Presentation Outline

• review modern survey methodologies available to support railway requirements
• measuring everything from whole states to tiny switches
• recent case studies showing what is possible.
Railway’s Survey Requirements

1. State: for network planning
2. Line: for design works
3. Section: for maintenance / duplication
4. Station: for upgrade works
5. Asset: for maintenance works.
Survey Technology Available

1. Large Areas / Initial Design: Satellite based
2. Medium Areas / Engineering Design: Aircraft based
3. Corridors: Vehicle based (rail or road)
4. Small Areas: UAVs and Field Surveys
1. Large Areas / Initial Design

30 cm Satellite Imagery of Delhi
1. Initial Design: Satellite Imagery

Features:
- Range of platforms including Cartosat, Digital Globe, …

Pros:
- No mobilisation costs
- Can provide the 3rd dimension with stereo coverage
- Suitable for design consideration of land use

Cons:
- Accuracy and resolution only suits high level planning, not engineering design.
10 cm Aerial photography
2. Engineering Design: Photos

Features:
• Aerial survey cameras, fitted to fixed wing or helicopters

Pros:
• Provides landuse details efficiently and accurately
• Resultant orthophotos provide valuable data layer for other project uses
• Height information available from stereo photos

Cons:
• Requires field completion of areas obscured by vegetation
• Mobilisation costs make it less efficient for small areas.
2. Engineering Design: LiDAR

Aircraft based measuring laser
Define terrain under vegetation and all above-ground features.
2. Engineering Design: LiDAR

Features:
- Aircraft based (helicopter or fixed-wing)
- Laser defines surface with many points per square metre (1 to 60 pt/m²)
- Often operated with aerial camera

Pros:
- Very dense definition of terrain and everything on it
- International technology of choice for engineering-grade terrain definition

Cons:
- Mobilisation costs make it less efficient for small areas.
3. Corridor: Mobile Mapping

Vehicle mounted laser and image measurement
3. Corridor: Mobile Mapping

Single pass records location of every visible feature to cm accuracy
3. Corridor: Mobile Mapping

Complete definition
3. Corridor: Mobile Mapping

Complete definition in 3D
3. Corridor: Mobile Mapping

Features extracted from the laser data:
- Rail centreline
- signs
- stanchions
- crossings
- signals
- rail furniture,
- trees,
- overpasses …. 
3. Corridor: Mobile Mapping

Complete rail model extracted from LiDAR pointcloud
3. Corridor: Mobile Mapping

Complete rail model extracted from LiDAR pointcloud
3. Corridor: Mobile Mapping

Concurrent imagery adds:

- Condition
- Clarity
- Understanding to location provided by LiDAR.
3. Corridor: Mobile Mapping

Complete clarity provided by combining LiDAR and Imagery
3. Corridor: Mobile Mapping

Complete clarity provided by combining LiDAR and Imagery
3. Corridor: Mobile Mapping

Features:
- Vehicle based, usually car or train, but also boat, rickshaw, trolley, backpack
- Laser defining surface with many points (50 to 1000+ pt/m²)
- Often operated with camera (to add “what” to the LiDAR’s “where”)

Pros:
- Acquisition at vehicle speed
- Very efficient means of defining roadside boundaries

Cons:
- Accuracy deteriorates in urban canyons (GCPs can assist)
- Mapping limited to that visible from sensor.
3. Corridor: Mobile Mapping

High accuracy available with experienced survey design

<table>
<thead>
<tr>
<th>Accuracy</th>
<th>Conditions</th>
<th>Example</th>
<th>Without GCPs*</th>
<th>With GCPs*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good</td>
<td>Open highway</td>
<td>&lt;3cm</td>
<td>&lt;1cm</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>Urban environment with occasional tall buildings</td>
<td>&lt;6cm</td>
<td>&lt;2cm</td>
</tr>
<tr>
<td></td>
<td>Bad</td>
<td>City environment with tall buildings</td>
<td>&lt;100cm</td>
<td>&lt;10cm</td>
</tr>
</tbody>
</table>

*GCPs = ground control points
4. Small Areas: UAVs
4. Small Areas: UAVs

**Features:**
- Small format camera,
- mounted on small un-manned aircraft

**Pros:**
- Easy to mobilise
- Low cost equipment
- High resolution available, typically 2 to 5 cm
- Automatic software can build 3D surface models

**Cons:**
- Short sortie duration, typically supporting 1 to 2 km² per day capture
- More problematic (less safe) over urban areas.
4. Small Areas: Field Survey

Features:
- Features mapped by brief GPS occupation, or ETS radiation

Pros:
- Highest pointing accuracy

Cons:
- Very slow: survey undertaken at walking pace
- Higher safety risk / cost.
Case Study 1: Whole Line

Task:

- Design major new rail corridor – accuracy required
- 1700km long – rapid acquisition required
- 8km wide – to provide design flexibility
Case Study 1: Whole Line

Client Requirement:

• refinement of the proposed route
• preliminary engineering design
• environmental impact assessments
• engagement with a diverse range of stakeholders
• base mapping for the future planning, construction and management of the rail line.
Case Study 1: Whole Line

AAM Project:
• Survey control
• 10cm imagery
• DTM by aerial LiDAR
• Project website to provide data access to stakeholders
Case Study 2: As Built Survey

Task:

• 188km of mainline track with various loop lines & sidings
• Define track related infrastructure and services:
  – Level crossings
  – Signals
  – Switches
  – Bridges
  – Culverts
Case Study 2: As Built Survey

Client Requirement:

- spatial data along the rail and surrounding infrastructure of the newly completed track work to assist in closing out contracts
- As-built to confirm the construction is to design without significant variation.
- Validate any variation claims.
Case Study 2: As Built Survey

AAM Project:
- Survey control
- MLS survey from rail vehicle
- Extract vectors
- Data accuracy: 2cm XY, 3cm Z
Case Study 2: As Built Survey

Control at 500m intervals

Pointcloud data
New rail infrastructure requires new survey support
Technology from satellites, aircraft and ground
Correct mix required to meet project requirements
Elongated geometry means corridor surveys high risk
Expertise and experience available to ensure successful completion.