The use of appropriate high-tech solutions for road network and condition analysis, with a focus on satellite imagery

Robin Workman, Team Leader
Background: What is the Problem?

- Limited data available on rural road networks
- Lack of resources to update and extend this information
- Terrain and conflict make areas inaccessible to survey
- Lack of information makes planning and prioritisation of maintenance difficult
- Leads to restricted access and ultimately affects poverty
What are the potential benefits of high-tech solutions?

- Rapid assessment over large areas
- Logistically easier
- Can provide a permanent record of the network
- Imagery can be used for other applications
- Safer, avoids the need to visit areas in conflict
Identify high-tech solutions

Identify a small number of high-tech solutions that will help to increase knowledge of rural road networks.
• UAVs with LIDAR or cameras

Mapping, road condition through photos or LiDAR, high cost, limitations on use, USA research

Figure 3-7: Densified point cloud created from 28 images.

Figure 3-8: Depth map after median filtering. Blue colors represent lower elevations, red colors represent higher elevations.

Figure 3-11: A 3-D point cloud generated through the project's structure-from-motion based remote sensing processing system software using overlapping UAV-collected imagery of Welch Road.

Figure 3-12: Part of the Welch Road segment displaying a height map where potholes and their depths can be seen.
• Archive imagery for back analysis?

Test frequency of condition assessment...
• Spectral reflectance for paved roads

Uses brightness of visual images, used for material identification (projects in Mozambique, Ethiopia)
• Internet of Things
Embedment of sensors, software and connectivity in devices, vehicles, buildings

• Internet related solutions
Linked-data, Semantic Web, use common data formats

• Machine learning and artificial intelligence
Speech recognition, learning algorithms, Google car

• Big data portals, focused on roads
Crosscutting, potential for many aspects of roads.
• Social Media apps
  Report defects on the road
• Crowdsourcing:
  - Fix-my-street
  - Mobile phone data for monitoring, journey times surveys, traffic monitoring
  - OpenStreetMaps (OSM), uses crowdsourcing to develop maps
  - OpenRoads, uses similar methodology, combines data
Recent advances

- Automation trials under way in Tanzania (by DFID) at present, FTL initiative, using drone imagery
- Pseudo-satellite called the ‘Zephyr’, solar powered, flies at 70,000 feet, high resolution photos & video, LIDAR, RADAR, Broadband, etc.
- Streaming of satellite imagery
Methodology for road condition monitoring by satellite imagery

- Original pilot in Nigeria on rural unpaved roads, to test with inaccessibility and conflict
- Successful enough to warrant further research
- Led to present project under AfCAP
Methodology

- Define an Area of Interest
- Carry out Ground Truthing
- Imagery Acquisition
- Train in software and image interpretation
- Mapping and Inventory
- Calibration
- Satellite imagery assessment
Carry out Ground Truthing

• Use existing system and methods of condition assessment:
  - Visual assessment
  - Speed assessment
  - Roughometer
RoadLab: Smartphone App

HD Video cameras with GPS: DashCam
Imagery Acquisition

- Very High Resolution imagery
  - Pleaides 0.5m
  - WorldView 0.5m and 0.3m
Software and Training

- GIS software = QGIS: Freely available so sustainable
- Train in QGIS and Image Interpretation, produce training materials

Mapping

- Digitise centre lines

Produce calibration guide
Inventory

• Locate inventory where possible
Assessment of Condition

- Identify features that indicate long-term change in condition:
  - Change in width of the road
  - Straightness and integrity of road edges
  - Surface texture/shading/hue
  - Surface colour
  - Shadow
  - Patterns in surface, wheel tracking if visible
Assessment of Condition
Assessment of Condition

- Three to five level assessment

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- Compare the ground truthing to the condition assessment results

IRIM2017 20-22 November 2017
### Zambia: Unpaved

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Misclassified as more than one level out:
- 2.223 4.22% > 1 level out

**Zambia**

**Zimbabwe Unpaved**
Ghana: Paved

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Misclassified as more than one level out: 0.118 | 0.40% > 1 level out
Cost Effectiveness

- Figures based on country estimates
- Discounts available for imagery
- Less environmentally damaging
- Good for inaccessible areas

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<th>Network Details</th>
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<th>Satellite assessment per km headline prices</th>
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Incorporation into a RAMS

Tanzania: DROMAS database
Potential for use with Rural Access Index (RAI)

High tech solutions that could be used:

- UAVs
- Satellite imagery
- GNSS
- HD videos
- Smartphones
- Open source mapping
Outputs

• Guideline on the use of high tech solutions for network and condition assessment

• Training materials
• Scientific paper, presented at an international conference

• Linked with the GEM project in Zambia.
  - Same area for trials used, Chongwe
  - Condition data used for ground truthing
Tanzania trial

• Test whether Road Fund Board requirements can be met:
  ➢ Accurately measure road lengths
  ➢ Assess road condition based on existing assessment system
  ➢ Determine how the system can integrate with DROMAS
  ➢ Test potential to roll out on a larger scale
  ➢ Link with DFID automation trials
Status

• Can provide a rapid assessment of large areas, but will need support or partnership with remote sensing organisations

• Flexible enough to fit with existing condition assessment systems and can be calibrated to local conditions

• Would benefit from embedment in a RAMS

• Most beneficial (at present) for countries that have limited knowledge of their networks via accessibility, conflict etc.

• Application depends on the needs of the asset owner and the level of information provided
The way forward

• High-tech solutions will play increasingly important role in asset management as technology improves and becomes more affordable

• Potential in the future to contribute towards more efficient maintenance planning and implementation:
  ➢ Automation through machine learning
  ➢ UAVs and pseudo satellites
  ➢ Streaming of satellite imagery
  ➢ Smartphone apps
  ➢ Crowdsourcing i.e. Fix-my-street type websites
  ➢ Big data applications
Thank you for your attention

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