

# Tunnel Asset Management

**Ben Swatton**

BEng(Hons) MSc CEng MIMMM AMICE



# What is asset management?

“The co-ordinated **approach, planning** and **implementation** of activities to **realise value** from items, things or entities that have potential or actual value to an organisation”

*Adapted from ISO 55000 Asset Management – Overview, principles and terminology*

# The challenge

83km structures 60+ years

Beam operations

Small civil engineering team

Restricted access

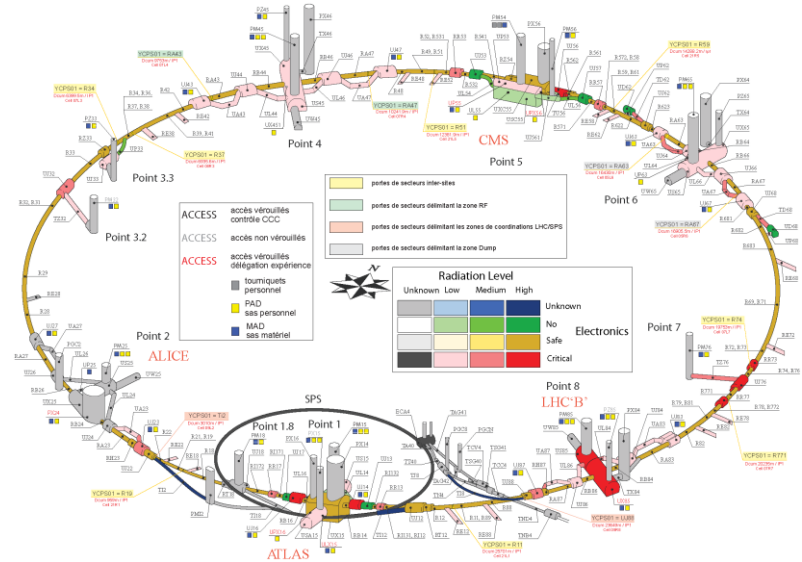
Use and re-use

Maintenance by design

Staff turnover

Hazardous Environments

Separate to CERN AMS



# Policy & Strategy



## Tunnel Asset Management Policy & Strategy

SMB-SE  
EDMS 2043027

Rev	Date	Comments	Revised by	Checked by	Approved by
1.1	04	(initial)	anderson	anderson	

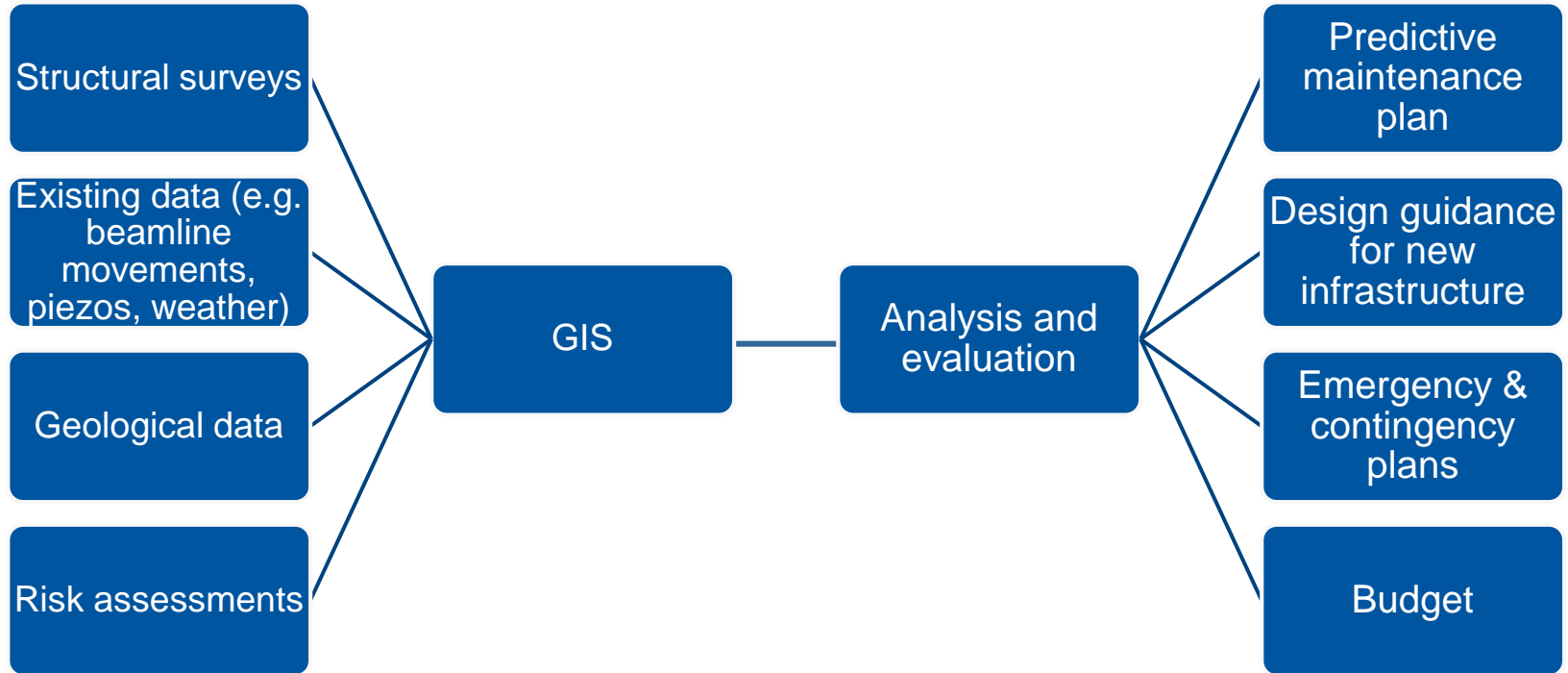


## Tunnel Asset Management Plan

SMB-SE  
EDMS 2080274

Rev	Date	Comments	Revised by	Checked by
1.1	04	(initial)	anderson	

# Data-Driven Asset Management

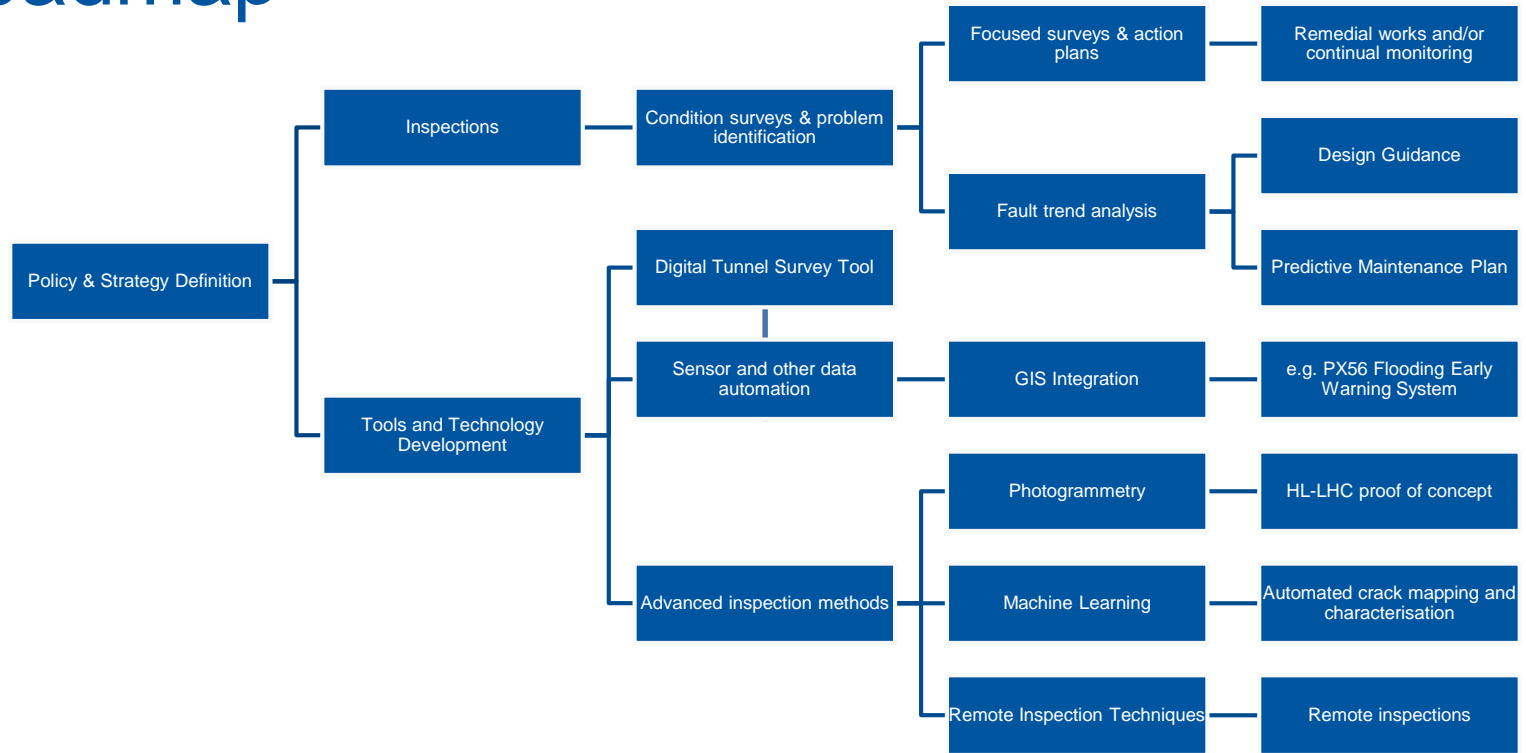


# Digitisation

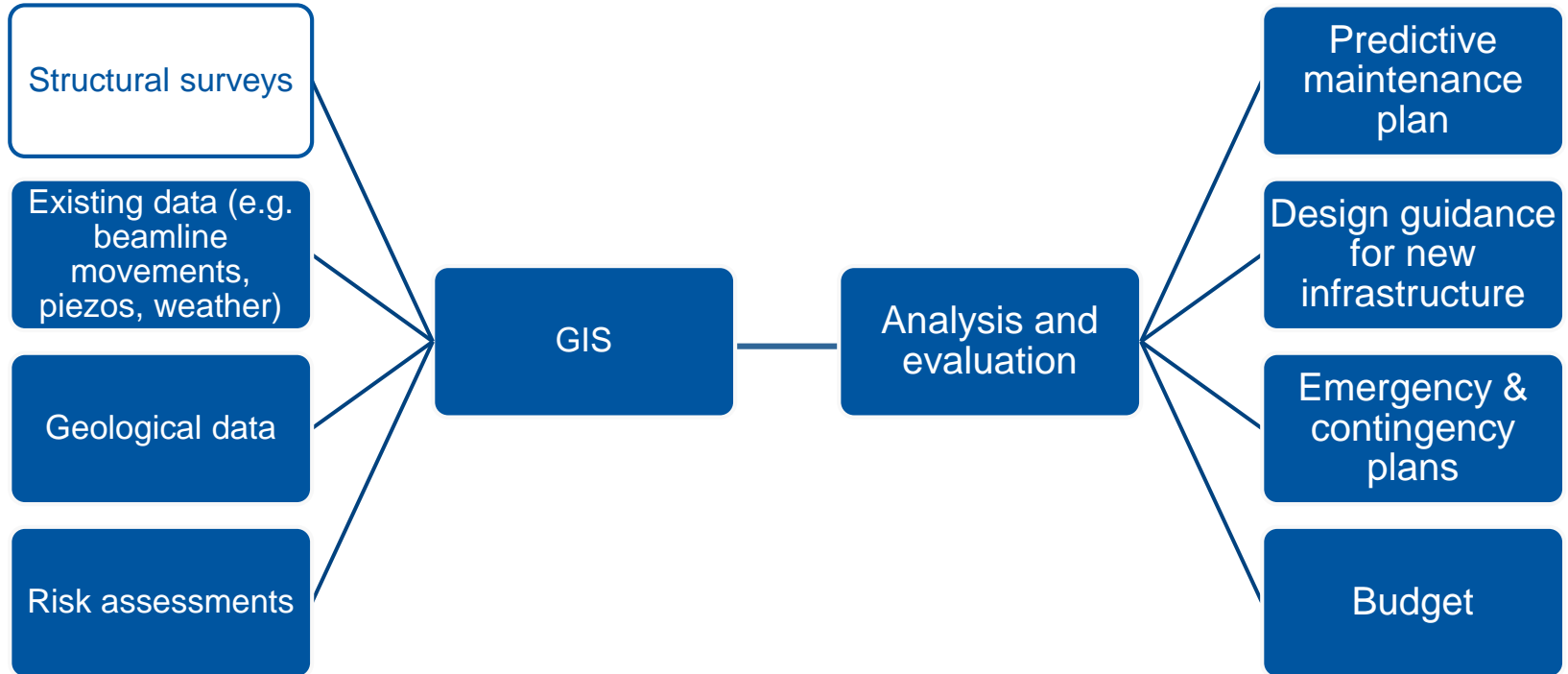
&

# Digitalisation

# Roadmap



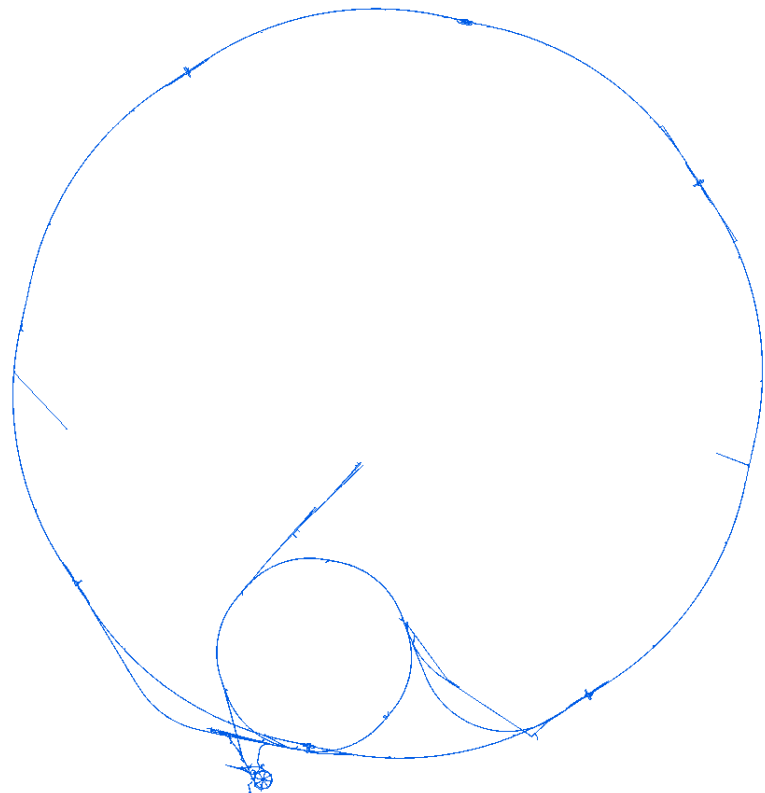
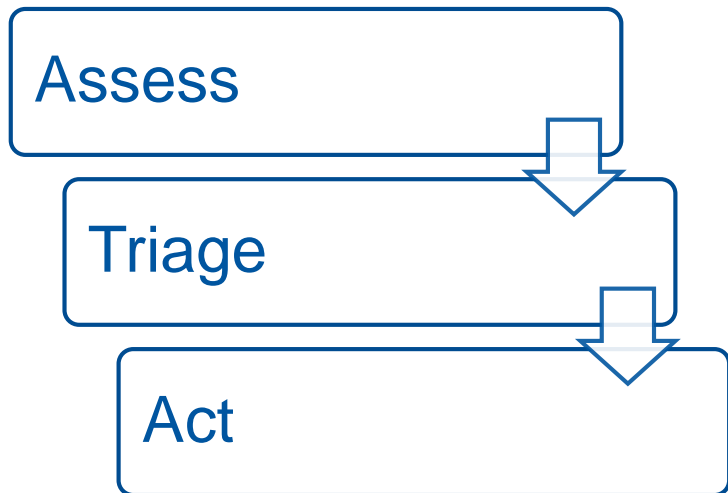
# Data-Driven Asset Management





# LS2 Tunnel Inspections

# Tunnel Inspections



# Traditional Tunnel Inspections



Hand-written notes by engineer

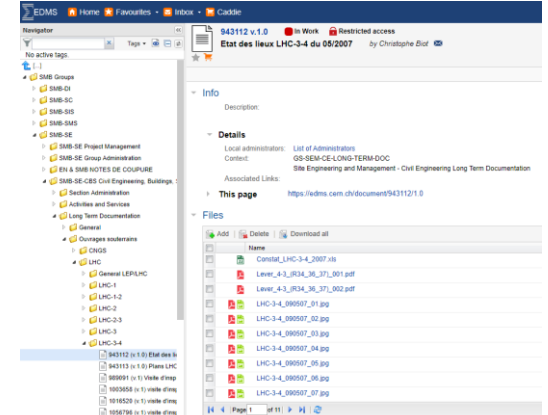


Tunnel LHC-3 - Tunnel LHC (diam 630)

CONSTAT OUVRAGE - T12		DATE INSPECTION: 14 mars 2007									
N°	IM	Etat (Structure, eau, atmosphère, contexte)	lever	photo	Action, solution proposée	Croquis	Façonnet	LABOT	REMI	autres photos	Observations
2	1230	POC. POC fissuration longitudinale. fissures - 1mm (dans RIVC26). Rouille + saleté	Lever T12 140307 001.pdf	T12 140307 001.JPG T12 140307 002.JPG							
3	1230	POC. POC fissuration transversale amince chaque 4m - 1mm. joints de montage subordonnés sur les pieds	Lever T12 140307 001.pdf	T12 140307 003.JPG T12 140307 004.JPG T12 140307 005.JPG T12 140307 006.JPG							
4	1230	POC infiltrations hydrocarbonées	Lever T12 140307 002.pdf	T12 140307 007.JPG T12 140307 008.JPG	à surveiller						
5	1231	POC infiltrations hydrocarbonées (plusieurs les ballons avec tâches d'humidité + calcare)	Lever T12 140307 002.pdf	T12 140307 009.JPG T12 140307 010.JPG T12 140307 011.JPG T12 140307 012.JPG							
6	1230	Restoration transverse peu importante et ponçage sur les joints de montage	Lever T12 140307 002.pdf	T12 140307 013.JPG T12 140307 014.JPG T12 140307 015.JPG							
7	1230	POC. POC fissuration longitudinale - 1mm	Lever T12 140307 003.pdf	T12 140307 016.JPG T12 140307 017.JPG T12 140307 018.JPG							
8	1230	POC. POC fissuration longitudinale - 1mm (dans 1220) débris importants (quilles)	Lever T12 140307 004.pdf	T12 140307 019.JPG T12 140307 020.JPG T12 140307 021.JPG							
9	1230	POC. POC fissuration longitudinale - 1mm (dans 1220) tâches humides et calcare	Lever T12 140307 005.pdf	T12 140307 022.JPG T12 140307 023.JPG T12 140307 024.JPG							
10	1216	1216 (dans route) + saleté	Lever T12 140307 006.pdf	T12 140307 025.JPG T12 140307 026.JPG T12 140307 027.JPG	à surveiller						
11	1210	POC. POC fissures longitudinales (dans 1210) débris importants	Lever T12 140307 006.pdf	T12 140307 028.JPG T12 140307 029.JPG	à surveiller						
12	1210	POC. POC fissures longitudinales (dans 1210) débris importants	Lever T12 140307 007.pdf	T12 140307 030.JPG							
13	1210	POC. POC fissures longitudinales (dans 1210) débris importants	Lever T12 140307 007.pdf	T12 140307 031.JPG							
14	1210	POC. POC fissures longitudinales (dans 1210) débris importants	Lever T12 140307 007.pdf	T12 140307 032.JPG							
15	1210	POC. POC fissures longitudinales (dans 1210) débris importants	Lever T12 140307 007.pdf	T12 140307 033.JPG							
16	1210	POC. POC fissures longitudinales (dans 1210) débris importants	Lever T12 140307 007.pdf	T12 140307 034.JPG							
17	1210	POC. POC fissures longitudinales (dans 1210) débris importants	Lever T12 140307 007.pdf	T12 140307 035.JPG							
18	1210	POC. POC fissures longitudinales (dans 1210) débris importants	Lever T12 140307 007.pdf	T12 140307 036.JPG							
19	1210	POC. POC fissures longitudinales (dans 1210) débris importants	Lever T12 140307 007.pdf	T12 140307 037.JPG							
20	1210	POC. POC fissures longitudinales (dans 1210) débris importants	Lever T12 140307 007.pdf	T12 140307 038.JPG							
21	1210	POC. POC fissures longitudinales (dans 1210) débris importants	Lever T12 140307 007.pdf	T12 140307 039.JPG							
22	1210	POC. POC fissures longitudinales (dans 1210) débris importants	Lever T12 140307 007.pdf	T12 140307 040.JPG							
23	1210	POC. POC fissures longitudinales (dans 1210) débris importants	Lever T12 140307 007.pdf	T12 140307 041.JPG							
24	1210	POC. POC fissures longitudinales (dans 1210) débris importants	Lever T12 140307 007.pdf	T12 140307 042.JPG							
25	1210	POC. POC fissures longitudinales (dans 1210) débris importants	Lever T12 140307 007.pdf	T12 140307 043.JPG							
26	1210	POC. POC fissures longitudinales (dans 1210) débris importants	Lever T12 140307 007.pdf	T12 140307 044.JPG							

Prochaine inspection détaillée:

Sketches and notes transcribed into Excel

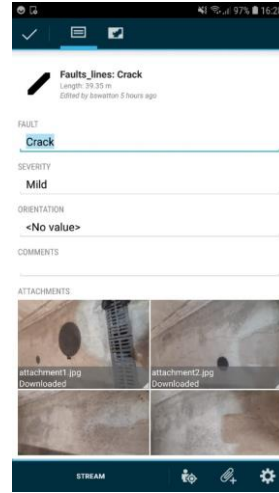


Uploaded to document server (never to be seen again...)

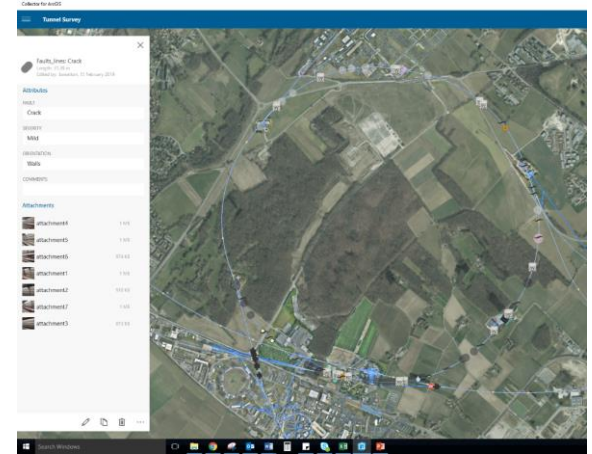
# The New Inspection Method



Faults recorded on a mobile app (TIC)

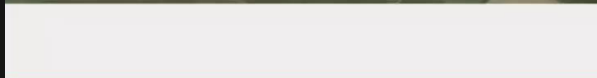
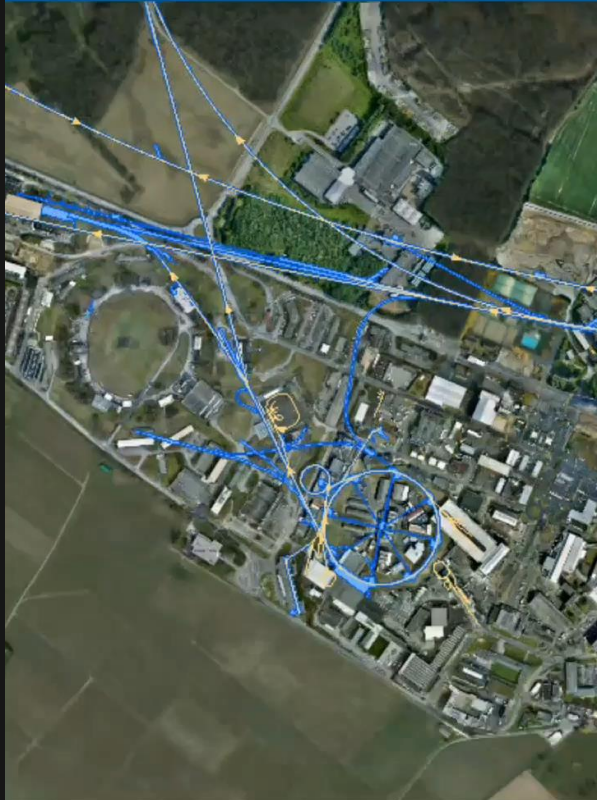


Photos, details and location all recorded

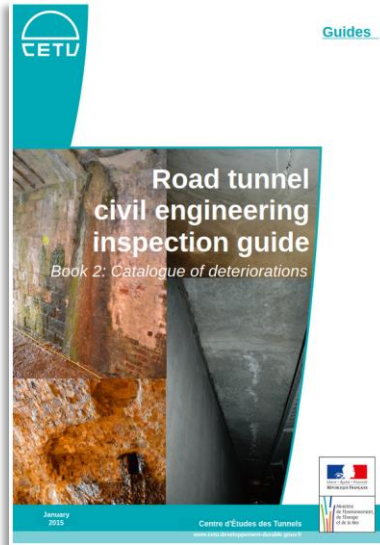


Automatically uploaded to CERN GIS

< Tunnel Survey



# TIC – Civil Engineering



TfL Management System

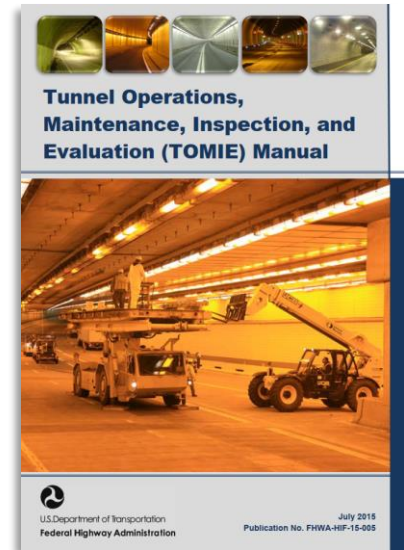
Standard Category **1**

S1055 A5 Civil Engineering – Deep Tube Tunnels and Shafts

Contents	
1 Purpose	2
2 Scope	2
3 Requirements	2
3.1 Selection and design	2
3.2 Construction, installation, testing and commissioning	17
3.3 Inspection	23
3.4 Analytical assessment	29
3.5 Condition assessment	31
3.6 Rehabilitation	36
3.7 Modifications to existing tunnel and shaft linings	38
3.8 Strengthening and internal	40
3.9 Decommissioning	41
3.10 Evidence of compliance	41
4 Responsibilities	41
5 Supporting information	42
5.1 Background	42
5.2 Safety considerations	42
5.3 Environmental considerations	43
6 Information references	43
6.1 References	43
6.2 Abbreviations	45
6.3 Definitions	45
6.4 Person accountable for the document	46
6.5 Document history	46
7 Attachments	51
7.1 Attachment 1 – Information to be included in conceptual design statement for Deep Tube Tunnel and shaft works	51
7.2 Attachment 2 – Conceptual General Report (GMR)	58
7.3 Attachment 3 – Tunnel management plan	58
7.4 Attachment 4 – Review meeting	58
7.5 Attachment 5 – Required Examination and Support Sheet (RESS)	62
7.6 Attachment 6 – Readiness review checklist	63

Page 1 of 55

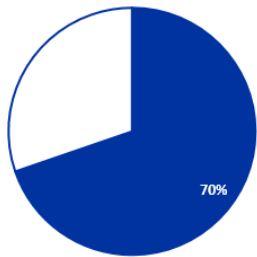
MAYOR OF LONDON Transport for London





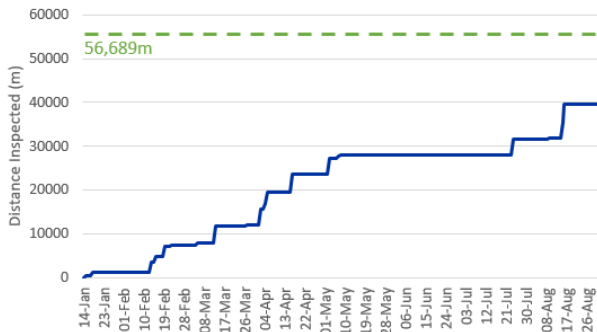
# LS2 Tunnel Inspections Progress Dashboard

Inspection Progress

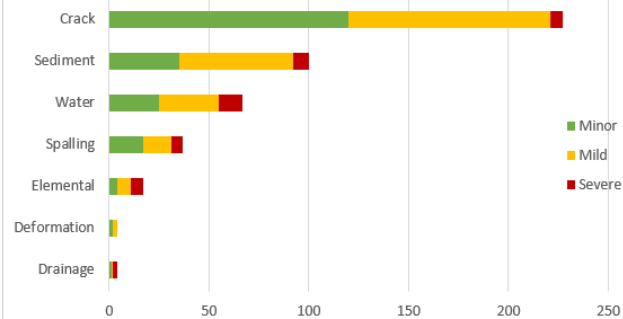


■ Tunnel Inspections Completed  
■ Tunnel Inspections To Do

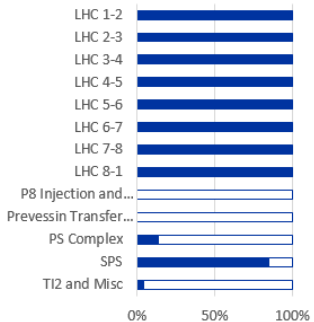
Cumulative Distance Completed



Faults by type



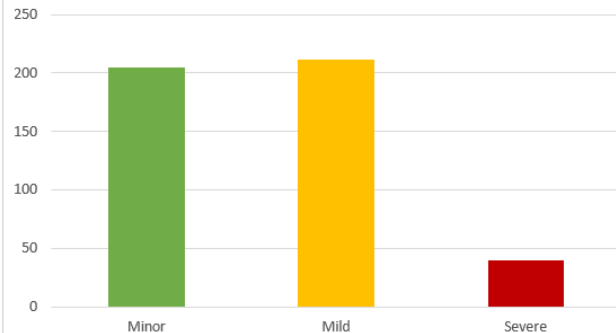
Inspection Progress by WP



Inspector's League



Faults by severity



# Inspection Results

CERN  
CH-1211 Geneva 23  
Switzerland

EDMS NO. 0000000 REV. 0.0 VALIDITY DRAFT

REFERENCE

Date: 2019-04-04

Technical Note

**LS2 Tunnel Inspection 2.3 Structural Condition Rating**  
**WP3: LHC Sector**

ABSTRACT:  
This report summarises the findings from the tunnel during the Long Shutdown 2 (LS2) with recommendation works

DOCUMENT PREPARED BY:  
Ben Swatton  
Alexandra Tudora

DOCUMENT TO BE CHECKED BY:  
John Andrew Osborne

DOCUMENT SENT FOR INFORMATION:  
(List of persons to whom the document is sent)

This document is uncontrolled when printed. Check the EDMS to verify

Table 1 - Tunnel Structure Class Rating

Structure	Class	Observations
<a href="#">R34</a>	2	Construction joints covered to prevent water
<a href="#">UP33</a>	2	Sediment ingress and historic water repairs
<a href="#">R36</a>	3	Free flows of water into tunnel drainage
<a href="#">R37</a>	2	
<a href="#">R38</a>	2	
<a href="#">RE38</a>	2	Extensive sediment/water ingress
<a href="#">R39</a>	2	Water and sediment ingress
<a href="#">R41</a>	3	Extensive deteriorations from water ingress
<a href="#">R42</a>	1	
<a href="#">RE42</a>	?	Electrical adit was inaccessible
<a href="#">UI43</a>	1	
<a href="#">RA43</a>	1	
<a href="#">UA43</a>	2	Cracks throughout
<a href="#">UI44</a>	1	
<a href="#">UL44</a>	1	



# Ad-hoc inspections

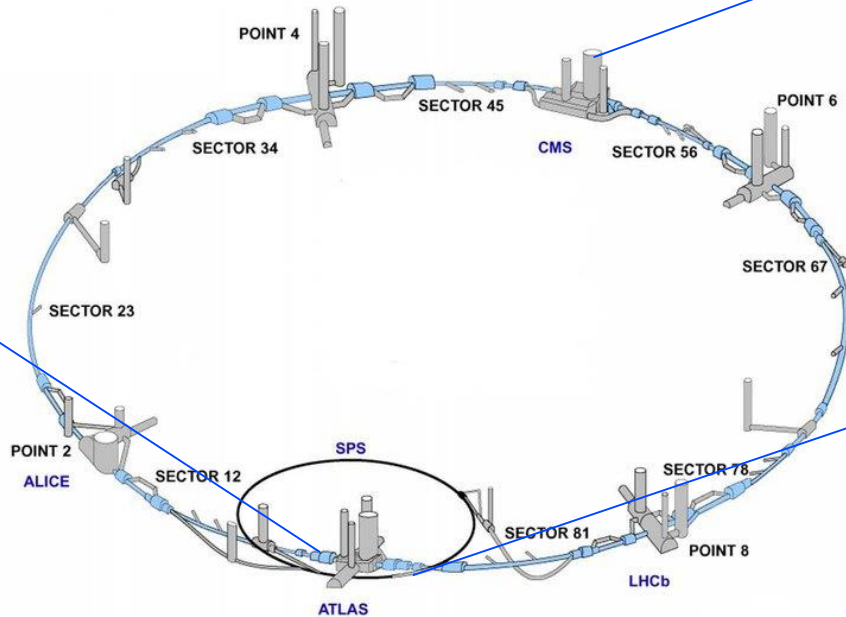


Figure 6 - Observations schematic for R113 between deum 26.530.0-26.580.0m

Table 4 - List of observations for R113

Ref (R113)	Observation Id	Point	Position	Comment
001	26486.0	26486.0	Crack	Multiple branching or mosaic cracking on walls of both sides of the tunnel, up to 2cm
002	26487.0	-	Crack	Crack on CI
003	26488.0	-	Crack	Marine crack
004	26489.0	-	Crack	Marine crack
005	26490.0	-	Crack	Marine crack
006	26491.0	26491.0	Crack	Horizontal branching crack in bed ends in one crack at either end
007	26492.0	26492.0	Crack	Branching crack in crown up to 2cm in places
008	26493.0	-	Crack	Marine crack
009	26494.0	-	Crack	Marine crack
010	26495.0	-	Crack	Marine crack
011	26496.0	-	Crack	Crack with bed ends diagonal on one, up to 2cm wide in places
012	26497.0	-	Crack	Up to 2cm in places, slightly stepped
013	26498.0	-	Crack	Marine crack
014	26499.0	-	Crack	Marine crack
015	26500.0	-	Crack	Up to 2cm in places
016	26501.0	-	Crack	Up to 2cm in places
017	26502.0	-	Crack	Marine crack
018	26503.0	-	Crack	Marine crack
019	26504.0	-	Crack	Up to 2cm in places
020	26505.0	-	Crack	Marine crack
021	26506.0	-	Crack	Marine crack
022	26507.0	-	Crack	Up to 2cm in places
023	26508.0	-	Crack	Up to 2cm in places
024	26509.0	-	Crack	Up to 2cm in places
025	26510.0	-	Crack	Up to 2cm in places
026	26511.0	-	Crack	Up to 2cm in places, some missing on one wall
027	26512.0	-	Crack	Up to 2cm in places
028	26513.0	-	Crack	Up to 2cm in places

HiLumi P1 Existing Condition Survey



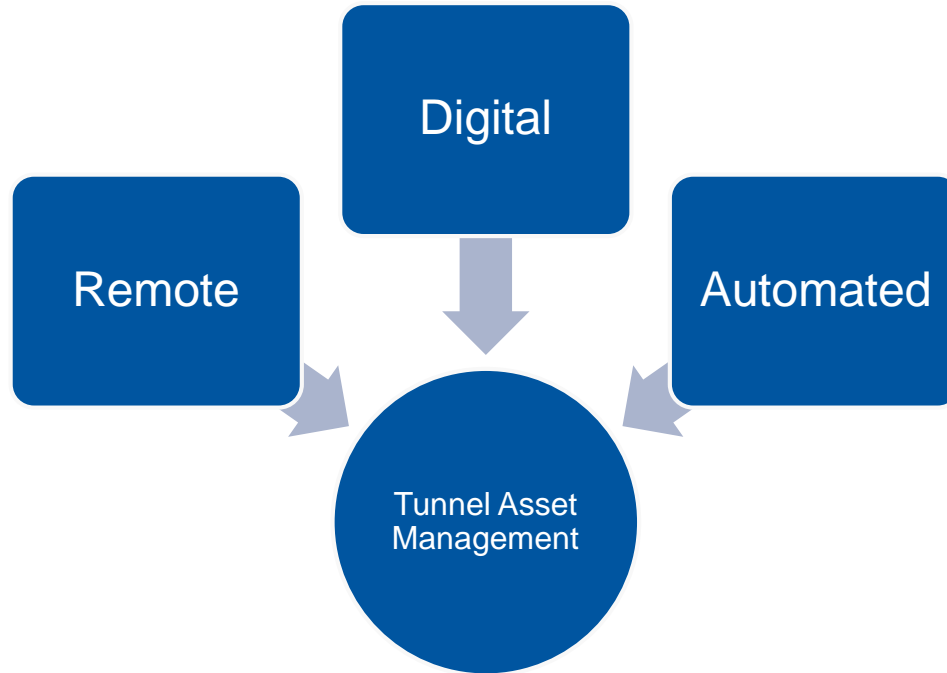
PM54 Ingress & Shaft Movements



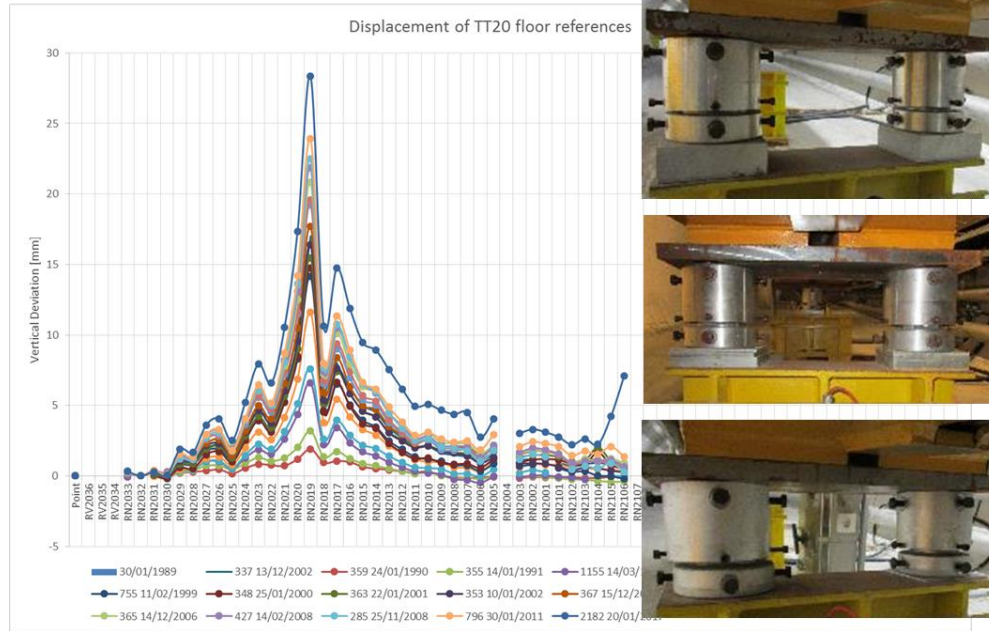
T112 Condition Report for FASER

# Monitoring Technologies Research & Development

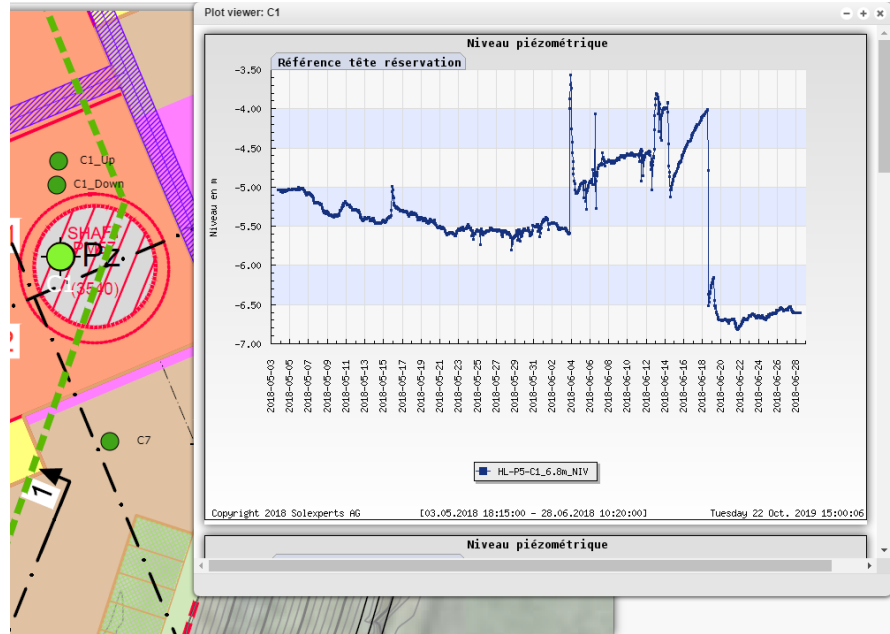
# Future Technologies R&D



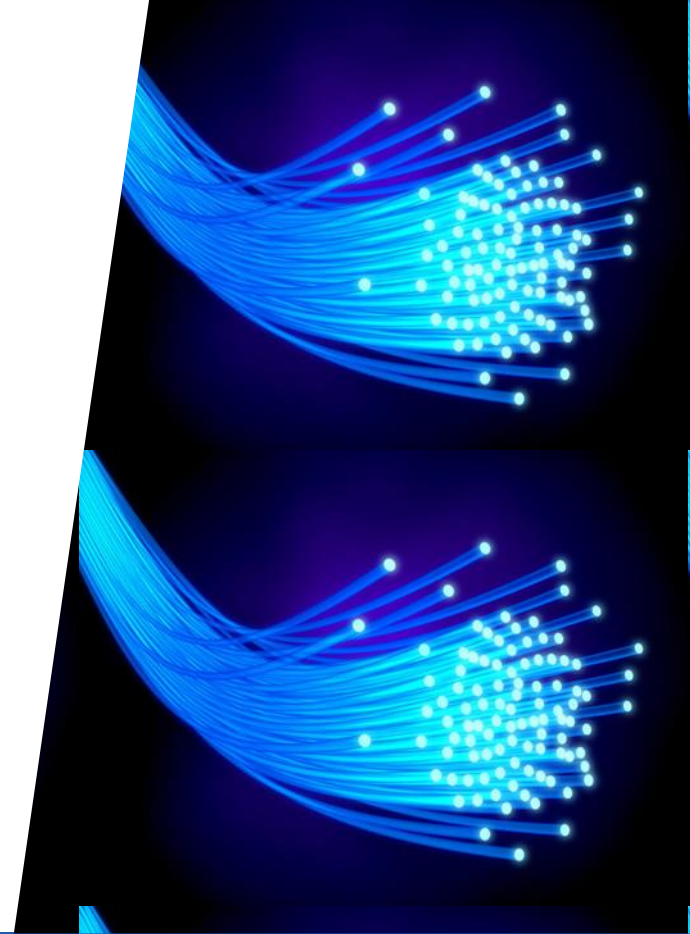
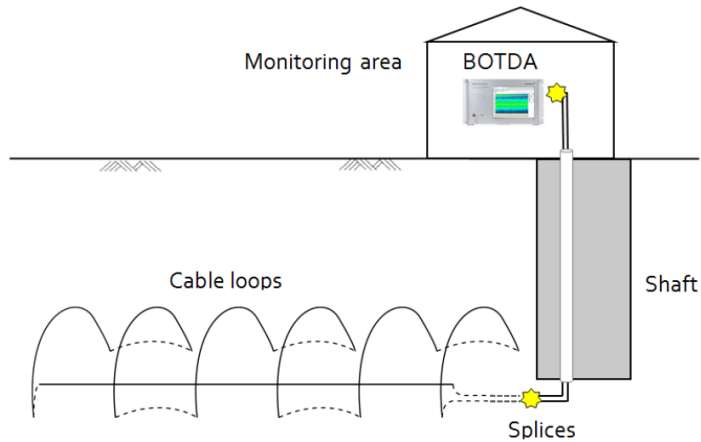
# Beamline Re-alignment Monitoring



# Upgrading to Smart Infrastructure



# Fibre Optic Measurement

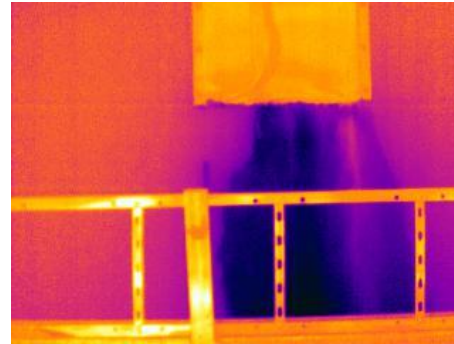


# Remote Inspections

Remote collection of photos and data using robots for **more regular inspections** and **less risk** to inspectors



# Automated Fault Classification





# Future of Tunnel Asset Management

- On-going development
- Finalised Policy, Strategy & Plan
- Preparation for LS3 inspections (2024 – 2025)
- Research partnerships for new technologies

