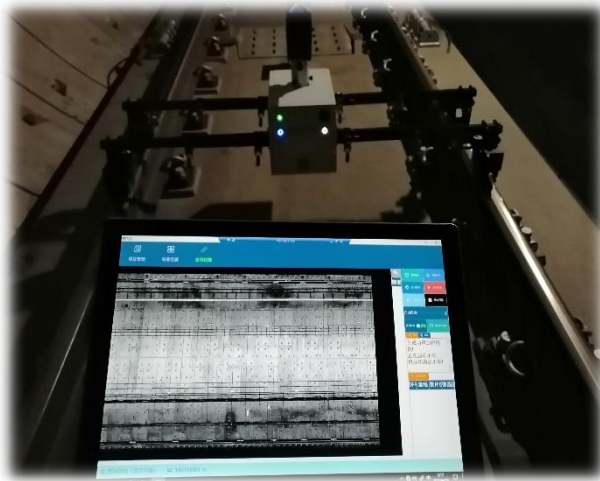
**4.**

**One-stop refers to ‘from field to office, up to final report’**



## 4.1. One-stop enjoys a complete workflow independent of a third party

Field



Office



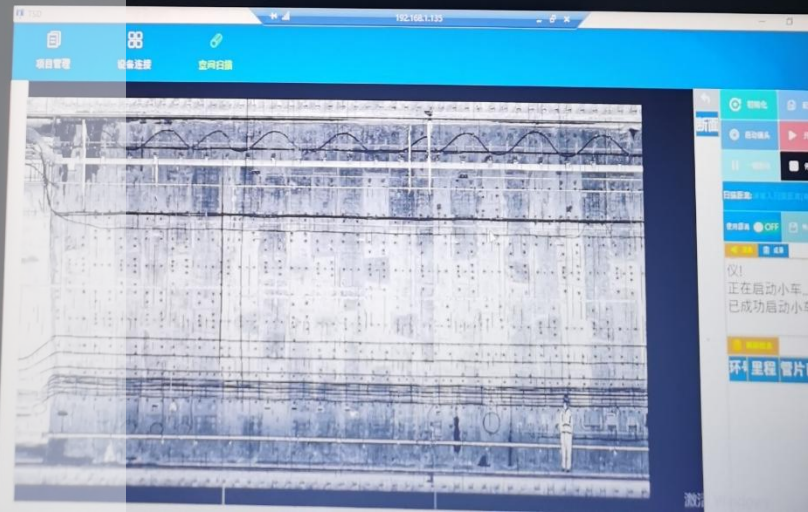
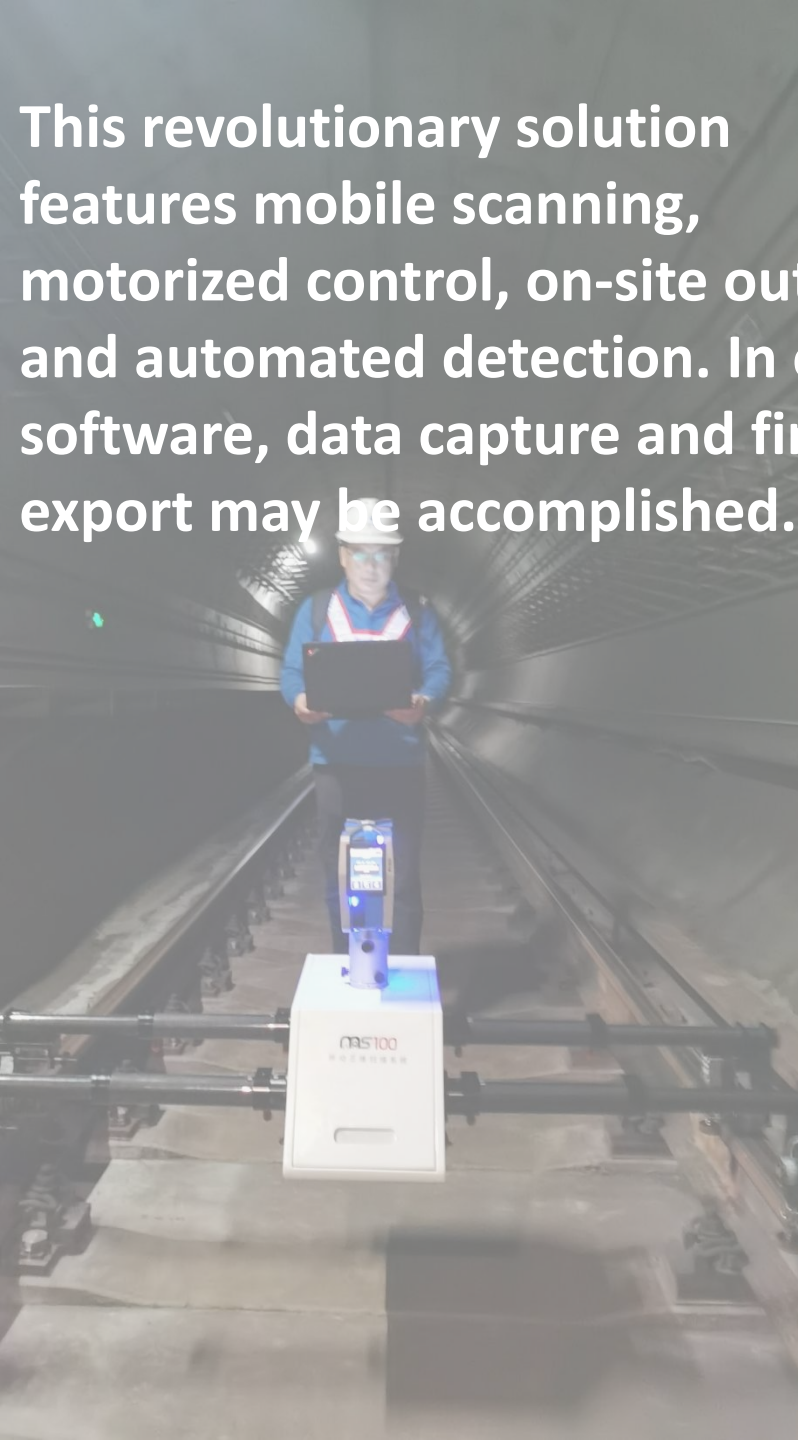
Submission

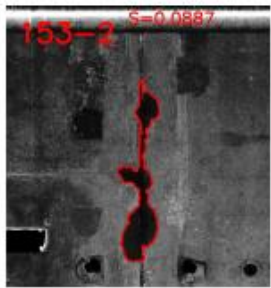
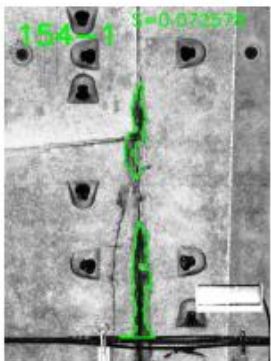
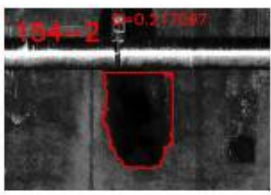

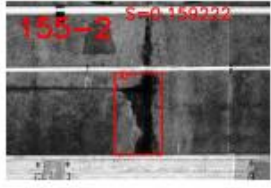
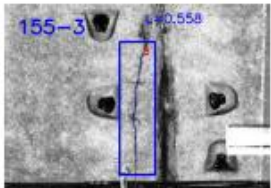


All the necessary hardware and software contributing to an acceptable submission to Rail Authority come from a single source. And all support would be provided by this team as well.



This revolutionary solution features mobile scanning, motorized control, on-site output and automated detection. In one software, data capture and final export may be accomplished.



153-2	0.0887	/	/	moist	
154-1	0.0726	/	/	seepage	
154-2	0.2171	/	/	moist	
155-1	0.1402	/	/	moist	
155-2	0.1592	/	/	moist	
155-3	/	0.5580	0.0024	crack	

## 4.2. Some Other Suppliers in the Industry

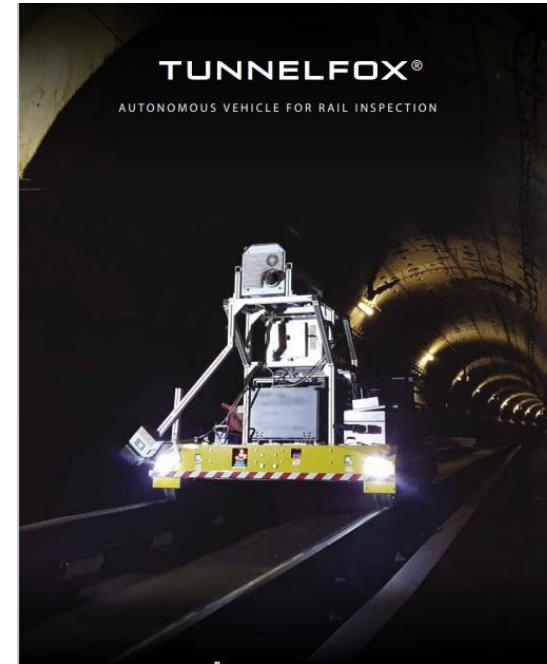
From one institute  
in Beijing, China

(approx. 300 kg)



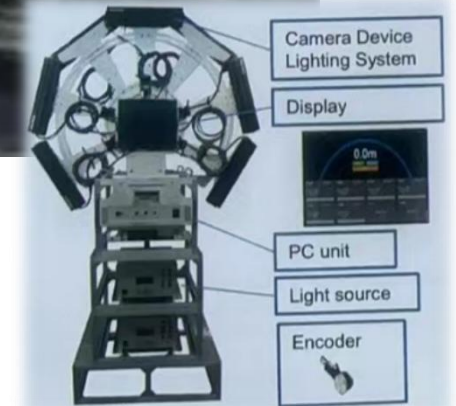
From one university  
in Wuhan, China

(approx. 270 kg)



From one company  
in Singapore

(approx. 250 kg)



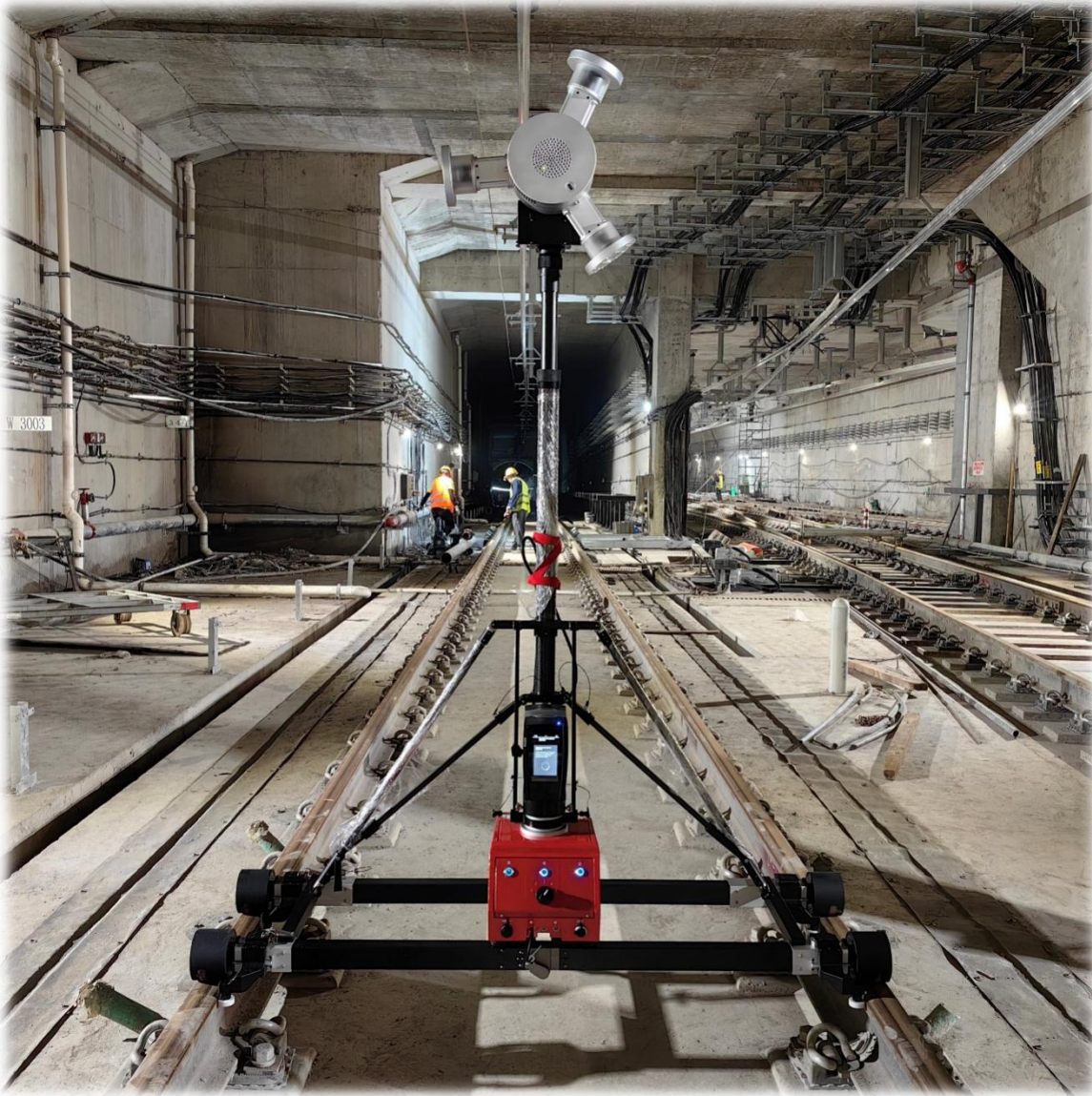
From one company  
in Japan

(approx. 150 kg)

It seems hard to move such bulky systems from one site to another. Instead, they could stay at depot after fieldwork.



## 4.3. A Ground-breaking Innovation, Unique on the Market



### Lightweight

- 27-40 kg (w/o and with camera system)

### Flexible

- easy to move to different sites

### One-stop

- final products tailored to rail authorities

### Site Tech

- idea originated from clients, co-developed

### Cost-friendly

- sales supply and job service both available

### Field-proven

- 60-80 km job services per year

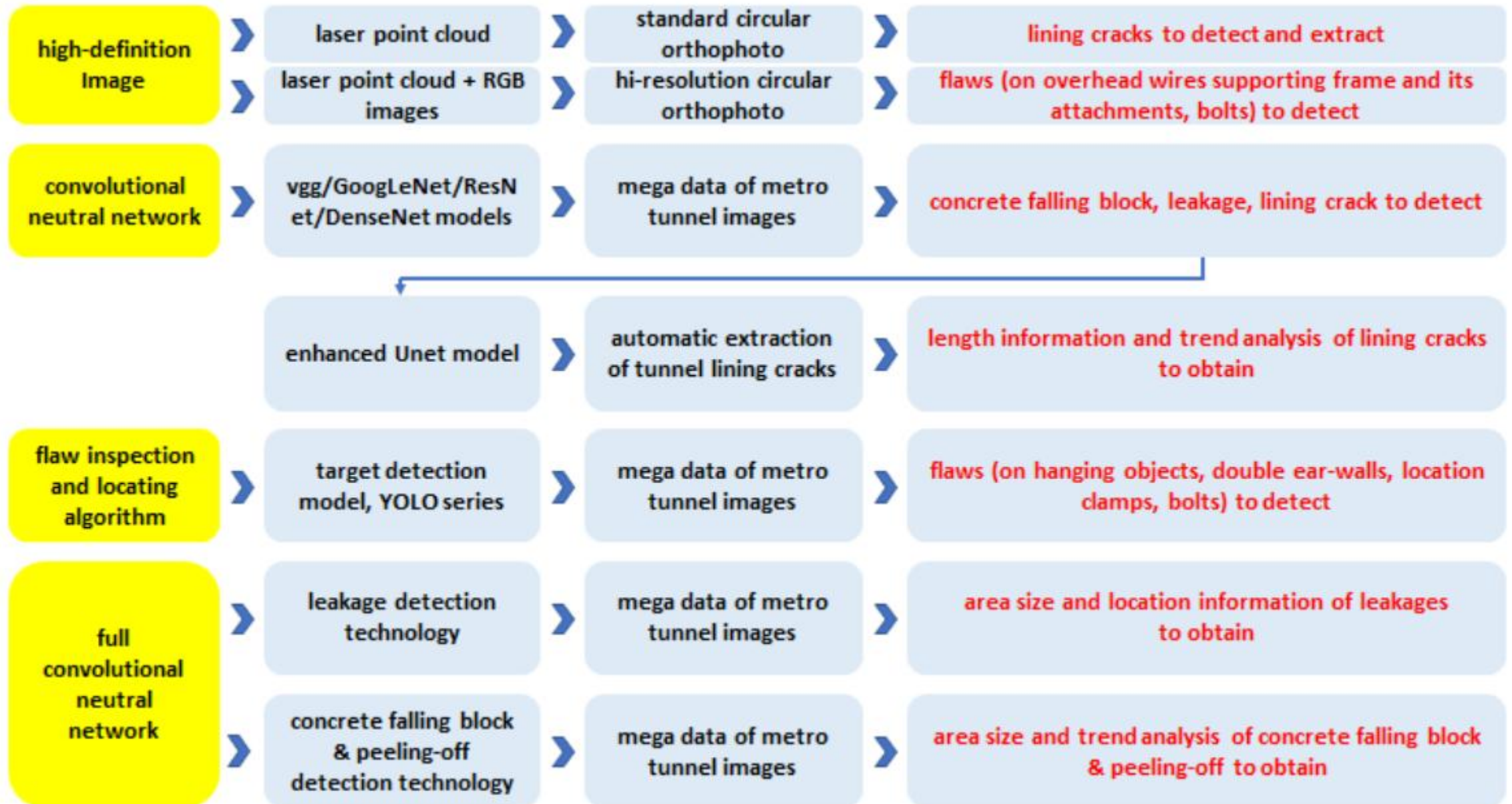
5.

How AI takes part in this workflow





## 5.1. Artificial Intelligence & Machine Learning Technology



## 5.2. AI Technology Applied to Dimensional Calculation & Feature Extraction

### Process Workflow:

*(fieldwork setting → on-site display →)  
data import → data analysis →  
sectional data computation →  
defects detection (by algorithm) →  
manual review → final report*

### Automated Detection

- *mega database reference*
- *computer vision*
- *machine learning & deep learning*
- *artificial intelligence*

### Full-life Cycle Control

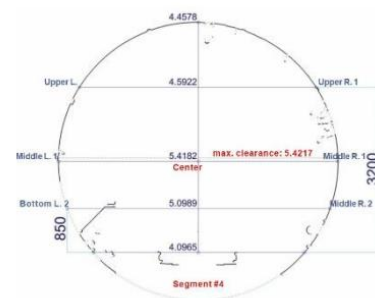
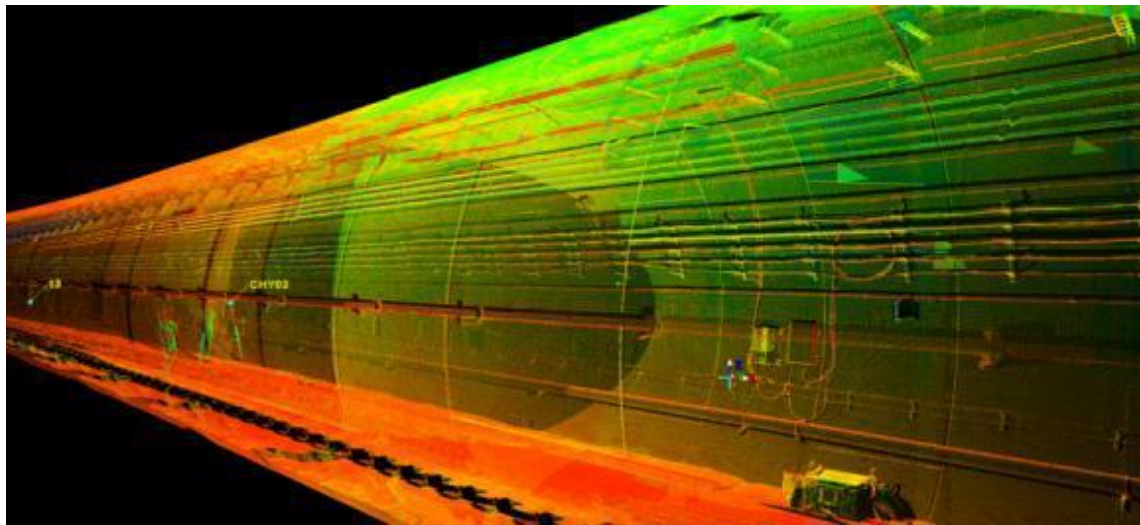
- *historical data management*
- *statistics, analysis and comparison*
- *out-of-tolerance alerts*

**MS100 All-in-One Software  
Tunnel Scan&Go Process Workflow**

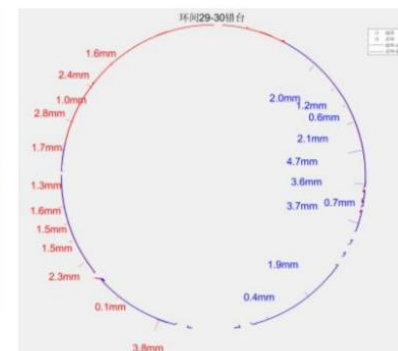
**SOUTH**



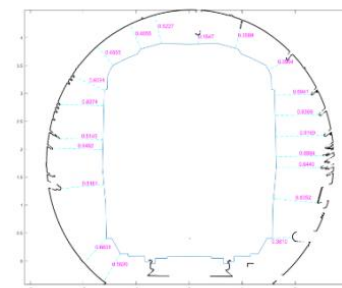




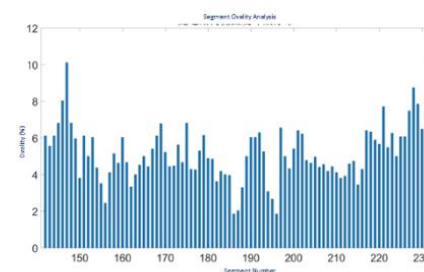
tunnel clearance



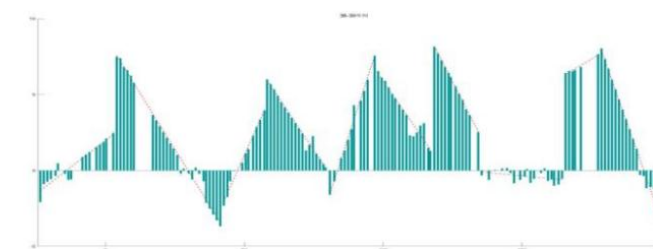
segment stagger



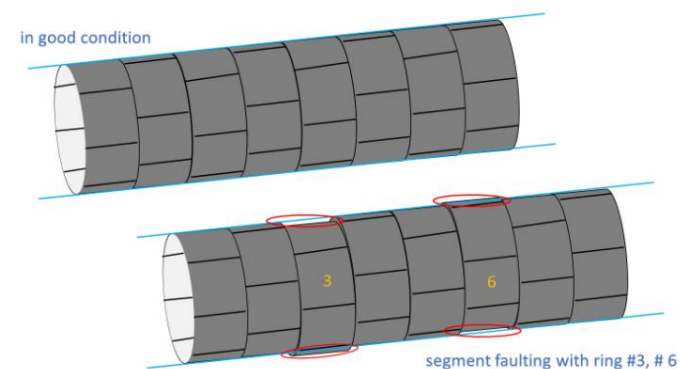
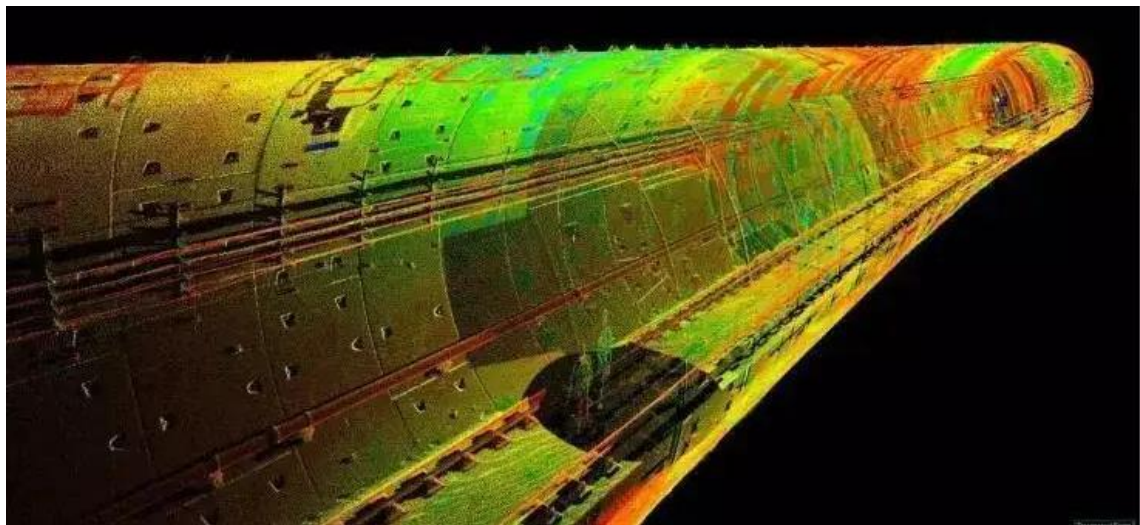
tunnel limit



segment ovality

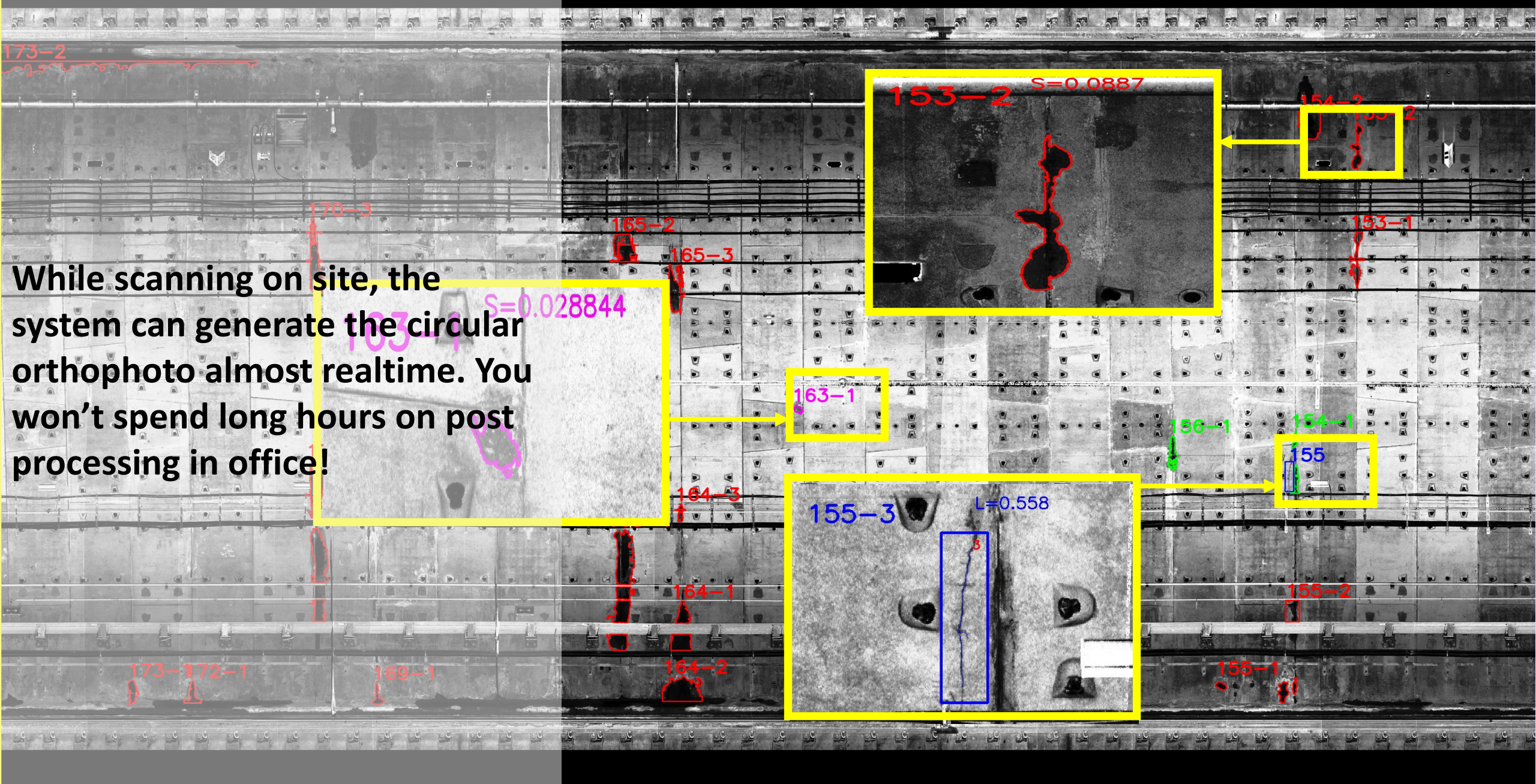


```
segment stagger data extracted
```

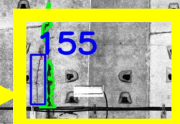
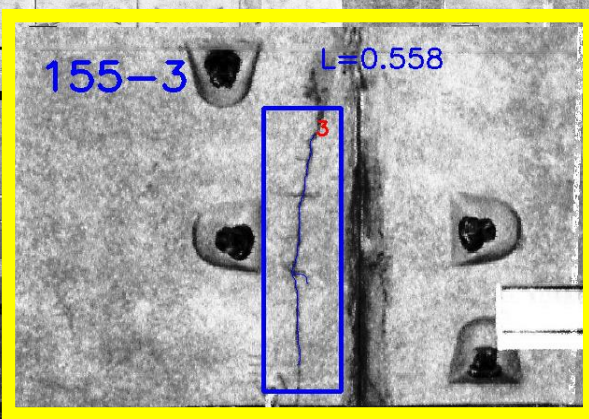
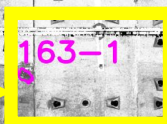
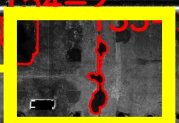


segment stagger

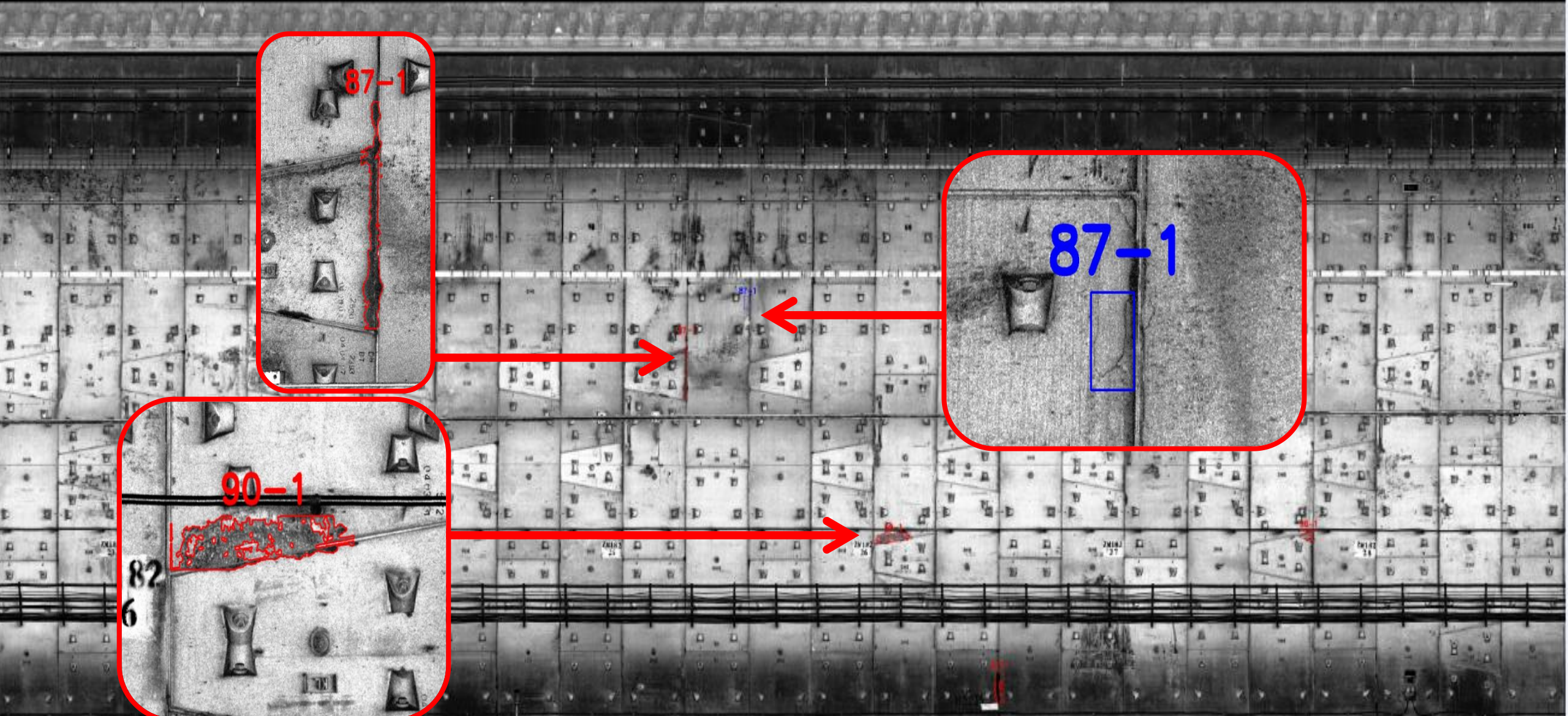




While scanning on site, the system can generate the circular orthophoto almost realtime. You won't spend long hours on post processing in office!

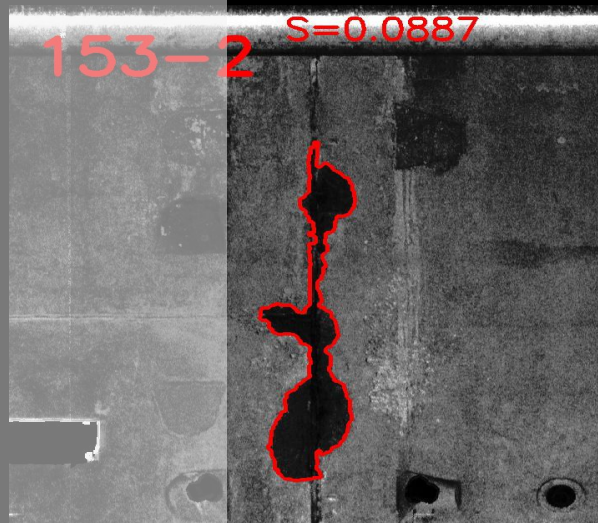




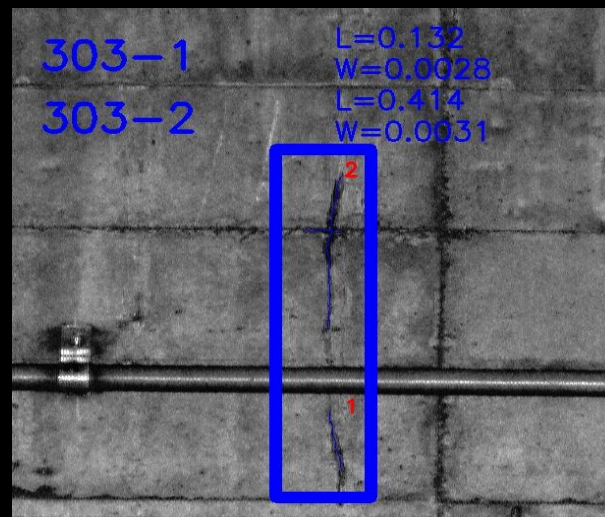


In the circular orthophoto, nothing could hide. The next step goes to computer vision and big data analysis and that's automated detection of the tunnel diseases.

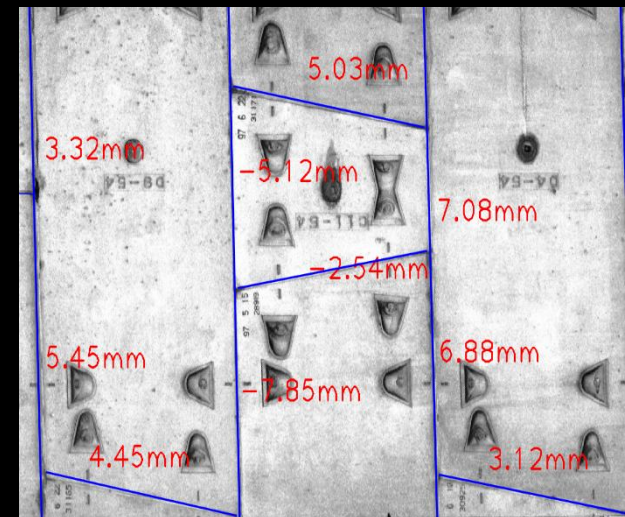




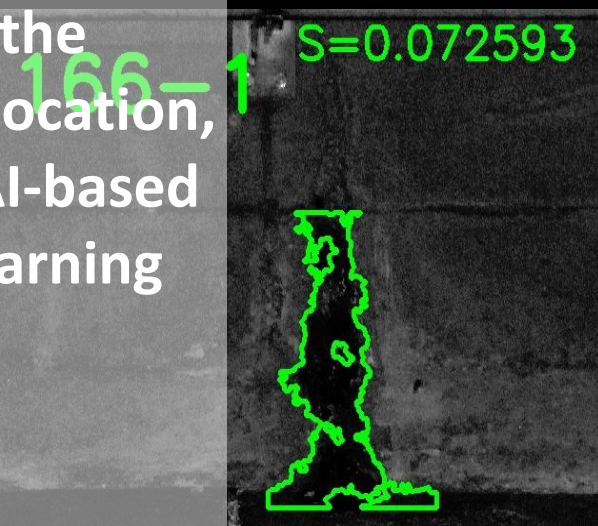
leakage



lining cracking



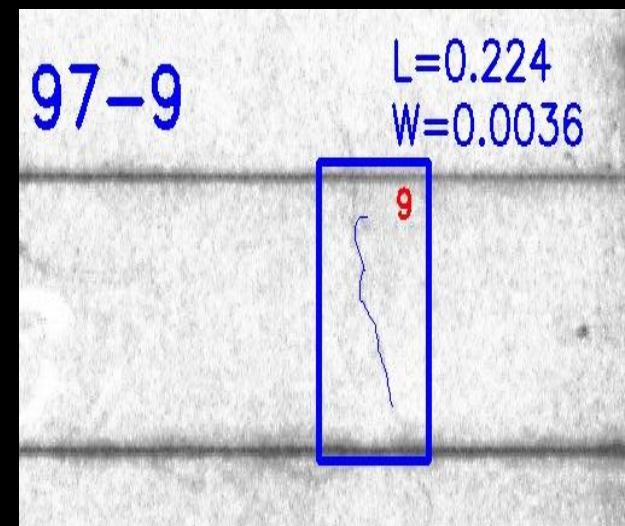
segment breakage



moist



concrete falling-off



inwall crack

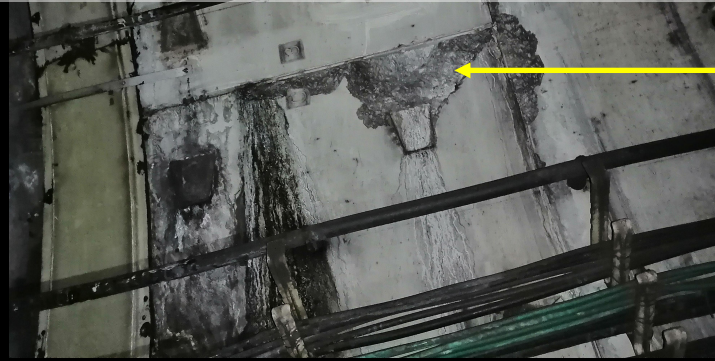
The system serves as a smart A&E doctor capable of automatically finding out the diseases with details like location, length, size, category by AI-based algorithm and machine learning techniques.



Nearly all problematic portions will be detected in big data computation and analysis while the remaining 10%, more or less, requires double checking and manual editing. Are you crazy about this kind of magic?



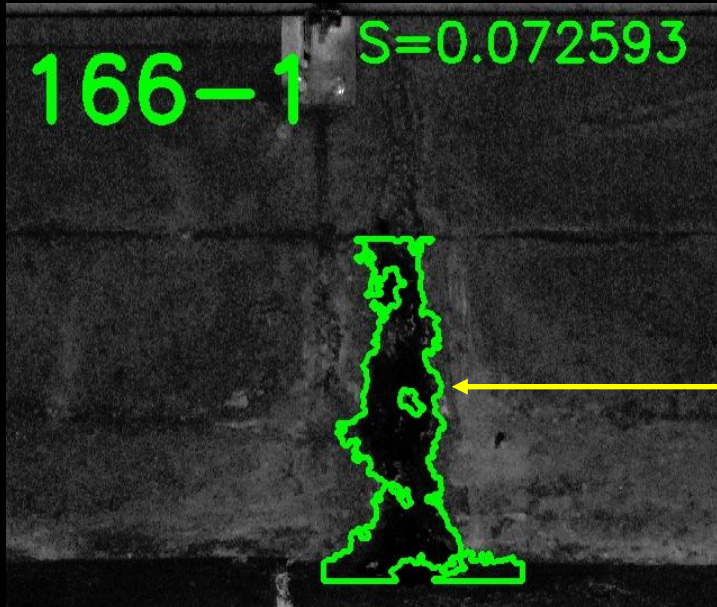
actual moist **on site**



actual concrete falling-off **on site**



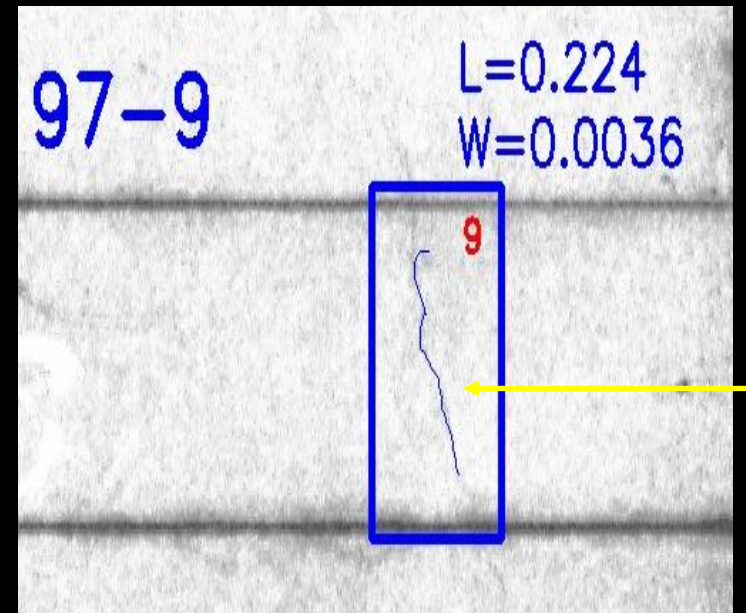
actual inwall crack **on site**



detected moist **in software**



detected concrete falling-off **in software**



detected inwall crack **in software**



Yuntu 2.1.8

文件隧道移动通用工具视图设置帮助

点云预处理影像预处理

断面提取椭圆分析净空收敛桥隧限界盾构错台一键处理

点云拼接病害筛选表观影像病害识别病害编辑影像手绘

成果导出一键报告

数据源几何结构影像分析成果管理

视图

表观影像

项目管理

项目资源

- 5号线怡景-黄贝岭区间左线
  - 2024-03-13\_02-51
    - pointcloud
      - 1(227)
        - 1#20043604#1.jpeg
        - 2#22729670#3.jpeg
        - 3#25405659#2.jpeg
        - 4#28087619#1.jpeg
        - 5#30772167#3.jpeg
        - 6#33452831#2.jpeg
        - 7#36133535#1.jpeg
        - 8#38822982#3.jpeg
        - 9#41497330#2.jpeg
        - 10#44178826#1.j...
        - 11#46864315#3.i

属性显示

- 属性名值
- 机位1(0)
- 照片数量227
- 方位角90°

3D点云模型

2D影像图

病害数据表

净空曲线图

隧道交通

点云相关

图像相关

传感器分析

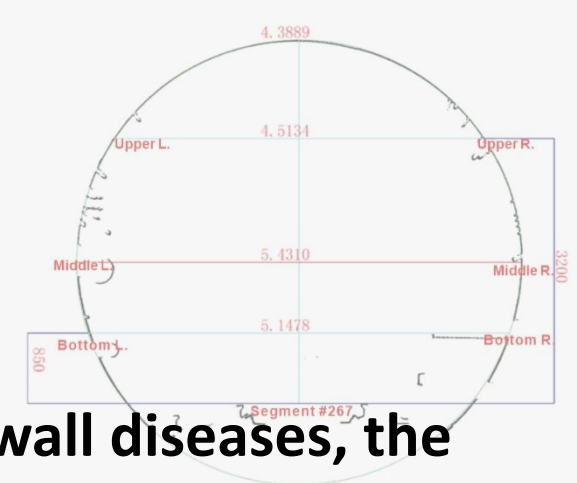
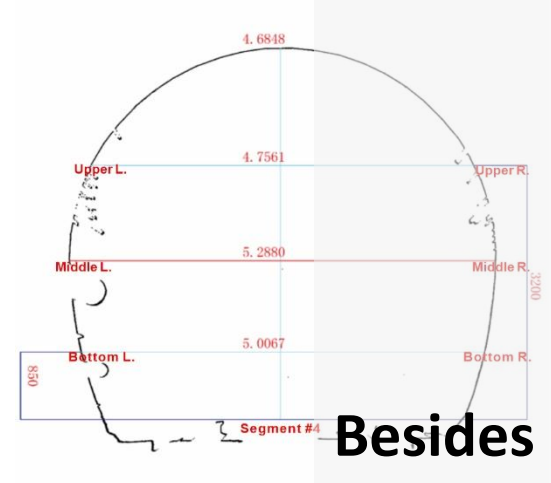
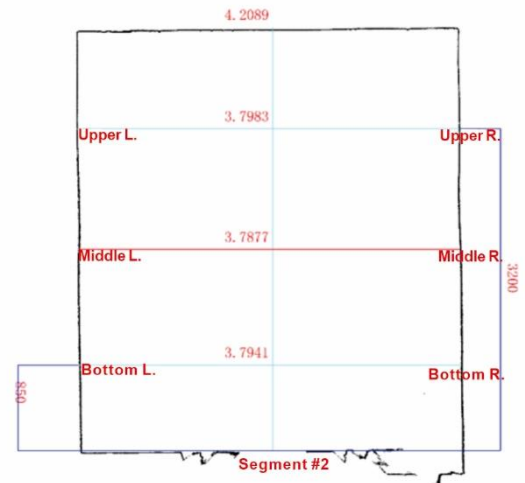
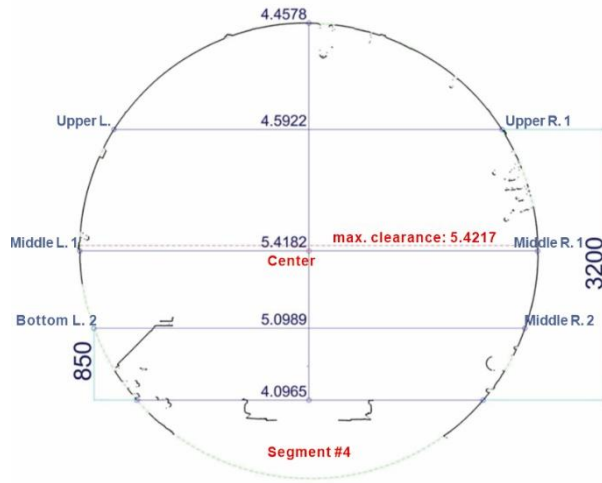
项目日志

环号	里程	水平净空	轨面垂
337	6555.48	5.42	4.5379
338	6556.97	5.4184	4.5293
339	6558.46	5.4166	4.5308
340	6559.95	5.4209	4.5393
341	6561.44	5.4189	4.5328
342	6562.97	5.4137	4.5383
343	6564.46	5.4164	4.5402

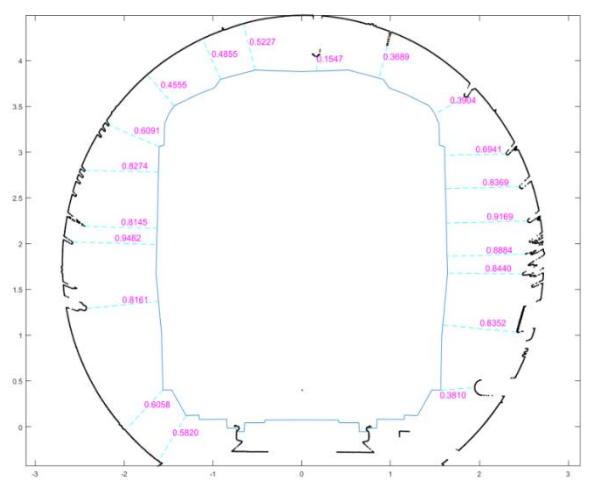
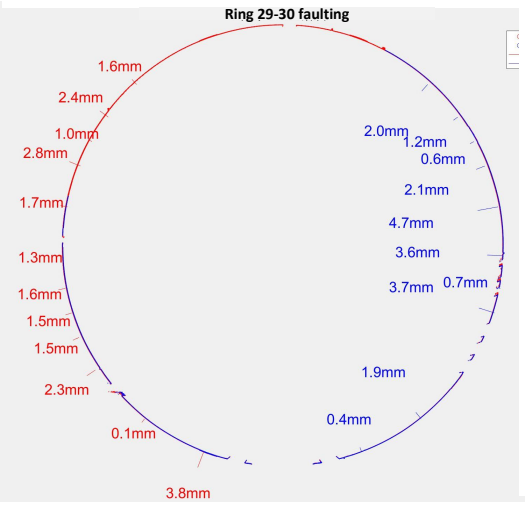
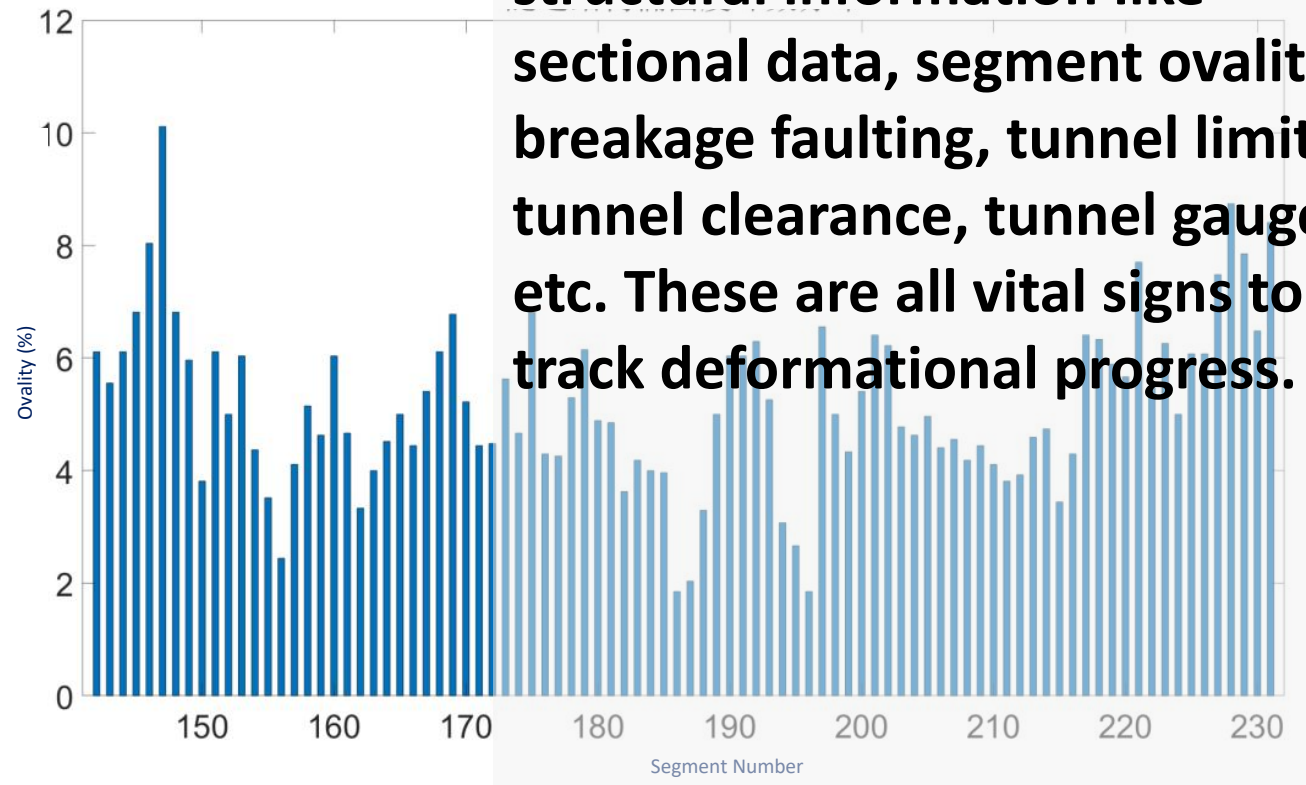
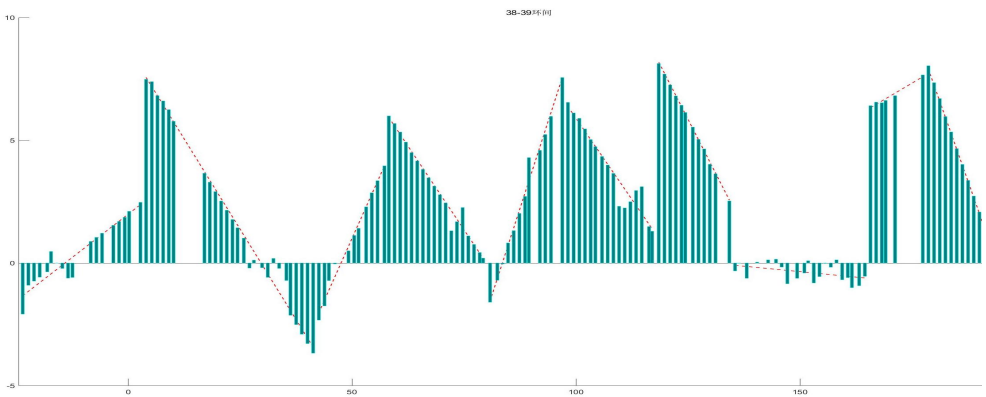
净空曲线图

隧道病害照片

项目日志



Besides inwall diseases, the system also deals with the tunnel structural information like sectional data, segment ovality, breakage faulting, tunnel limit, tunnel clearance, tunnel gauge, etc. These are all vital signs to track deformational progress.





## Inspection Missions

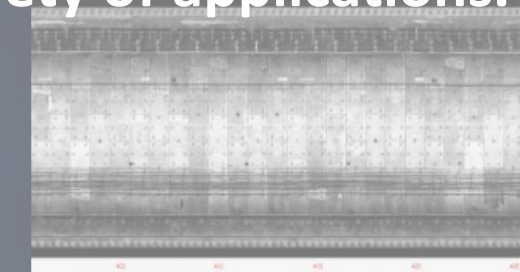
- Shenzhen Metro Line 7
- Guangzhou Metro Line 3
- Guangzhou Metro Line 6
- Guangzhou Metro Line 8
- Shenzhen Metro Line 2
- Guangzhou Metro Line 5
- Shenzhen Metro Line 11
- Shenzhen Metro Line 10
- Guangzhou Metro Line 1



The system platform will be responsible for the tunnel full-life cycle management. All data is traceable and of great reference value in a variety of applications.

sectional view

circular orthophoto



病害标注

tunnel structural ovality

tunnel structural diameter



disease info 455-1

scanned &amp; detected

site photo



area (m²)

length (m)

type

/

0.3560

crack



2020.9.30

With the 3D data, the site will be within your approach any time. In the long run, all inwall diseases and deformational progress could be scientifically analyzed and tracked at home, which is really amazing.

Disease Information

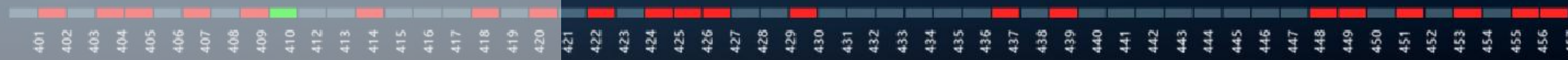
Section

Ovality

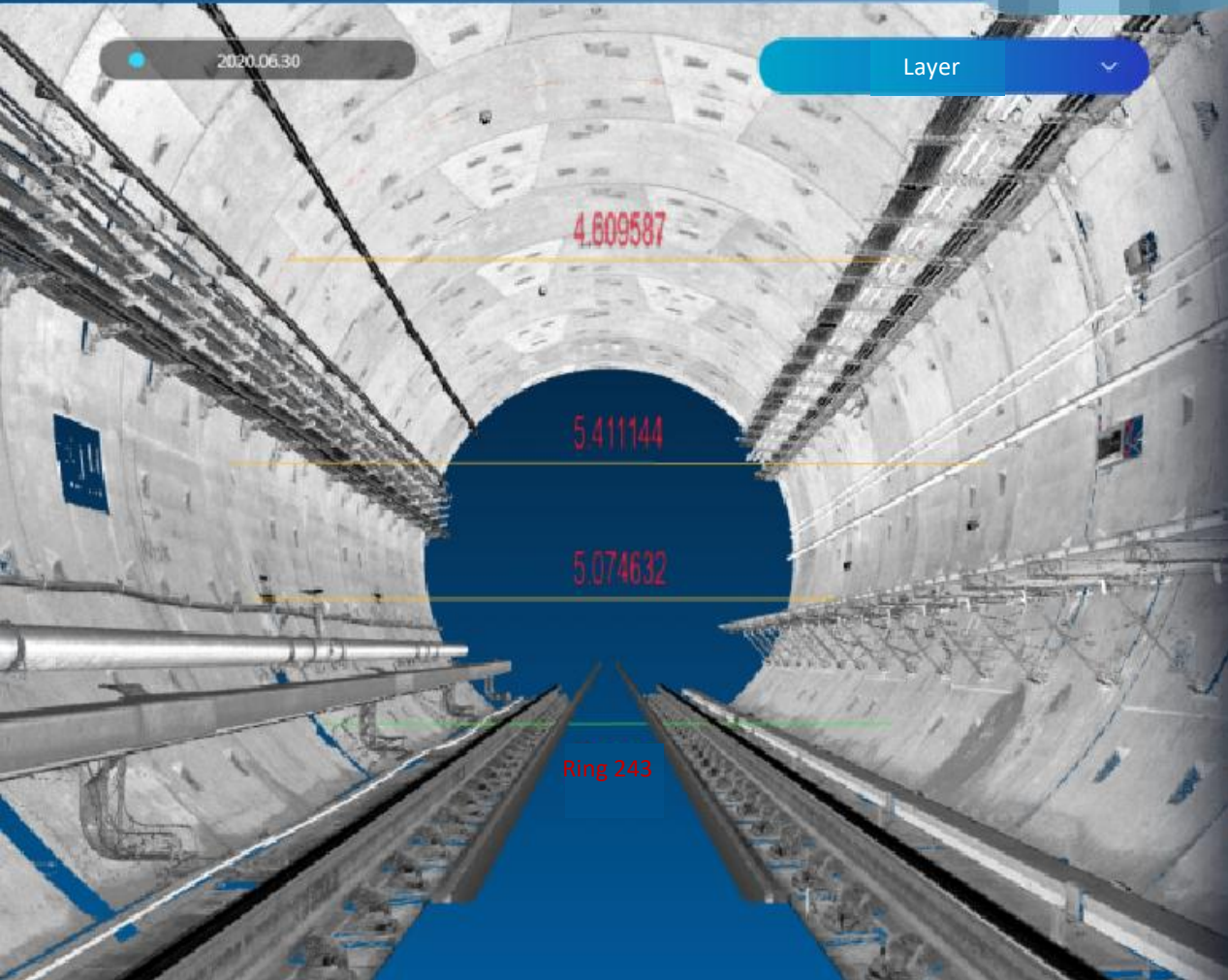
Faulting

✓ Disease Information

✓ 3







You may find it much easier to extract any of the historical data and compare it with the recent groups. And that's the way to find out periodical changes against deformation monitoring.

[Extend](#)



## 蔡思貝 何廣沛 主演 TVB 2023 良心劇 《你好，我的大夫》

《黃帝內經》提到醫學道理——  
上醫治未病，中醫治慾病，下醫治已病。

Shortly after accident occurred（已病）：  
News, announcement, rescue, repair, research, inspection,  
maintenance,,, and plenty of handling came up.

While accident is on the brink（慾病），  
Only inspection and maintenance (if necessary).

Long before accident comes（未病），  
Only inspection and maintenance (if necessary).

**Why not try a scientific solution for the routine inspection to  
治未病/慾病? Hey, there's no replay button in reality!**

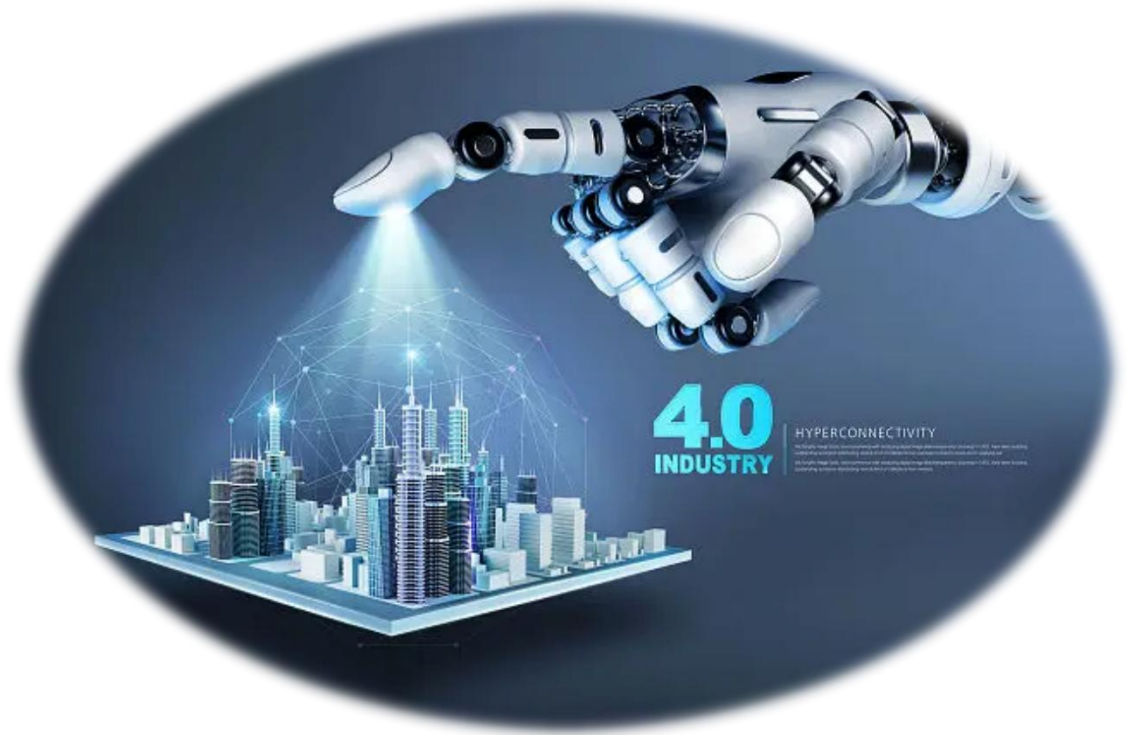
程嘉应父亲去世，更为了能和辜清劲一起在教研中心工作，考试故意考差，放弃了转去工商管理的机会，谁知辜清劲一点商量的机会都没有，就说自己决定去大陆义诊，增加行医经验，但是义诊是不算工作经验的。经过一晚的深思熟虑，辜清劲还是选择了分手，原因是要去“治未病。”



PS:也是看了这个剧，我才去了解“治未病”的意思。1.根本就没得病的时候，有轻微不舒服的时候，我们去调整它。2.得了病，我们避免它的转移，或者是进一步的恶化。



# C A BETTER TOMORROW



No news is good news, isn't it? ☹