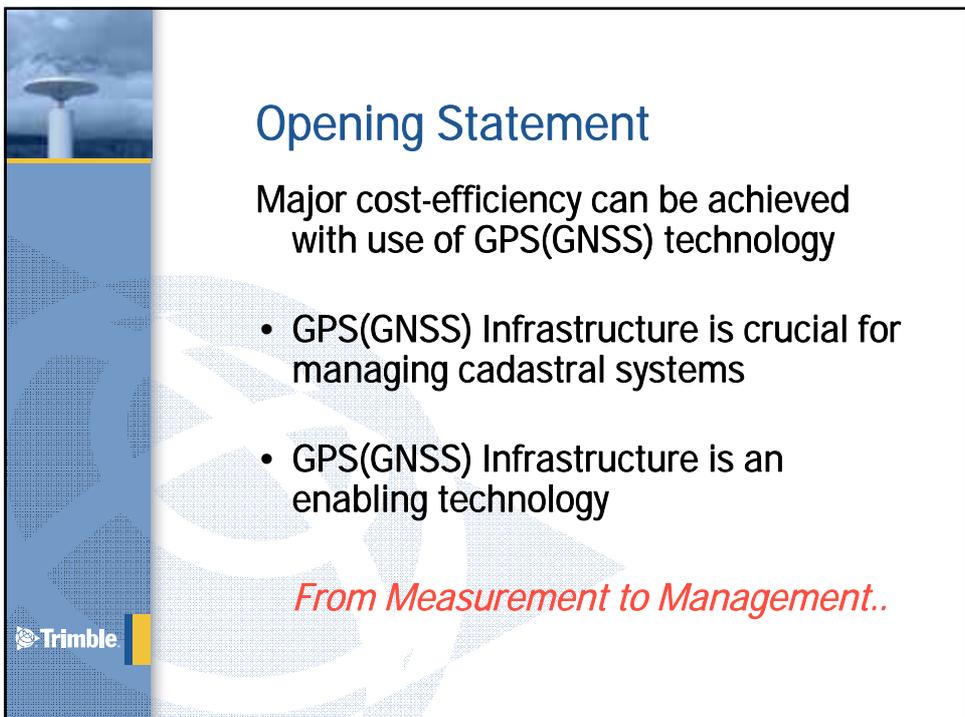




# *Economic Benefits of Global Positioning System (GPS) technology in developing countries for Land Management, Geographic Information and Agriculture*

*Keith Hofgartner*

Trimble Navigation Limited  
July 2008



## Opening Statement

Major cost-efficiency can be achieved with use of GPS(GNSS) technology

- GPS(GNSS) Infrastructure is crucial for managing cadastral systems
- GPS(GNSS) Infrastructure is an enabling technology

*From Measurement to Management..*



## GPS (GNSS) – Civil Use

**Police Enforcement**      **Surveying & Mapping**      **Utilities**  
**Personal Navigation**      **Aviation**      **Railroads**      **Offshore Drilling**  
**Communications**      **Trucking & Shipping**      **Recreation**      **Power Grid Interfaces**

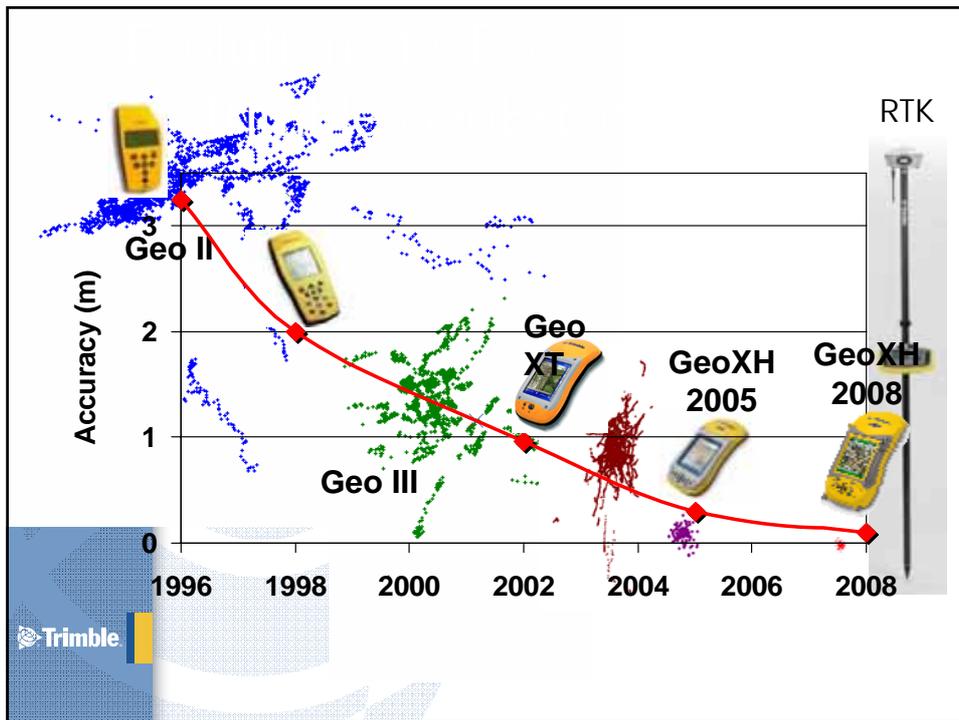
## How accurate is GPS(GNSS)?

Mapping Grade Receiver

Autonomous Navigation Receiver

Military GPS receivers

Survey Grade GPS



## What is a GPS (GNSS) Infrastructure?

**GPS (GNSS) Infrastructure:**

- GPS (GNSS) Receivers
- Enterprise Class Servers
- Communications Links
- Enterprise data processing software



*GNSS Infrastructure is the positioning backbone to enable high accuracy surveying and any positioning related application*



# Components of Infrastructure

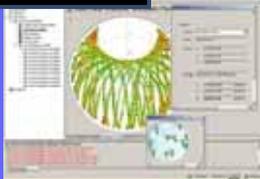
### Monumentation



### Hardware



### Software

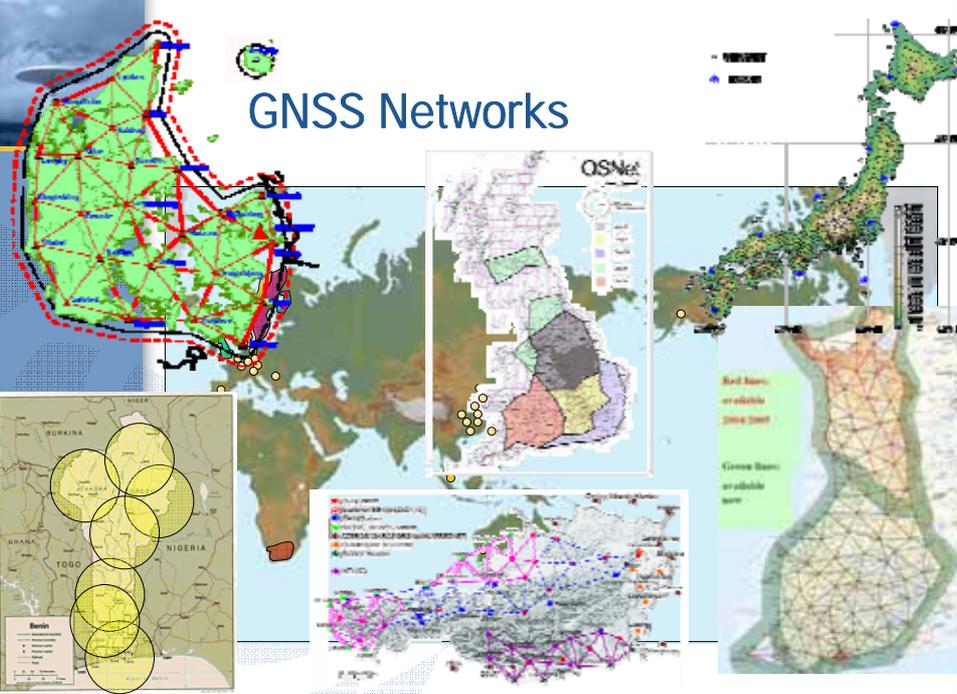


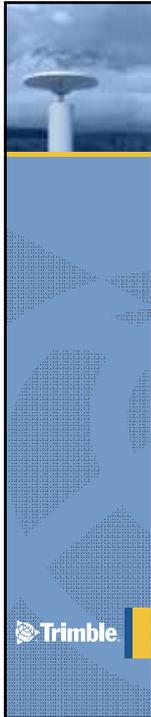
### Communications





# GNSS Networks

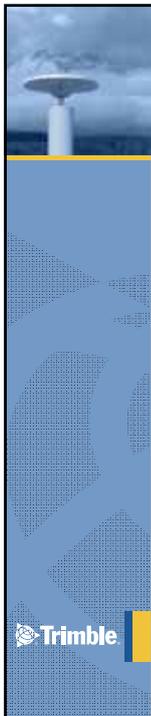




## Scalable Infrastructure

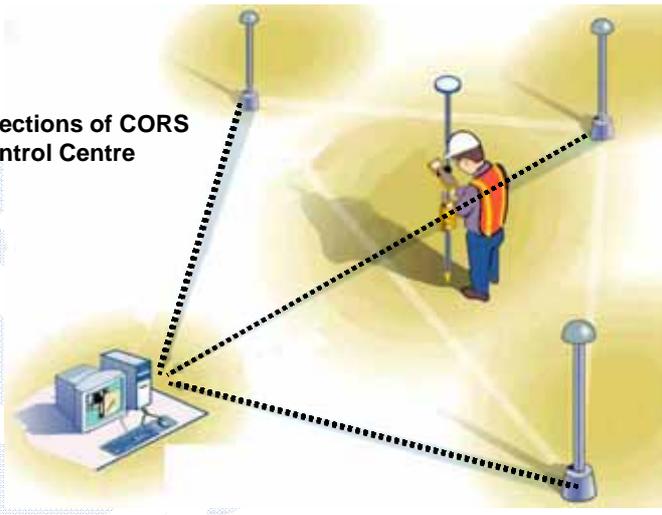


A map of the African continent is shown with a network of CORS (Continuously Operating Reference Station) stations. The stations are represented by white dots, and they are interconnected by a network of lines. A central station is highlighted with a yellow dot, and lines radiate from it to other stations across the continent. The map is overlaid on a blue background with a white grid pattern.



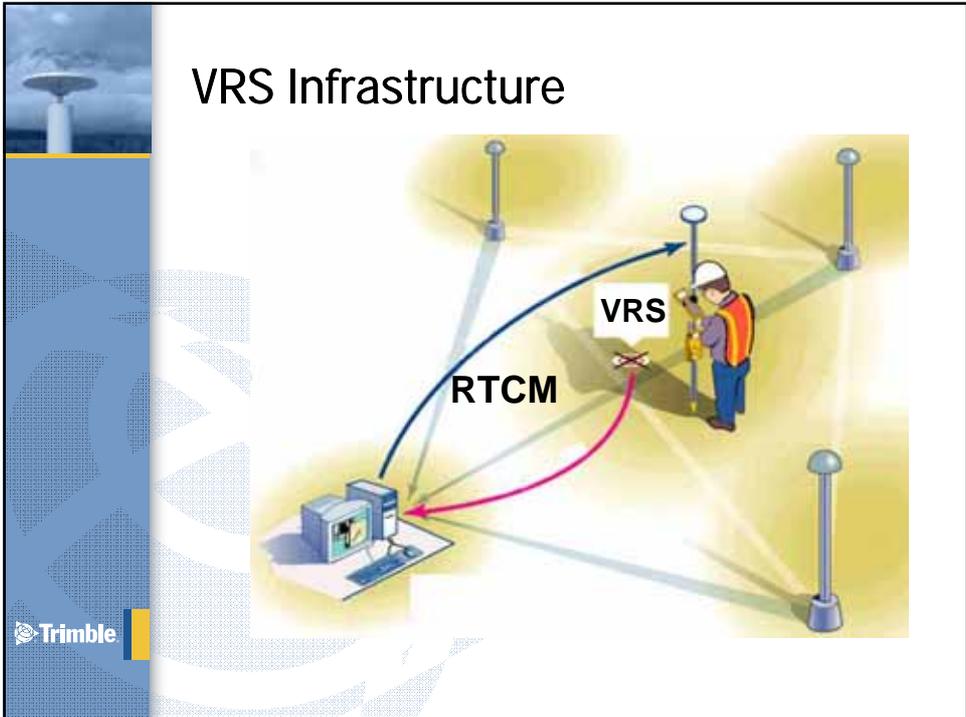
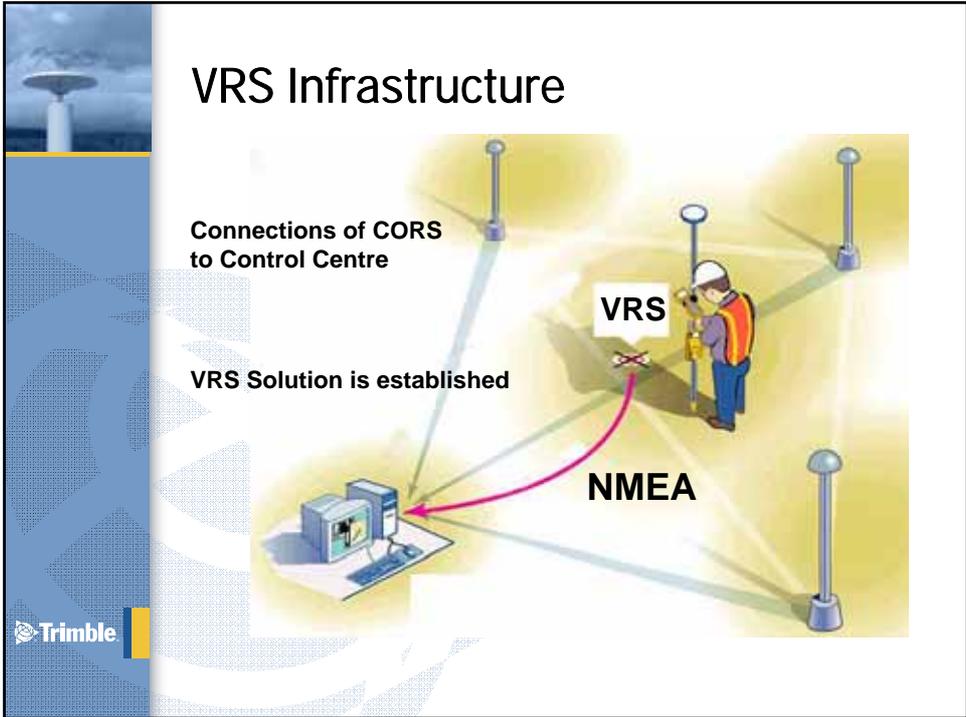
## VRS Infrastructure

**Connections of CORS to Control Centre**



The diagram illustrates the VRS (Virtual Reference Station) infrastructure. It shows a central control center (a computer monitor and keyboard) connected via dashed lines to four CORS (Continuously Operating Reference Station) stations. A user, wearing a hard hat and safety vest, is shown using a surveying instrument (a total station or similar) to measure a point. The user is positioned between two CORS stations, and the dashed lines represent the data flow from the CORS stations to the control center and then to the user's instrument. The background is a yellowish glow.





**GPS Infrastructure**  
*.....an enabling technology*

**Enables you to reduce costs for Cadastre and Land Reform Projects**



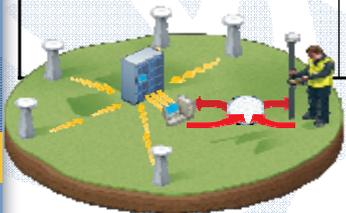
Cadastre



**Economic Benefits....**  
*Cadastre Management and Land Reform*

Precision GPS: **Traditional Monumentation** vs. **Active Monumentation**

Method	Requirements
<b>Traditional Monumentation</b>	<ul style="list-style-type: none"> <li>• Spacing -- 10km grid for base station setup and coverage</li> <li>• Cost -- 100 monuments @ \$15K = \$ 1.5m</li> </ul>
<b>Active Monumentation</b>	<ul style="list-style-type: none"> <li>• Spacing -- 50-60kms</li> <li>• Cost -- 5 reference stations @ \$40K = \$ 200K</li> </ul>



Cadastre





## Economic Benefits....

### *Cadastre Management and Land Reform*

Precision GPS: **Traditional Monumentation vs. Active Monumentation**

Feature	Benefit
Single Coordinate framework	<ul style="list-style-type: none"> <li>Maintain consistent spatial Coordinate System               <ul style="list-style-type: none"> <li>–GIS tend to use a countrywide coordinate system</li> <li>–Survey tend to use Local Coordinate systems that do not necessarily relate</li> </ul> </li> </ul>
Quality Control and Integrity Monitoring	<ul style="list-style-type: none"> <li>Moving to an Active Control System               <ul style="list-style-type: none"> <li>–Replacement of traditional monumentation and associated costs of maintaining</li> </ul> </li> </ul>





**Cadastre**




## GPS Infrastructure

### *.....an enabling technology*

Enables you to reduce costs for capital improvement projects





**Now and in the future**

**Cadastre Infrastructure**



**GPS Infrastructure**  
*.....an enabling technology*

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Infrastructure



Enables adoption of stakeless construction with machine control systems

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**GPS Infrastructure**  
*.....an enabling technology*

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Infrastructure  
Asset Management

Supports asset inventory and management

- Moving
  - fleets, boats, containers
- Fixed
  - Utility hardware, building inventories



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## GPS Infrastructure

*.....an enabling technology*

### Geographic Information Collection






Enables smaller entities to adopt positioning technology

Cadastre  
 Infrastructure  
 Asset  
 Management  
 GIS




## Economic Benefits....

### *Geographic Information Collection*



Features	Benefits
<ul style="list-style-type: none"> <li>• <i>GNSS Positioning</i></li> </ul>	<ul style="list-style-type: none"> <li>• <i>Common Coordinate system</i></li> <li>• <i>Easy to use</i></li> </ul>
<ul style="list-style-type: none"> <li>• <i>GNSS Precisions</i></li> </ul>	<ul style="list-style-type: none"> <li>• <i>Use the accuracy required for the task</i></li> </ul>
<ul style="list-style-type: none"> <li>• <i>Time stamp</i></li> </ul>	<ul style="list-style-type: none"> <li>• <i>Automatic verification of time of measurements</i></li> </ul>
<ul style="list-style-type: none"> <li>• <i>Relocate</i></li> </ul>	<ul style="list-style-type: none"> <li>• <i>Use same coordinate system to relocate 'lost' assets</i></li> </ul>

Cadastre  
 Infrastructure  
 Asset  
 Management  
 GIS





**GPS Infrastructure**  
*.....an enabling technology*

**Disaster Prevention and Management**

Monitoring of natural hazards,  
*(volcanoes, plate tectonic boundaries)*  
and manmade structures  
*(dams, slopes)*




Cadastre  
Infrastructure  
Asset Management  
GIS  
Disaster Prevention & Management




**GPS Infrastructure**  
*.....an enabling technology*

**Disaster Prevention and Management**

Improves disaster response  
in accuracy and time

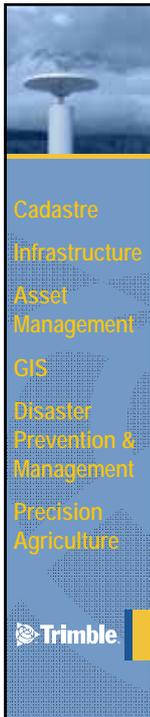
- Natural, Non-natural, Accident/Crime Scene, Homeland Security

Sri Lanka Tsunami Relief  
2005




Cadastre  
Infrastructure  
Asset Management  
GIS  
Disaster Prevention & Management





## GPS Infrastructure *.....an enabling technology*

### Augment Lasers to GPS for Land Leveling

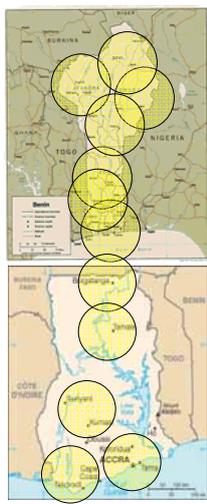
- Improve crop yield by 20% -30% over conventional leveling technology
- Improve crop yield by 50% on new fields
- Conserve water
- fields can be leveled to within +/-1cm
- Reduce surveying costs or give surveying
- Improved topsoil management
- Reduces chemical runoff
- 24 operation



## Land Administration Projects utilising Trimble Solutions

### Two recent examples

- Benin
  - Access to Land Project (MCC)
- Ghana
  - Pilot Project (MCC)
  - Land Administration Project (WB)
  - Clinton Global Initiative Project





## Benin GNSS Applications

- Used for Cadastral, GIS, Engineering Survey applications

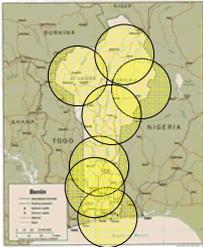


- Potential for Control Surveys, Earthquake / Deformation Studies and Precision Farming




## Benin GNSS Applications

- Surveying Using Local RTK Base stations and surveying land parcels
- Post Processing of the survey data into National Grid using the CORS Station data centrally stored in Cotonou

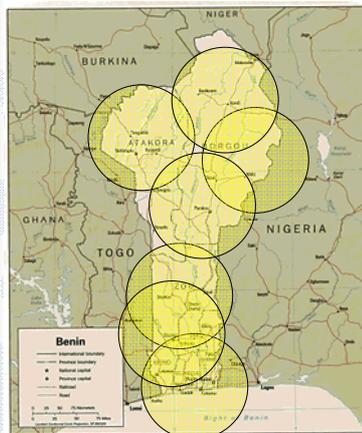


## Benin New Mapping Handheld Receivers

- Investment in 45 new High Accuracy GIS data collectors
- Using data from the new GNSS Reference Stations
- Delivers sub-foot (30cm) accuracy in post – processed position



## Benin Establishment of GNSS Reference Stations



- Cost effective tool for land development
- GNSS development enhances Benin's integration with global mapping systems
- 100km coverage using Regional Survey offices
- 100% national coverage
- Potential for VRS Network upgrade



## Ghana Land Administration Projects

- Supported by
  - Millennium Challenge Corporation
  - World Bank
  - Private funding (Opportunity International)



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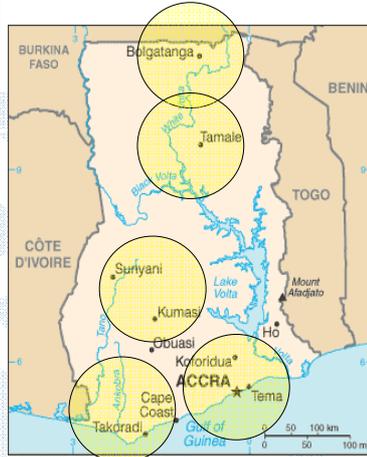
## Ghana State of Survey Infrastructure

- A sparse network of triangulation beacons
  - Unable to basis for accurate cadastre
- Different co-ordinate systems
  - War Office
  - Clark Modified 1880 Ellipsoid.
  - The lack of a homogenous co-ordinate system has led to multiple sale of land and the high of cost of access to land for development.

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## Ghana Spatial Distribution of GNSS COR



- Initial Pilot project
- Further densification of network
- Cost effective tool for land development
- GNSS development enhances Ghana's integration with global mapping systems
- 7km range Real time coverage using Regional Survey offices



## Ghana Millennium Challenge – Pilot Project

- Local offices with GNSS Reference Stations storing Raw Data for Post Processing
- Additional 35W Radios transmit Real Time corrections to users in field (7-10k range), or set up local base station and Post Process to National Coordinate system for remote sites
- Latest GNSS RTK rovers for cm precision
- Robotic Optical Total Stations for in-fill in built-up areas, (no GNSS coverage)
- High Accuracy GIS data collectors
  - Delivers sub-foot (30cm) accuracy in post – processed position
- Potential to utilise Reference Stations as part of a National Network with potential for a deliverable VRS solution





## Ghana Pilot for Opportunity International

- First American – the US's leading provider of business information relating to real estate transactions
- Opportunity International - delivering tailored microfinance products to the world's poor
- ESRI – the global leader in GIS technology
- Trimble - leading provider of advanced positioning solutions
- International Land Systems - develops sustainable land recording and registration systems and consulting worldwide
- Sibus – one of Ghana's leading ICT companies





## Ghana New Mapping Handheld Receivers

- Investment in over 50 new High Accuracy GIS data collectors
- Delivers sub-foot (30cm) accuracy in post – processed position
- Investment in many lower accuracy units for Parcel Identification only
- All using data from the new GNSS Reference Stations






## Ghana Pilot for Opportunity International

- Opportunity International is well established
- Use of existing infrastructure is critical
- Existing clients first in line
- Government support is strong



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## Ghana Elements of approach

- Start with Opportunity International clients
  - schools first.
- Use private sector resources to document de facto ownership as basis for paralegal title.
- Rely on paralegal title to grant micro mortgages.
- Use paralegal title and economic validation to incentivize formalization of title.
- Develop low cost registry solution (< \$1000) based on ESRI/ILS software; data model to adhere to GLTN standards.
- Build a public/private partnership for long-term success.

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## Ghana Results so far..

- School Loan offering developed by Opportunity International.
- Forms and procedures under review for approval by government.
- First schools in loan program surveyed using GPS.
- Determination of rights being made in the field.



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## Ghana Conclusion

- GNSS infrastructure will underpin the intended efficiency in the land administration through increased security in tenure.
- It will provide the basis for the capture and utilization of the so called critical GIS spatial dataset coherent in nature country for more effect spatially correct to improve the efficiency of Industry.
- Ghana is poised to be an example of an emerging country that has leverage GNSS technology for sustainable development

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## African Reference Station Frame AFREF

- A unified geodetic reference frame for Africa
- Fundamental basis for the national and regional three-dimensional reference networks
- Goal: Continuous permanent GPS stations allowing free user access of GPS Data anywhere in Africa




## Continuous Operation Reference Stations



**Countries with:**  
 South Africa, Egypt,  
 Morocco, Namibia,  
 Kenya, Zambia,  
 Cameroon, Senegal,  
 Uganda and Ivory  
 Coast, Benin

**Countries in Progress:**  
 Tanzania, Botswana,  
 Malawi, Ghana,  
 Nigeria, Namibia,  
 Ethiopia,  
 Swaziland





## Summary

GNSS Infrastructure is an enabling technology ideal for developing and transitional regions for the following applications:

- Cadastre Management
- Urban Infrastructure development
- Geographic Information System data collection
- Asset Management
- Disaster prevention and management
- Precision Agriculture

*From Measurement to Management*