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REGIONAL CONFERENCE 2024
Climate Responsive Land Governance and Disaster Resilience: Safeguarding Land Rights

Low-Cost GNSS Receiver Systems for Early Warning System (EWS), Air-Quality Monitoring (AQM), and Gateless-Toll-Gate (GTG)

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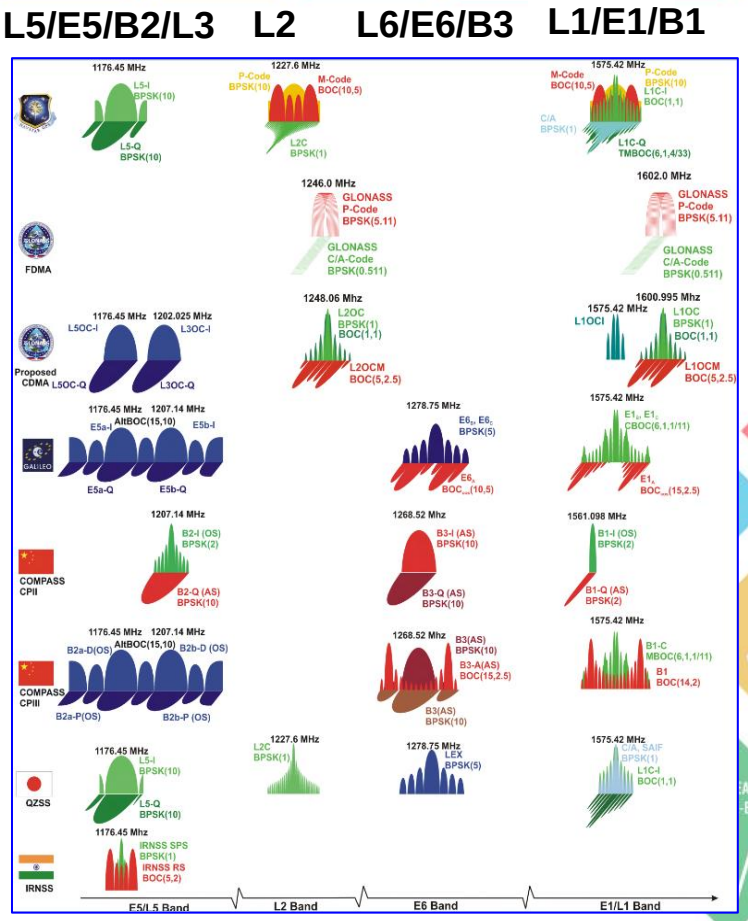
GNSS Introduction

- GNSS (Global Navigation Satellite System) is an acronym used to represent all Navigation Satellite Systems such as

Satellite	Country	Coverage
GPS	USA	Global
GLONASS	Russia	Global
Galileo	Europe	Global
BeiDou (BDS)	China	Global
QZSS (Michibiki)	Japan	Regional
NavIC	India	Regional



https://gssc.esa.int/navipedia/images/c/cf/GNSS_All_Signals.png

GNSS Applications

Pay-As-You-Drive
Toll Fee
ERP

Legal & Law Enforcement
Geo-Fencing
Geo-Security
Illegal Fishing

ITS / ADAS
V2V / V2X
Traffic Congestion
Air Quality

Transport
Vehicles
Rail
Aviation
Space

Tax Collection
Insurance
Alternate for Fuel Tax Collection

IoT
M2M
Robotics

Secured Transport of Dangerous Goods
Supply-Chain Management

Emergency & Safety Services
SoL, e-Call
ERA-GLONASS
Early Warning

Agriculture
Precision Farming

AI
Medical Health Services
People Flow

Surveying
Mapping
GIS
UAV / UMV

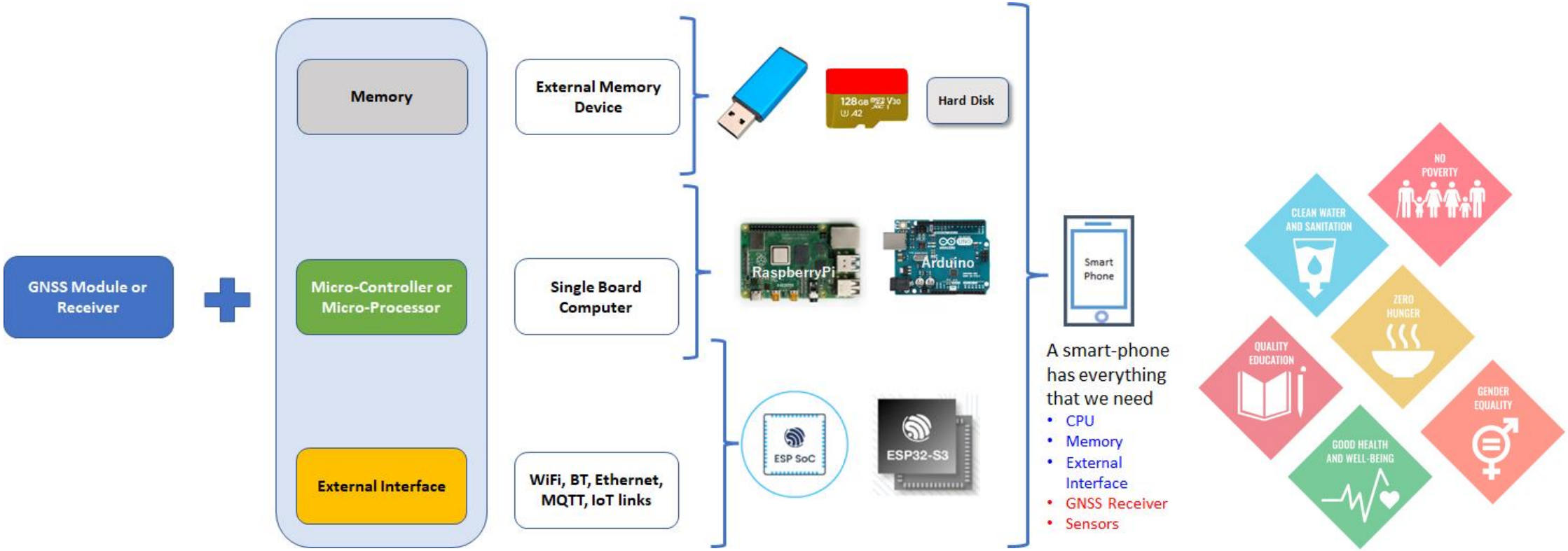
Timing Applications
Telecom
Finance
Power Grid

LBS
Game
Entertainment
Advertisement
Marketing

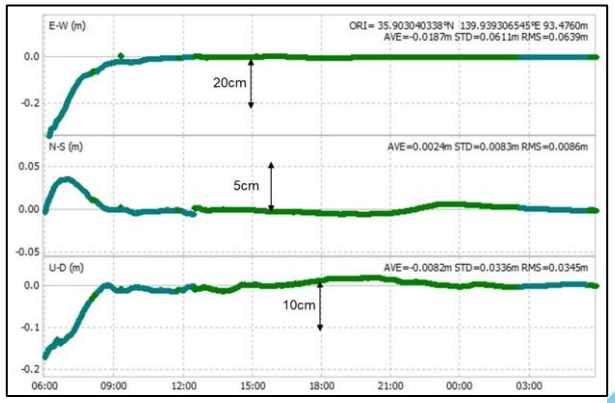
Scientific Applications
Space Weather
VLBI

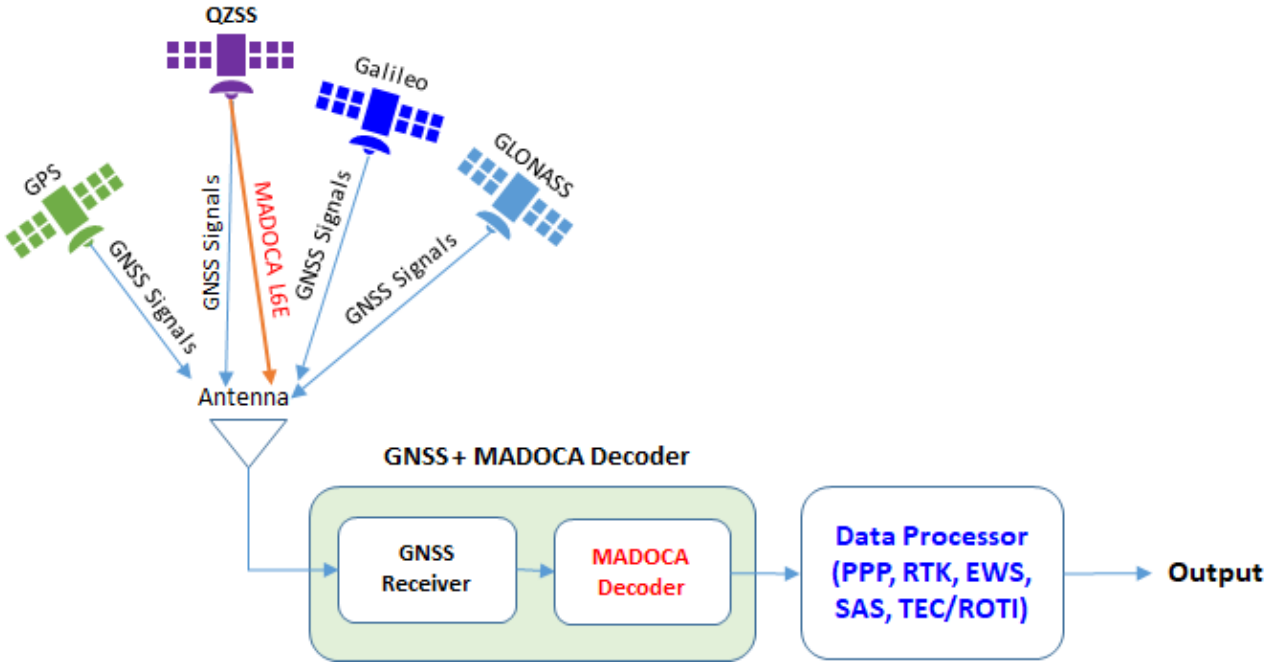
How to Make a Low-Cost GNSS Receiver System?

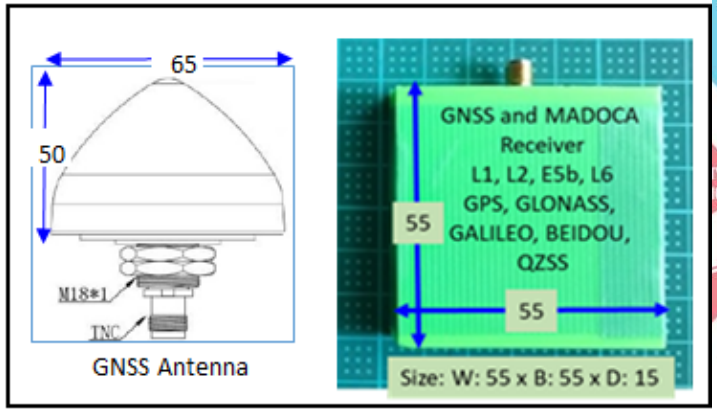
A system that costs less than $1,000, Our target is $100



High-Accuracy Low-Cost GNSS Receiver System
RTK, MADOCA-PPP, QZSS SAS, EWS Compatible

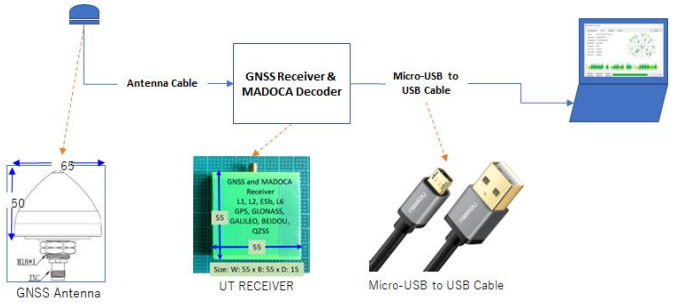




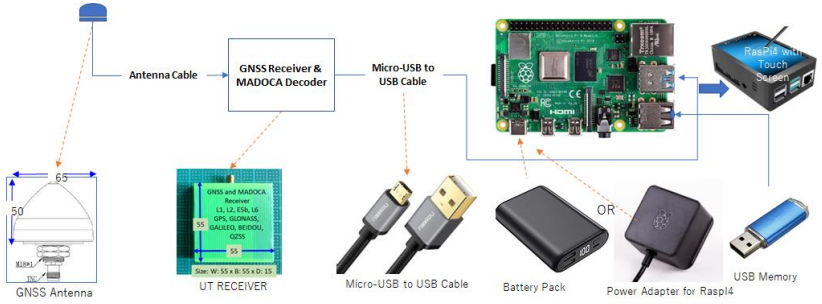


High-Accuracy Low-Cost GNSS Receiver System:
MAD-WIN, MAD-PI and MADROID

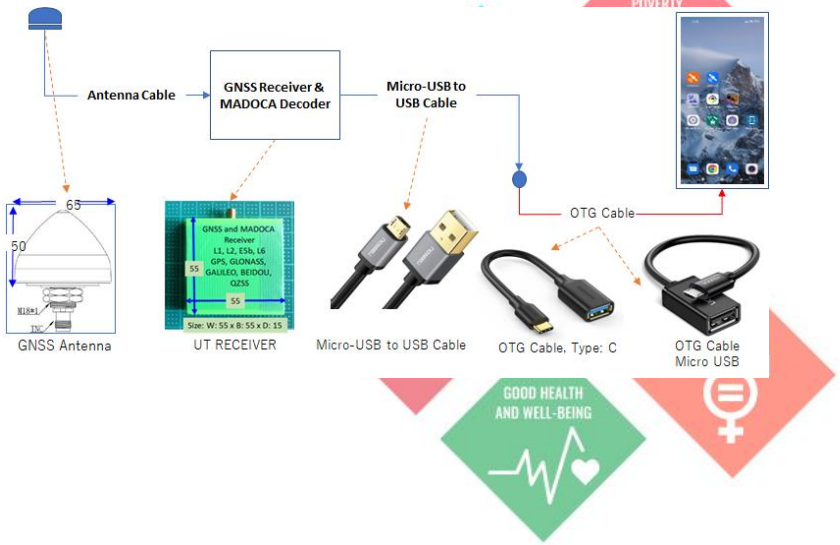
MAD-WIN (Windows)



MAD-PI (RaspberryPI)



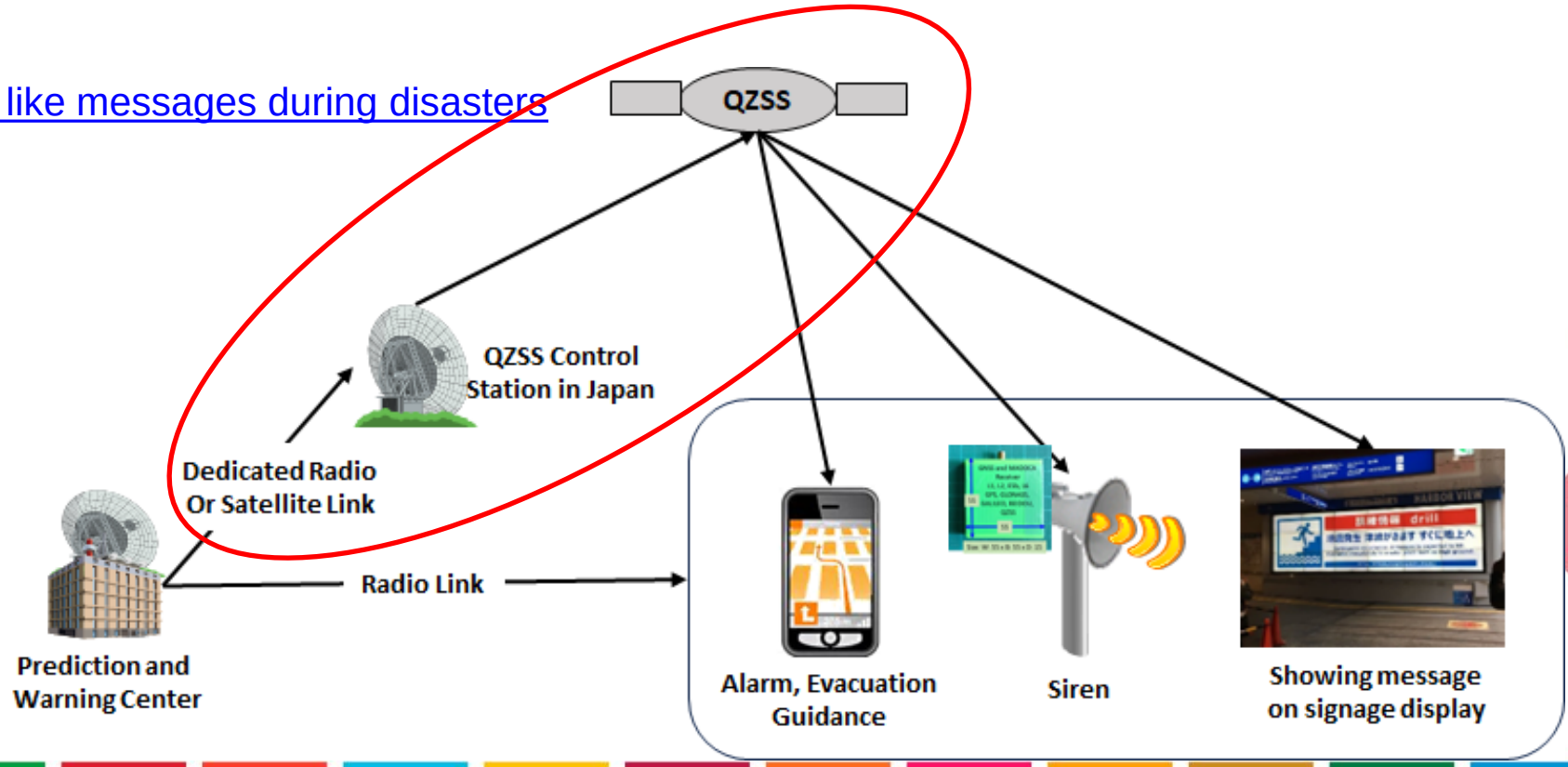
MADROID (Android)



- ✓ **Provides 20cm absolute accuracy**
- ✓ **Base-Station is not required**

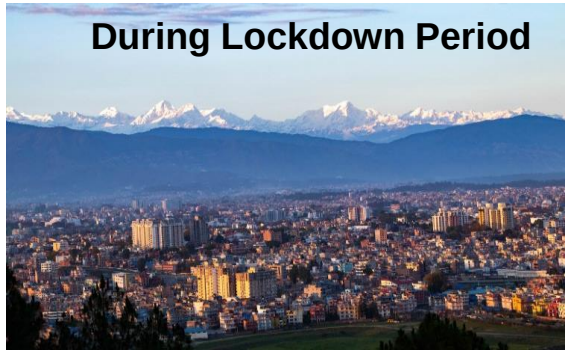
Low-Cost GNSS Receiver Systems for QZSS Early Warning System (EWS)

Broadcasts SMS like messages during disasters



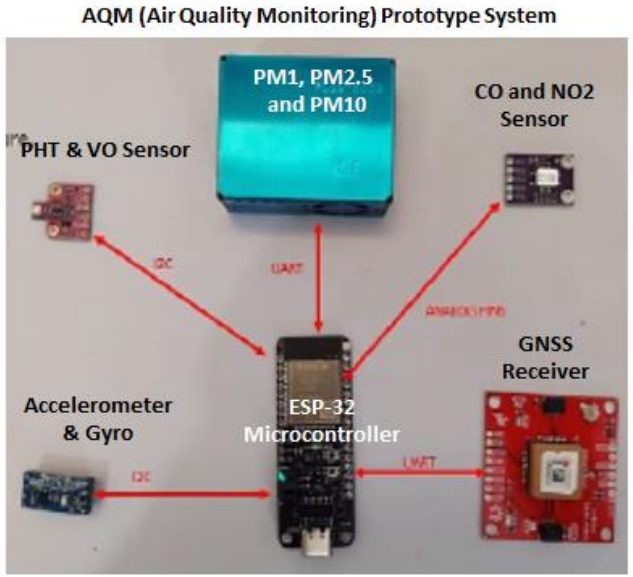
Low-Cost GNSS Receiver Systems for Air Quality Monitoring (AQM)

Integration of Environment Sensors with a Low-cost GNSS Receiver System



EPA has designated six major air pollutants as "criteria" pollutants:

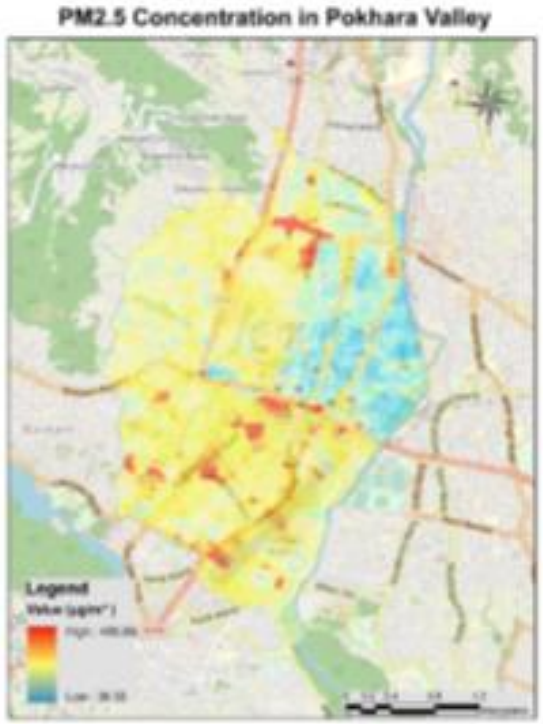
- Carbon monoxide (CO)
- Nitrogen Oxides
  - (NO and NO2)
- Sulfur Dioxide (SO2)
- Ozone (O3)
- Particulate Matter (PM)
- Lead (Pb)

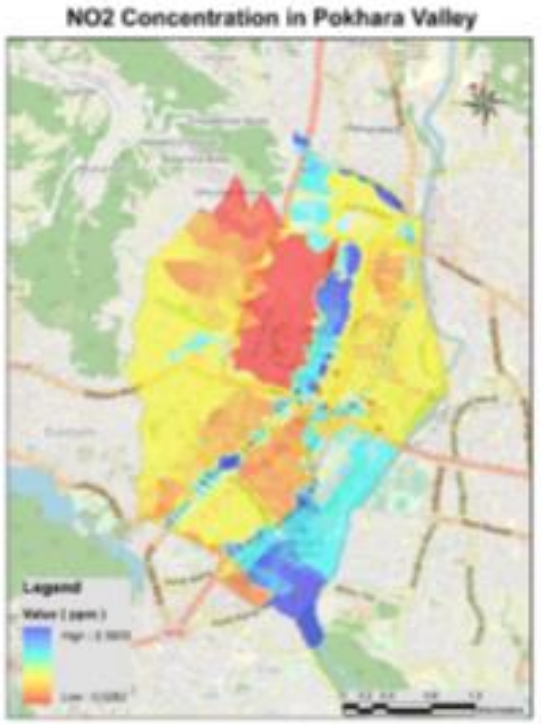


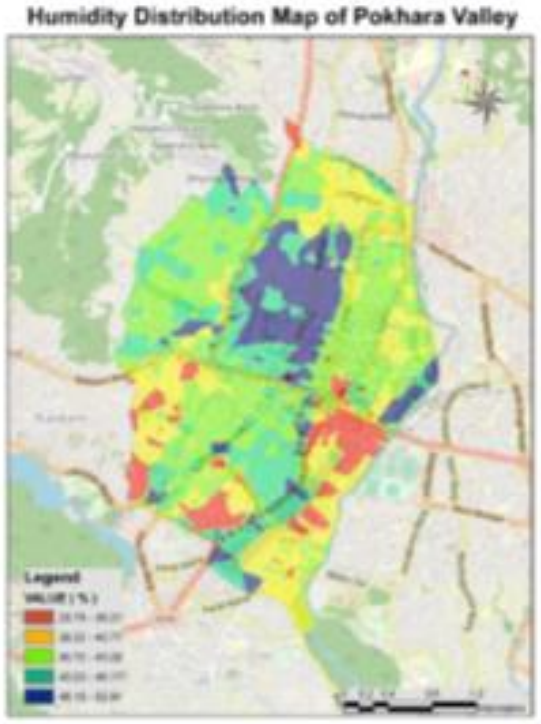
Lockdown Photo Sources: https://www.nepalitimes.com/here-now/nepals-smoky-mountains/?fbclid=IwAR31xbeCKSSj9_gN0AU7BKMquQAzTg0Z6J-LUTmtsZu9o7o9ozsddu8Z5Vo

Low-Cost GNSS Receiver Systems for Air Quality Monitoring (AQM)

Air Quality Data Analysis: PM2.5, NO2, Humidity etc.







Low-Cost GNSS Receiver Systems for Gateless Toll Gate (GTG)

Merits and Demerits of the Systems

Type	Sensor Type	On Board Device Unit (OBDU)	Gantry System	OBDU Implementation	System Impact on Traffic Congestion	MLFF Compatibility	Privacy Issues	Real-Time Monitoring	Real-Time Charging	Dynamic Pricing	Use on Any Road	Gantry Cost (IOM)	OBDU Cost
ANPR	Optical Camera	NA	Required to Setup Camera	NA	No	No	Limited to Gantry and Toll Roads connected to Gantry	No	No Post-paying	No Flat Tariff	May be	High	$0
DSRC	Short range radio signal at 5, 8 GHz	Yes	Required	Self-Implementation possible	May be	No	OBDU stores user ID and other info	Yes (at the gates)	Yes	No (Point-based charging rate)	No	Very High	< $100
RFID	Radio signal at 860 – 960MHz	RF Tag Passive Type	Required	Self Implementation	Yes	No	RF Tag stores user ID	Yes (at the gates)	Yes	No (Point-based charging rate)	No	Very High	< $10
GNSS	GNSS signals	GNSS receiver system	No	**Agent Implementation**	No	Yes	**Location surveillance of vehicle all the time**	**Yes**	Yes	Yes (Point, Distance or Congestion based)	Yes	No Gantry or Zero Cost	< $100

Low-Cost GNSS Receiver Systems for Gateless Toll Gate (GTG)

Why are GNSS based Toll Gates Necessary?

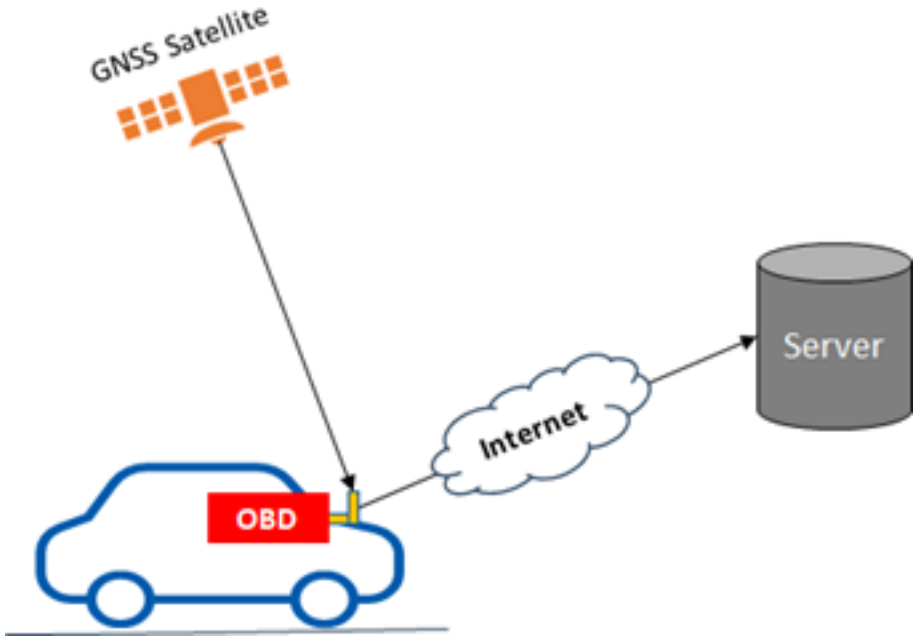
- No Physical Toll Gates
- Real-Time Traffic Congestion Management
- Dynamic Road Pricing
  - Distance, time, location,
  - Vehicle type, lane and occupancy
  - Traffic congestion condition
- Global Seamless Implementation
  - Cross-border operation
- Reward Road Users
  - Using alternate routes to avoid congested route

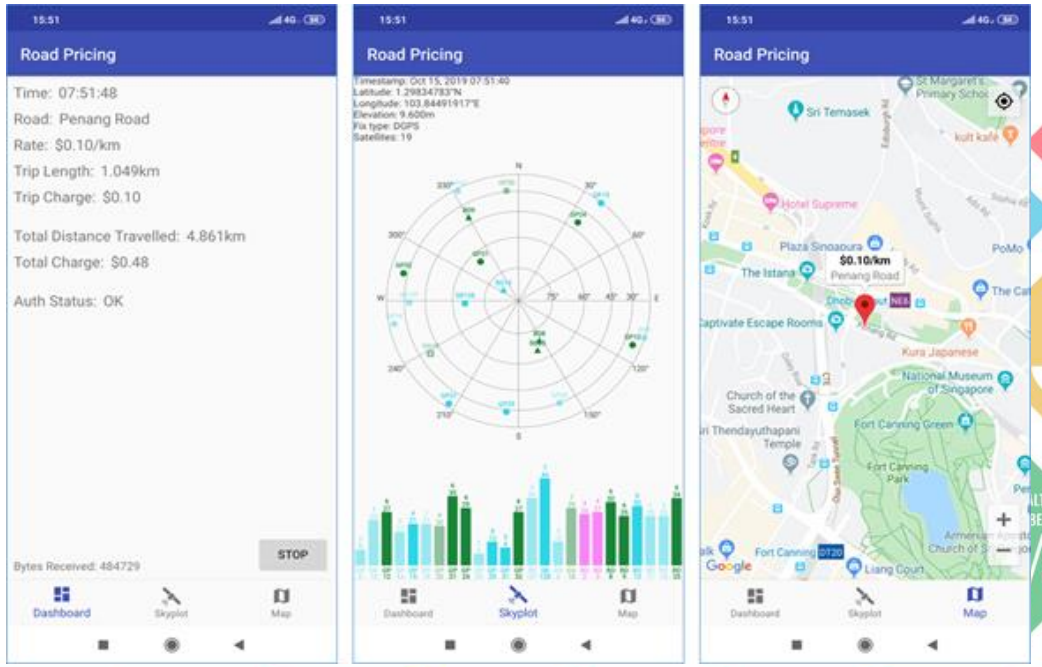
✓ Singapore: ERP to ERP 2.0
✓ ERP 2.0 is based on GNSS ➔ No Physical Gates

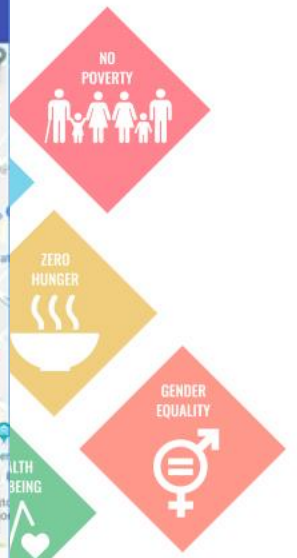
ERP: Electronic Road Pricing

Low-Cost GNSS Receiver Systems for Gateless Toll Gate (GTG) Prototype System Architecture and Test Data

A Gateless Toll Gate (GTG) can be implemented by using a GNSS-based Toll System







Summary

- We have developed low-cost GNSS receiver systems that can be used for Early Warning System, Dynamic Air Quality Monitoring, and Gateless Toll Gate.
  - These devices are available (free of cost) for joint research or pilot projects under the MTA (Material Transfer Agreement) contract.
- The system is also useful for many other applications such as high-accuracy surveying using RTK or MADOCA-PPP, GNSS signal authentication, and space weather parameter computations such as TEC (Total Electron Content).
- Some organizations and universities use these devices for research, pilot projects, and capacity development.
- We encourage conducting joint research or pilot projects using low-cost receiver systems.