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LINKING MOBILITY SOLUTIONS

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Using high-tech solutions and remote sensing to increase knowledge on the extent and condition of rural road networks

Robin Workman
Principal International Consultant
TRL
rworkman@trl.co.uk

TRL

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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

Potential solutions

- Satellite applications
- Pseudo satellites
- UAVs
- High definition video
- Smartphone applications

Potential benefits of remote sensing?

- Rapid assessment over large areas
- Logistically easier
- Can provide a permanent visual record of the assessment
- Can be used for other purposes
- Safer, avoids the need to visit areas in conflict

Road condition from satellite imagery

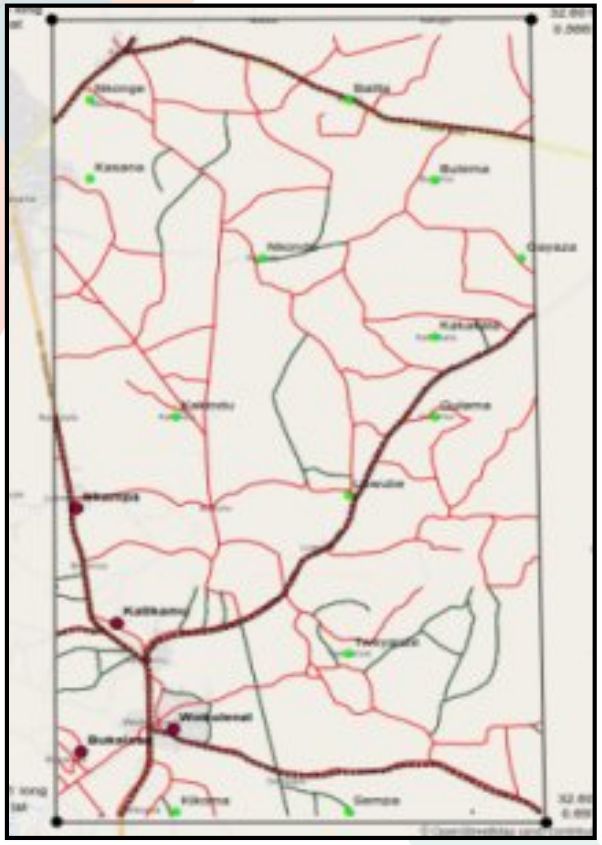
- Original pilot in Nigeria, to test with conflict and inaccessibility
- Rural, unpaved roads
- Successful enough to warrant further research
- DFID funded research under AfCAP in Ghana, Kenya, Tanzania, Uganda and Zambia

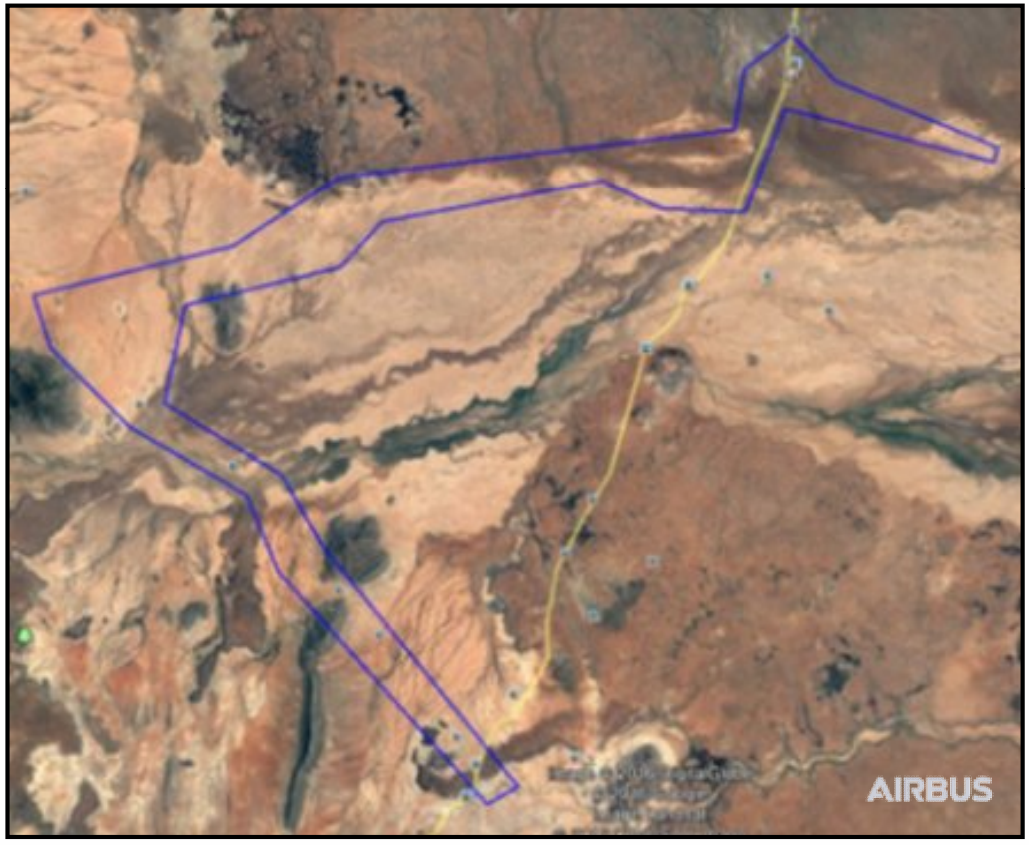
Develop a Methodology

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

Define an Area of Interest (AoI)

- Select an area with a range of conditions
- Avoid areas with no roads





Carry out Ground Truthing

- Use existing system and methods of condition assessment:
  - Visual assessment
  - Speed
  - Roughometer
  - Smartphone app: RoadLab
  - HD video cameras

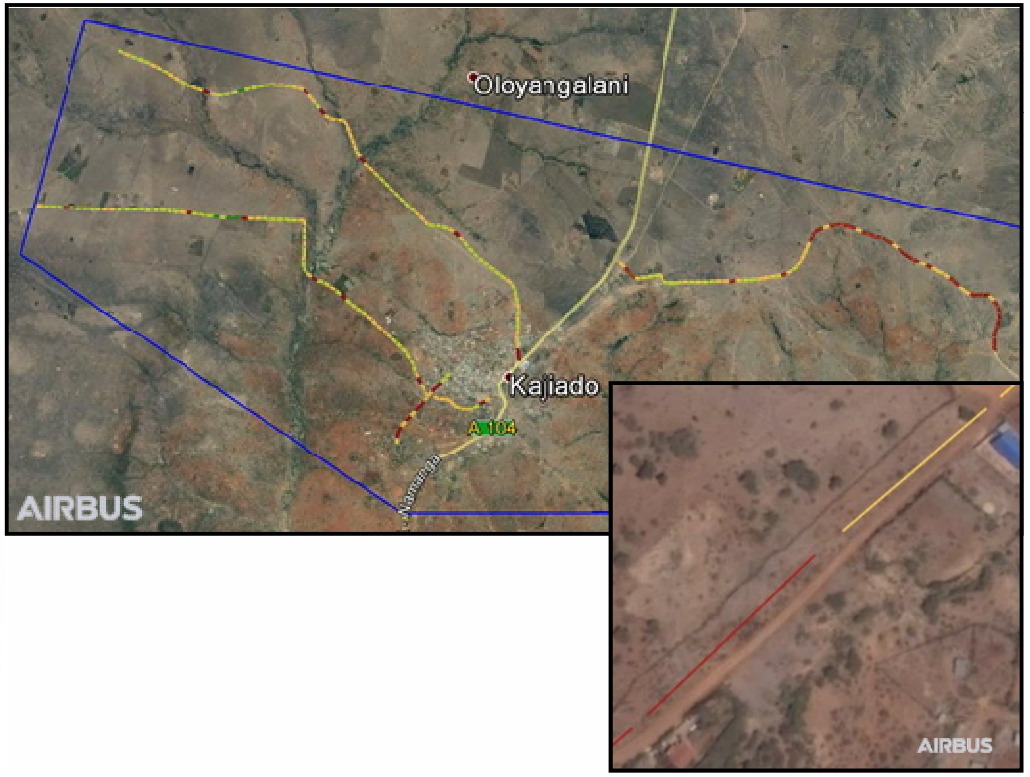
Ground Truthing

- Speed - World Bank Scale;

Condition rating (WB rating)	Typical Speeds achieved in km/h on an unpaved road
Very Good (Excellent)	80-100
Good (Good)	70-80
Fair (Fair)	40-70
Poor (Poor)	30-40
Very Poor (None)	<30

Ground Truthing

- Roughometer: Less accurate at low speeds on poor roads
- RoadLab: Smartphone App for IRI measurement



Carry out Ground Truthing

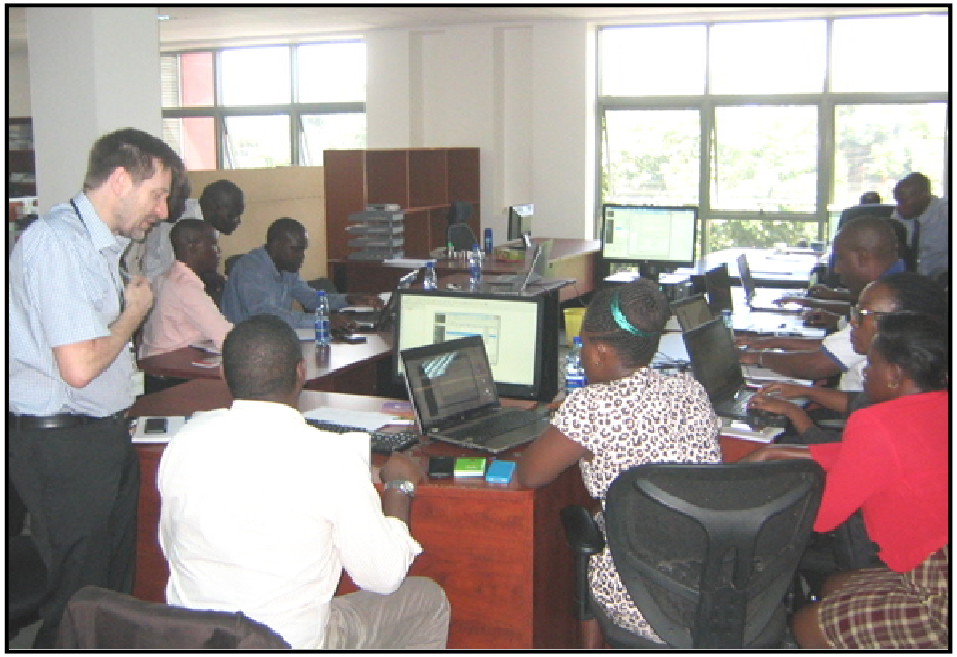
- HD Video cameras with GPS: DashCam

Imagery Acquisition

- Very High Resolution imagery < 0.5m
  - Pleaides 0.5m resolution
  - WorldView 0.5m and 0.3m resolution

Software and Training

- GIS software = QGIS: Freely available, so sustainable
- Involve local remote sensing organisations
- Produce training materials

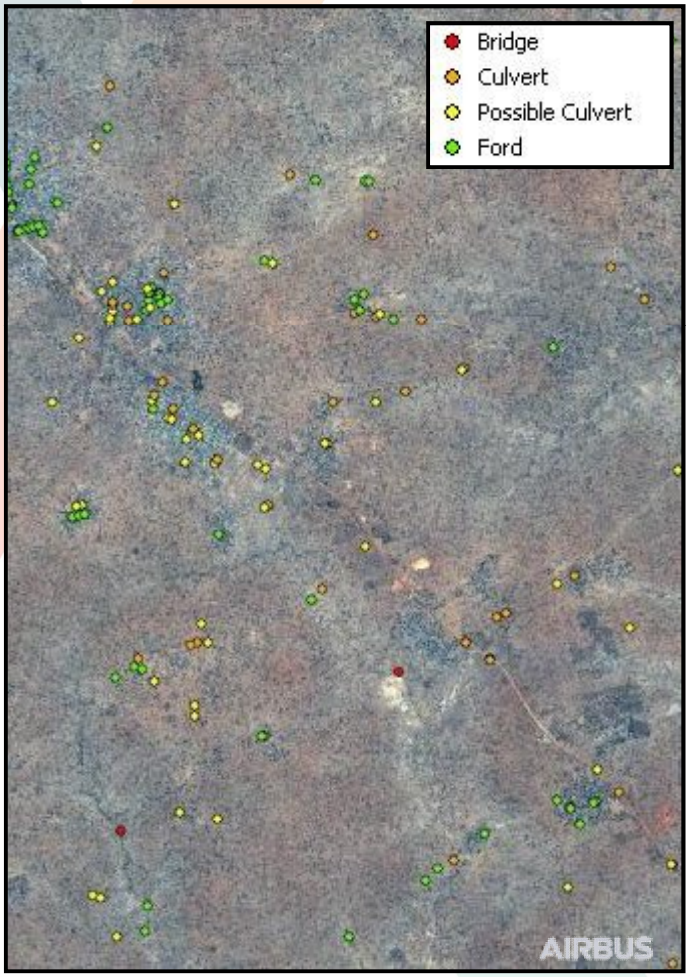


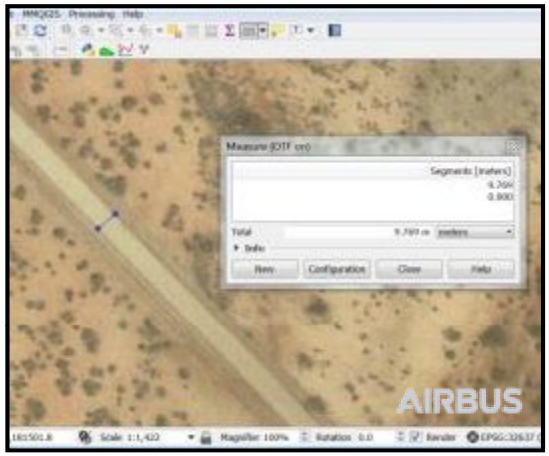
Mapping

- Digitise centre lines as accurately as possible

Inventory

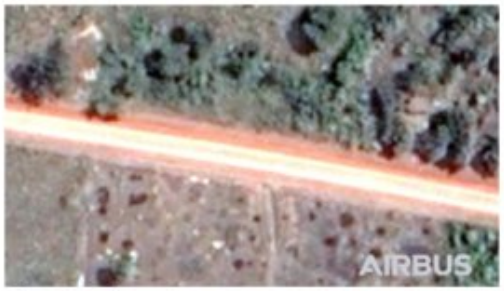
- Locate inventory where possible





Calibration to local conditions

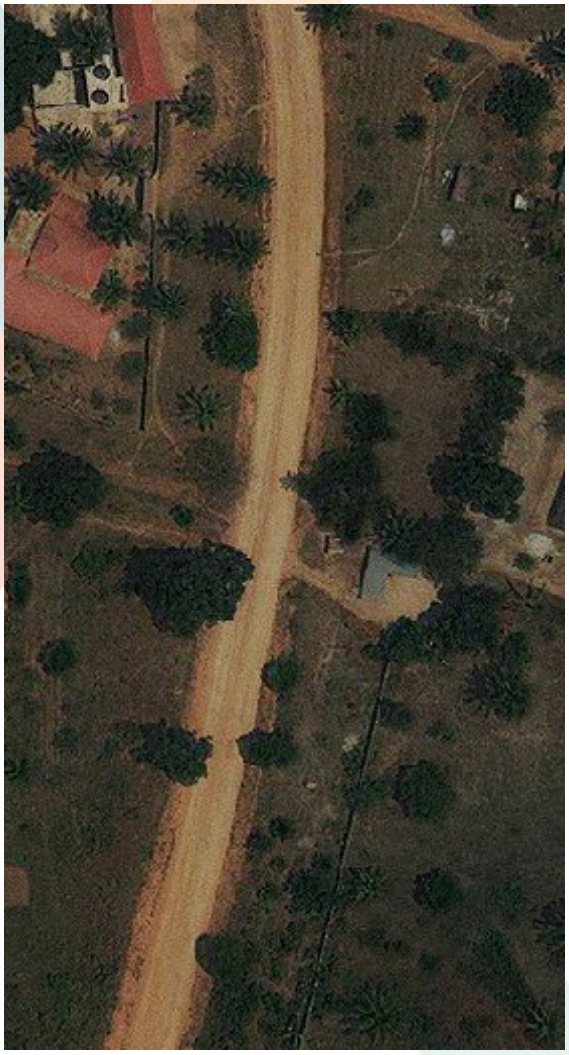
- Produce a calibration guide

Description	Example
Good (Green): Some slight differences in surface colour and texture can be seen, but generally very even. Negligible or slight variation in width, up to 10%. Edge of road consistent and straight, but may vary slightly in isolated areas. See Figures 1.1 to 1.5. Condition can be relative for earth and gravel roads. If the surface can be determined, the condition of earth roads can be shown as good when the width and edges vary slightly and some surface irregularities can be seen. For unpaved roads this category will normally apply to recently constructed or rehabilitated roads, or roads that have received regular maintenance and grading.	**Figure 1.1 Newly rehabilitated road, hence light coloured gravel, striaght edges**  © Airbus Defence and Space **Figure 1.2 Well maintained road inpopulated area**  © Airbus Defence and Space

Assessment of Condition

- Identify features that indicate long-term 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

Very Good	Good	Fair	Poor	Very Poor	Unknown
Dark Green	Light Green	Yellow	Amber	Red	Blue

Good	Fair	Poor	Unknown
Light Green	Yellow	Red	Blue

Ground Truthing

Condition Assessment

Assessment of Condition

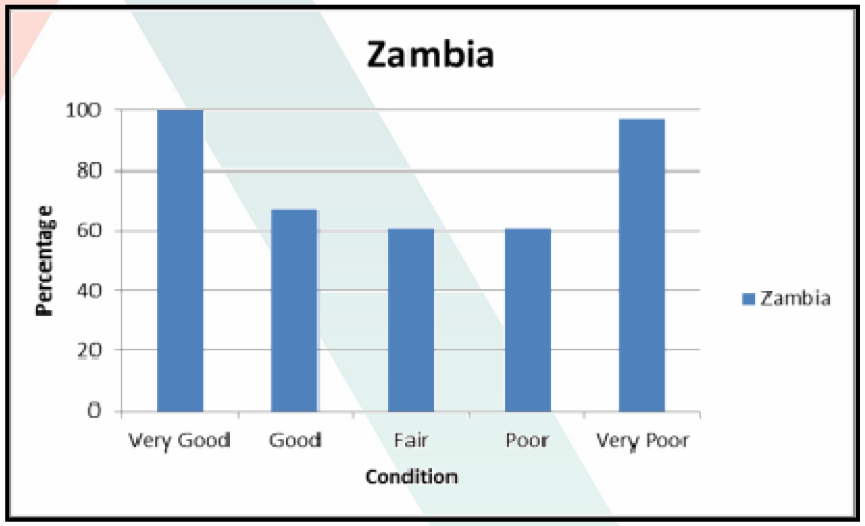
- Compare the ground truthing to the condition assessment results
- Analyse results

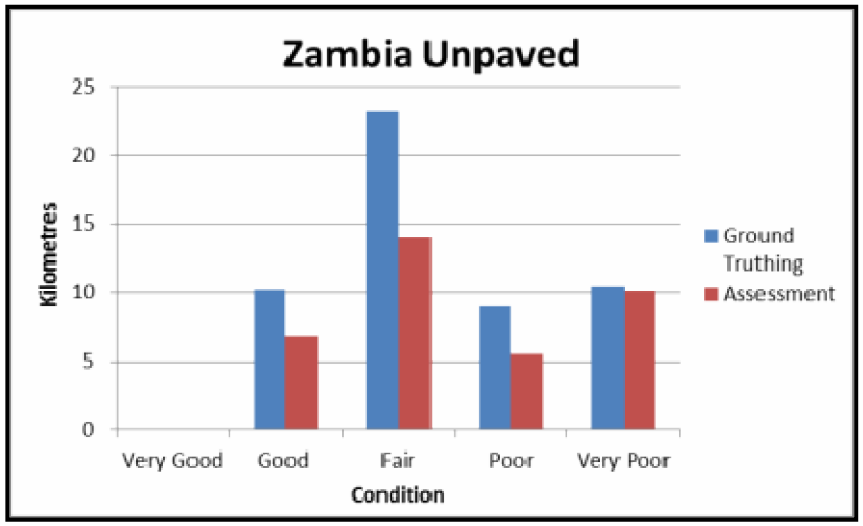
Zambia

Assessment			Misclassified as;					
	Ground truthing (km)	Corresponding Satellite assessment (km)	V.Good	Good	Fair	Poor	V.Poor	Unknown
V Good	0	0						
Good	10.191	6.829			1.139	2.223		
Fair	23.153	14.087		6.835		2.231		
Poor	8.973	5.514			3.459			
V Poor	10.402	10.129				0.273		
	52.719	36.559						

Correlation			Percentage of correctness
V Good	0.00	0.00	100%
Good	10.191	6.829	67%
Fair	23.153	14.087	61%
Poor	8.973	5.514	61%
V Poor	10.402	10.129	97%
	52.72	36.56	69%

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





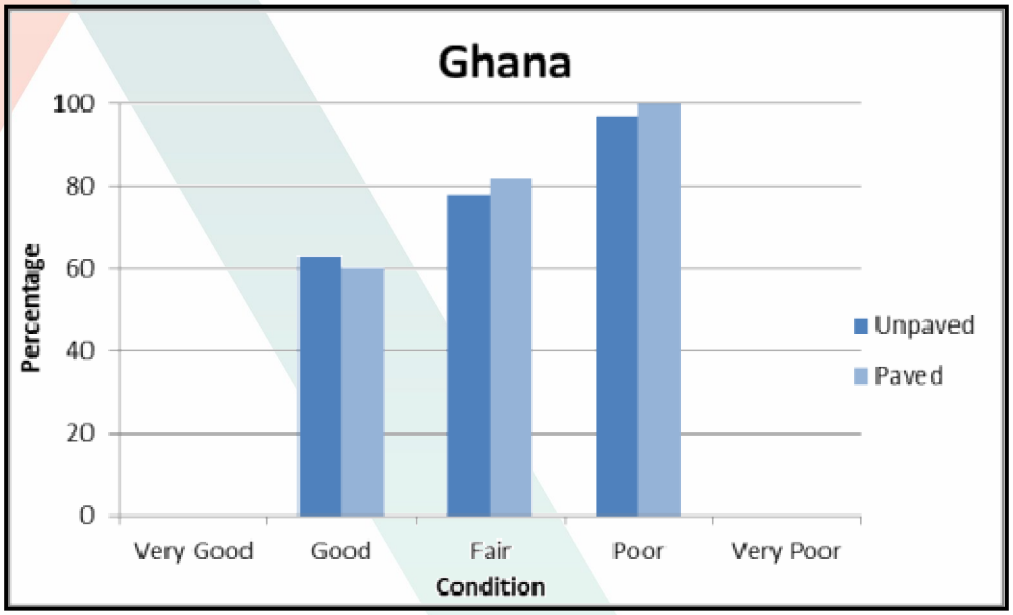
PAVED Assessment			Misclassified as;					
	Ground truthing (km)	Corresponding Satellite assessment (km)		Good	Fair	Poor		Unknown
Good	4.527	2.716			1.693	0.118		0
Fair	22.934	18.918		3.467		0.549		0
Poor	1.845	1.845						0
	29.306	23.479						

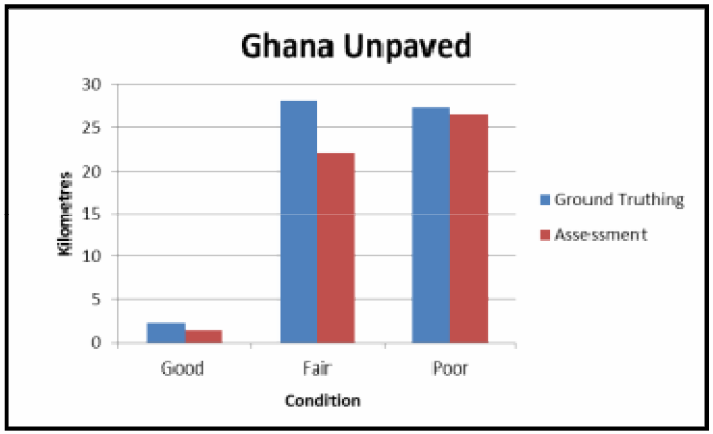
Correlation			Percentage of correctness
Good	4.527	2.716	60%
Fair	22.934	18.918	82%
Poor	1.845	1.845	100%
	29.306	23.479	80%

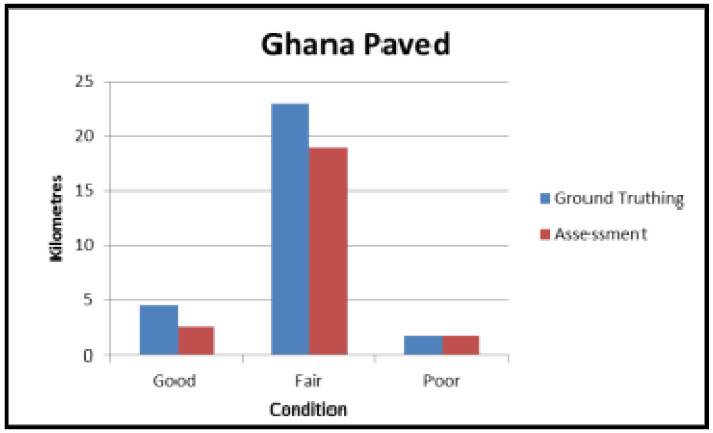
Misclassified as more than one level out:

0.118 0.40% > 1 level out

Ghana







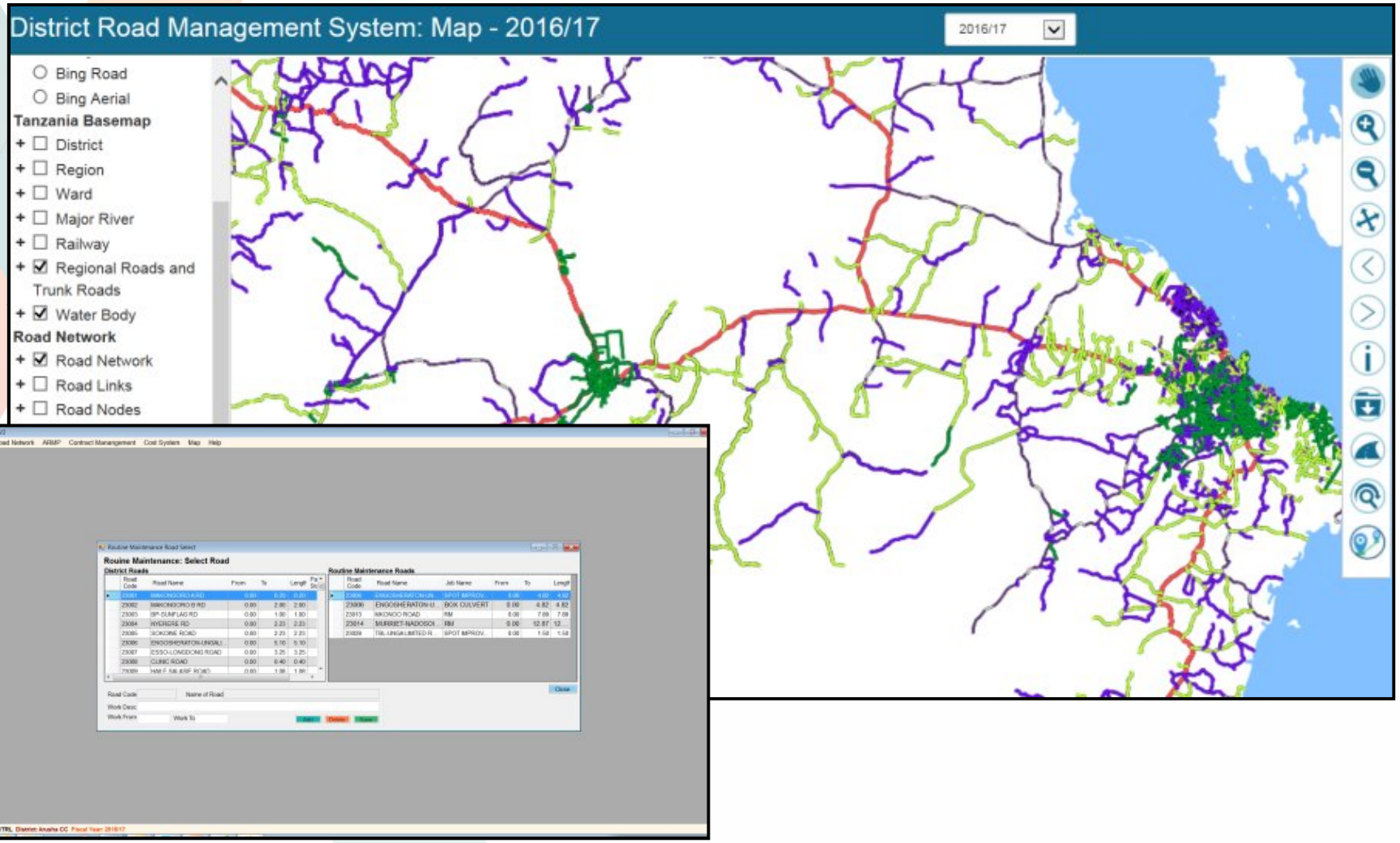
Cost Effectiveness

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

Country Details	Network Details	Satellite assessment per km this project	Satellite assessment per km headline prices	Traditional condition assessment per km
Ghana		£	£	£
Length of road km	37.562	22.65	67.12	21.30
Square area km^2	153			
Road Density km/km^2	0.25			
Imagery cost £	590.75			
Kenya				
Length of road km	77.882	30.56	58.40	21.40
Square area km^2	288			
Road Density km/km^2	0.27			
Imagery cost £	2088			
Uganda				
Length of road km	145.715	10.26	23.49	9.22
Square area km^2	187			
Road Density km/km^2	0.78			
Imagery cost £	836.46			
Zambia				
Length of road km	52.719	30.62	40.24	30.00
Square area km^2	119			
Road Density km/km^2	0.44			
Imagery cost £	1251.52			

Incorporation into a RAMS database

- Nigeria: iROADS, Tanzania: DROMAS



Conclusions

- Can provide a rapid assessment of large areas
- Not as detailed as traditional systems
- Will need support or partnership with remote sensing organisations in short-medium term
- Flexible enough to calibrate to existing local condition assessment systems
- Process is subjective, but there is scope for developing an automated system

Conclusions

- Results reasonably consistent, show that 3 levels of condition can be assessed more accurately
- More appropriate for unpaved roads, but can be used for paved roads
- Would benefit from embedment in a RAMS
- DashCams cheap and appropriate for ground truthing
- Cost effective if significant discount on imagery
- Optimum solution is likely to be a combination of more than one technology

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Thank You

http://www.research4cap.org/SitePages/SatelliteImagery.aspx

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