GNSS Applications

Dinesh Manandhar

Center for Spatial Information Science

The University of Tokyo

Contact Information: dinesh@csis.u-tokyo.ac.jp

GNSS Applications - 1

- Surveying, Mapping and Geodesy
- Transportation
  - Car Navigation, ITS, ADAS, V2X
  - Road Pricing, Toll Collection
  - Congestion Management
  - Railway Network
  - Marine : AIS, VMS
  - Aviation : SBAS / GBAS
  - UAV / DRONE
- Vehicle Accidents / Emergency Services
  - eCall/ ERA-GLONASS / E-911
- Tax / Insurance
  - Tax based on location or distance traveled

ITS: Intelligent Transport System
ADAS: Advance Driving Assistance System
V2X: Vehicle to Anything
V2V: Vehicle to Vehicle
AIS: Auto Identification System
VMS: Vessel Monitoring System
GCP: Ground Control Point

GNSS Applications - 2

- Legal and Law Enforcement
  - Fishing Zone Management, Illegal Fishing Control
  - Crime Prevention
- Agriculture
  - Precise farming, Auto or Semi-Auto Driving of Tractors
  - Product Supply-Chain Management
- Location Based Applications
  - Services, Entertainment, Advertisement, Gaming, Marketing
- Warning during Disasters
  - EWS of QZSS and GALILEO
- Geo-Fencing / Geo-Securities
- Robotics
  - Navigation, Actions based on Location
- Scientific Applications
  - Space Weather : Scintillation, Radio Occultation, Plasma Bubble

EWS: Early Warning System

GNSS Applications - 3

- Telecommunication
  - Synchronize cell towers
    - microsecond order for CDMA
    - Few hundred nanoseconds for 5G
  - Network Time Protocol
    - millisecond order
- Power Grid
  - Phase Synchronization between grids is required for higher efficiency and avoid power failures
- Time Stamping of
  - Financial and Banking Transactions
  - Legal, Clerical, Shipping Documents
- Scientific Timing Applications
  - Time stamping of events
    - e. g. Global VLBI Observation, earthquake occurrences, arrival of neutrino in particle physics

Geo-Fencing
Geo-Security
Data Security

Anti-Spoofing
Signal Authentication
Position Authentication

Seamless Connectivity
Indoor / Outdoor
Communication
Timing

ITS, Auto-Driving or
Semi-Auto Driving,
ADAS, UAV, UMV,
DRONE

Mobility Data
Micro-Mobility
Big-Data
Supply-Chain Management

Everything on Internet
Remote Control
Remote Access
Time Synch.

Satellite-based Road Pricing (SRP)

Use GNSS for Road Pricing (ERP, ETC, Toll-Fee, MLFF etc.)

SRP For:

- *Gate-less Toll Charging*
- Dynamic Road Pricing (DRP)
- Traffic Congestion Monitoring and Reduction
- Parking Service and Management
- Emergency Route Planning
- Vehicle Monitoring for Safer and Secure Services
- MaaS (Mobility As A Service)
- Micro-Mobility Services and Management
- Driver's Behavior Monitoring
- Traffic Data Analysis

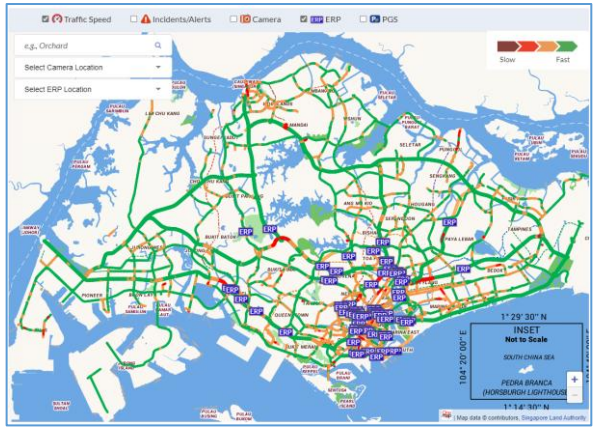
Key Features of SRP:

- High-Accuracy Position Data
  - *Lane-level positioning capabilities*
- *Point-based or Distance-based Charging*
- *Rewarding the Driver for Driving during Off-Peak Hours*
- *Secured and Certified Position Data*
  - Using signal authentication and Position certification system to protect from spoofing, data tampering
- Proprietary AI based Technology
  - Prediction of traffic congestion in advance for better route management
- Cross-border Implementation System
  - The same system can work seamlessly regardless of national boundary
- Easy and Simple implementation in vehicles

Singapore: Electronic Road Pricing (ERP) System

Singapore Case

- Singapore has already dedicated
  - 12% land for roads and 14% land for housing
- 45% households own a car
- Traffic Congestion Control is necessary for smooth traffic
  - Use ERP to charge the road users on some of the road sections.
  - ERP encourages the drivers to consider alternative routes
  - It also encourages to use public transports
- Singapore was the first country in the world to manage road congestion by implementing an Electronic Road Pricing system (ERP).
  - ERP has since been used as a reference by other cities like London.
- ERP-2.0 is now being developed based on
  - Global Navigation Satellite System (GNSS) Technology

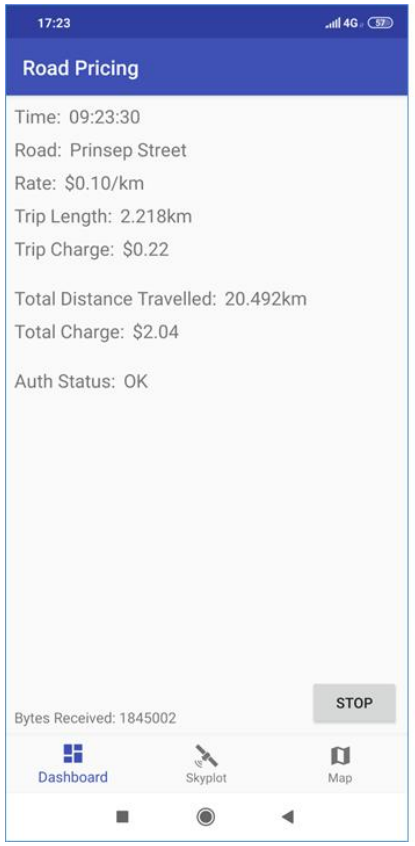


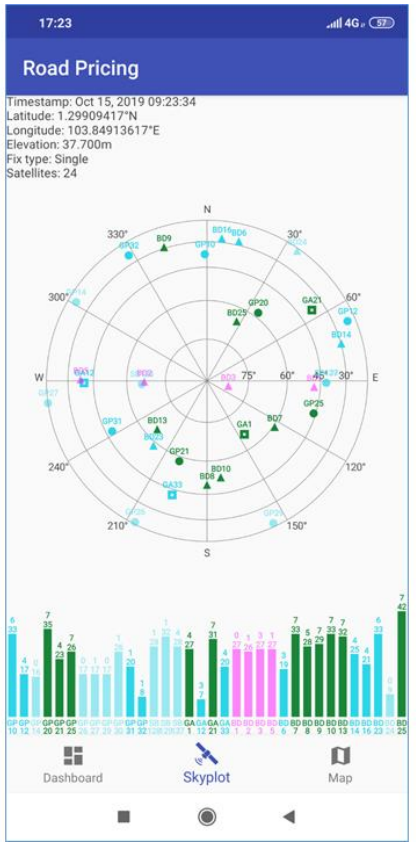
Space is limited to built new ERP gates

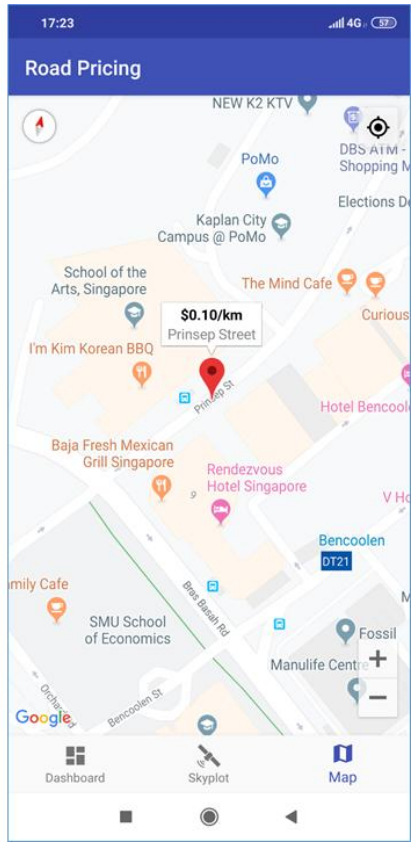
Car Ownership (CoE) costs S$100K – 150K (by auction only), Valid for 10 Years

ERP to DRP (Dynamic Road Pricing)

Toll Charging, Traffic Congestion Management, Traffic Monitoring







Indonesia to use gateless multi-lane toll system from next year Nationwide implementation in 2023

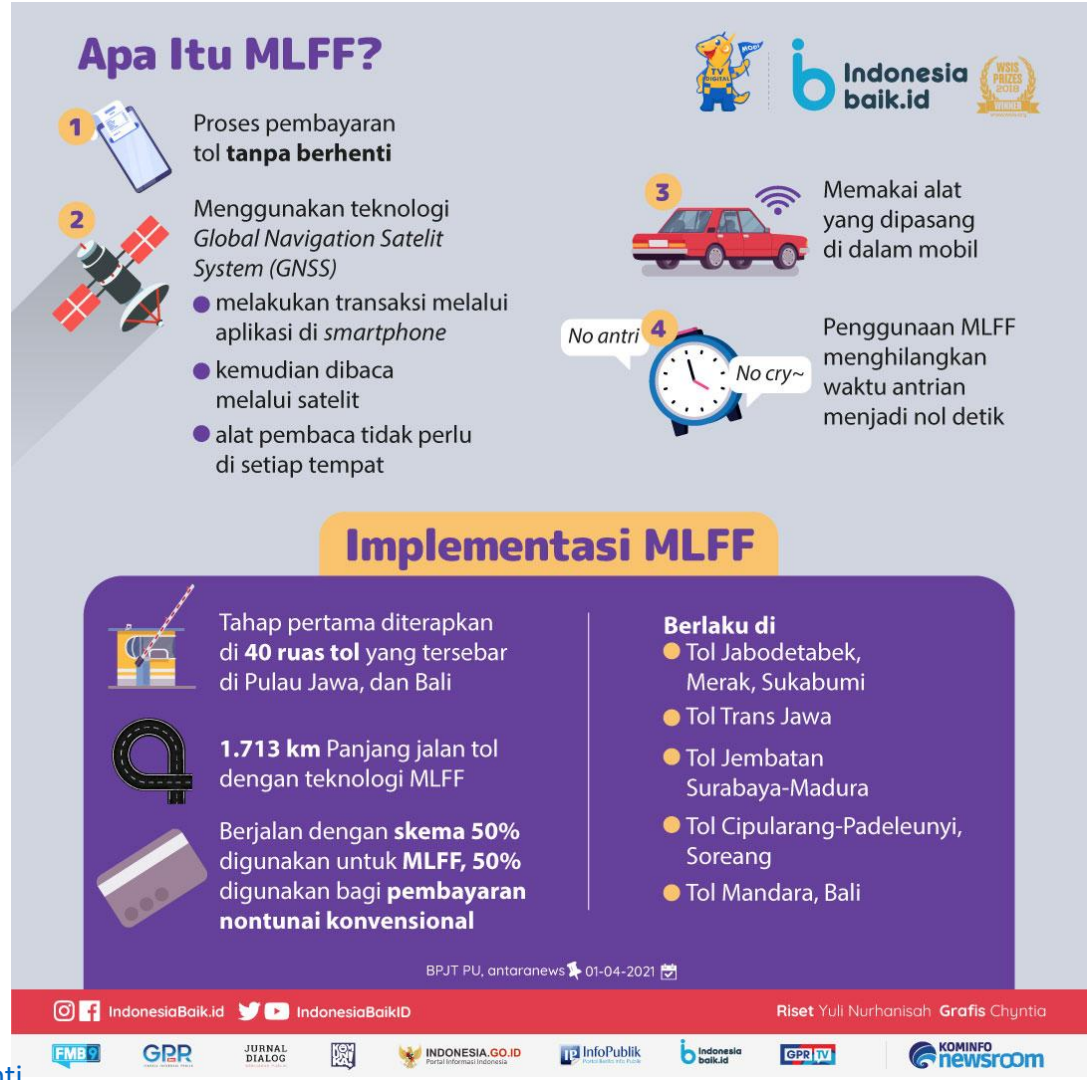
- Indonesia will be implementing its gateless highway toll collection system by next year, beginning in Jawa and Bali, according to Indonesian news site ***Detik***. Following its implementation in the two locations, the system has been planned for nationwide rollout in 2023, according to the news site.

- The uninterrupted-flow toll gantries use what is known as a mutli-lane free flow (MLFF) system, which is one of the methods aimed at at reducing traffic congestion. The system for Indonesia is provided by Hungarian company Roatex through local Indonesian firm PT Roatex Indonesia Toll System.

- There will no longer be physical gates or barriers, so it can be said that from the users' perspective, these will be replaced with virtual gates, said chief business development officer at PT Roatex Indonesia Toll System, Emil Iskandar.

Source: https://paultan.org/2021/08/16/indonesia-to-use-gateless-multi-lane-toll-system-from-next-year-nationwide-implementation-in-2023-report/

MLFF (Multi Lane Free Flow)



Source: https://indonesiabaik.id/infografis/mengenal-mlff-bayar-tol-tanpa-harus-berhenti

MLFF (Multi Lane Free Flow)

What Is MLFF?

Multi Lane Free Flow (MLFF), which is a toll payment process without stopping, it means that toll road users do not have to pick their vehicles at toll gates. The technology applied to MLFF is the Global Navigation Satellite System (GNSS), which is a system that allows transactions through applications on smartphones and read via satellites.

This technology makes readers unnecessary in every place because they use satellites, in contrast to radio frequency identification or RFID. GNSS wears tools installed in the car. When the vehicle is at the toll road substation, it will be read through the system on the satellite.

MLFF Implementation Plan

By using **Global Navigation Satellite System (GNSS) technology**, for the implementation of the first phase, MLFF technology will be applied to 40 toll roads in Indonesia spread across Java, and Bali in 2022. The investment value of the MLFF project is IDR 4.4 trillion, with PT RITS's concession period being 9 years from the date of commercial operation.

The use of electronic money has reduced the transaction time to 4 seconds compared to 10 seconds of manual transactions. So, the use of MLFF certainly has enormous benefits because it can reduce the queue time to zero seconds.

The implementation will run with a scheme of about 50% of the total substations at toll gates will be used for MLFF, while 50% will be used for users who make conventional cashless payments. Let's support this sophisticated contactless payment technology or known as MLFF so that it will soon run in Indonesia.

Source: https://indonesiabaik.id/infografis/mengenal-mlff-bayar-tol-tanpa-harus-berhenti

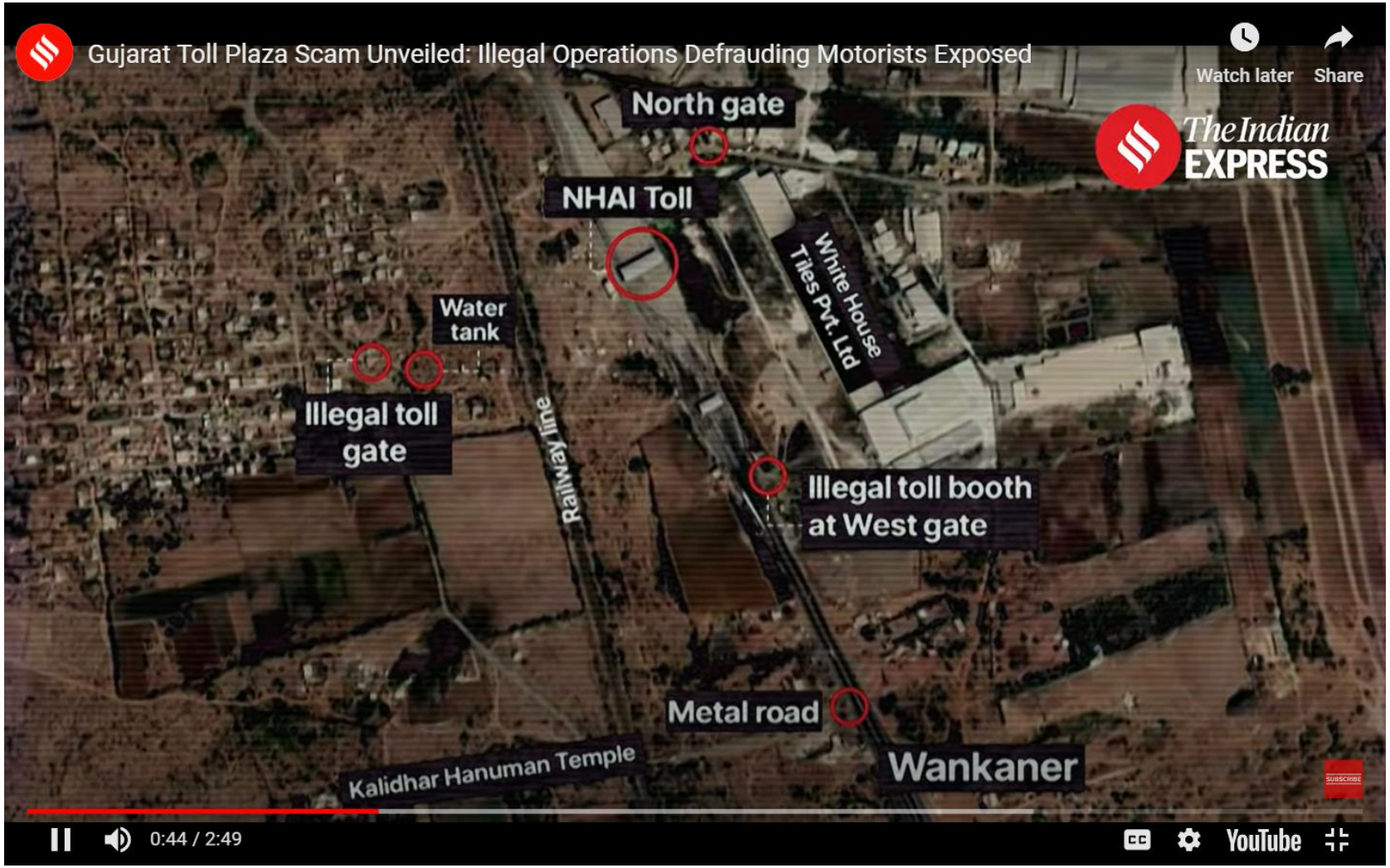
Toll System in India

FASTAG TO GNSS ETC SYSTEM TRANSITION – Road Infrastructure & MLFF

- **Technology Integration:** Integrating GNSS with existing tolling infrastructure, including both hardware and software.
- **Infrastructure Upgrade:** Upgrading or replacing existing toll plazas and related infrastructure to support GNSS technology. Also an opportunity to upgrade FASTag readers/ANPR cameras.
- **Phased Transition:** Managing the transition period where both traditional tolling (FASTag) and GNSS tolling coexist.
- **Communication Networks:** Enhance communication networks to ensure reliable data transmission between vehicles, satellites, and tolling servers.
- **Public Awareness and Acceptance:** Educating the public and ensuring acceptance of the new tolling method by dedicating Lane.

4

Toll Plaza Scams



https://indianexpress.com/article/explained/gnss-new-satellite-based-highway-toll-collection-9562340/

India: Government notifies satellite-based toll collection for highways

Revenue from National Highways:
INR: 180 billion in 2015-16
INR: 480 billion in 2022-23
INR: 1.3 trillion by 2030 @ Average Annual Growth of 15%

Source: https://www.livemint.com/industry/infrastructure/tolls-on-indian-roads-will-take-a-greater-toll-11705898232007.html

https://www.livemint.com/news/india/fastag-satellite-based-toll-collection-gnss-technology-obu-vehicles-national-highway-ihmcl-gps-navigation-11725980862906.html

Published: 10 Sep 2024, 09:59 PM IST

GNSS based Fishery Management

- IUU (Illegal, Unreported and Undocumented) Fishing Control and Management
  - Protect marine ecology and biodiversity
  - Protect the livelihood of fishermen
  - Promote marine agriculture
  - Uplift life standard of people in the fishing sector
- Supply-Chain Control and Management
  - Let the end-customers know the sources of the marine products
  - Provides better price value
  - Branding of products
  - Controls Illegal products

May 2018

Presenting how GPS can help fishermen

About 50 local fishermen attended the program

May 2018

Queensland (Australia) Monitoring Fishing Boats

Queensland to introduce mandatory GPS trackers for commercial fishermen to track sustainable catch
https://www.youtube.com/watch?v=2qWTAZ8hmOY&t=77s

4 Vessel Tracking Obligations

4.1 Vessel tracking requirements for all commercial fishing boats

Unless otherwise specified under this policy or the *Vessel Tracking Guidelines*, all commercial fishing boats (including primary and tender boats fishing under Commercial Fishing Boat Licences, Commercial Harvest Fishing Licences and Charter Fishing Licences) are required to have a vessel tracking unit installed and operational while undertaking commercial and non-commercial activities.

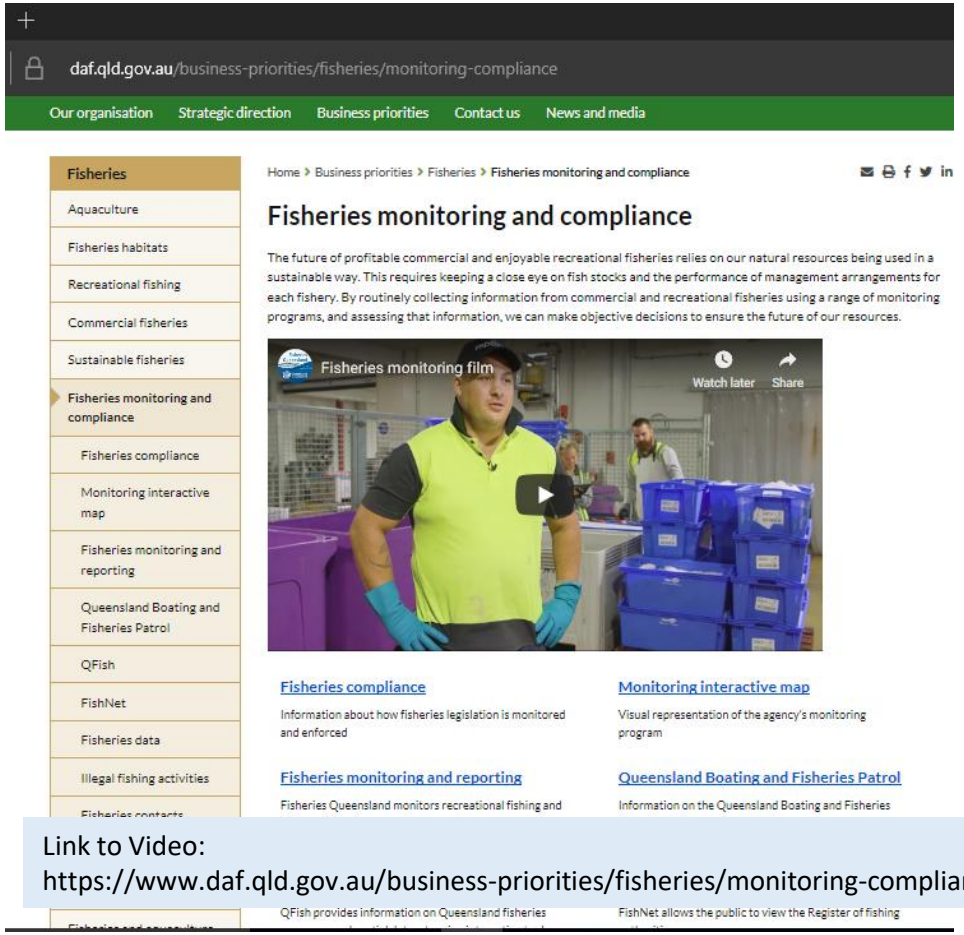
This obligation will commence from 1 January 2019 for all crab, net and line boats, and from 1 January 2020 for all other commercial fishing boats.

The vessel tracking unit must be an approved unit and installed and maintained in accordance with the Fisheries Queensland's *Vessel Tracking Installation and Maintenance Standards*.

Penalties apply for using a commercial fishing boat without an approved and operational vessel tracking unit.

Queensland Government

https://www.abc.net.au/news/rural/2017-10-20/queensland-introduce-mandatory-gps-trackers-commercial-fishing/9066936

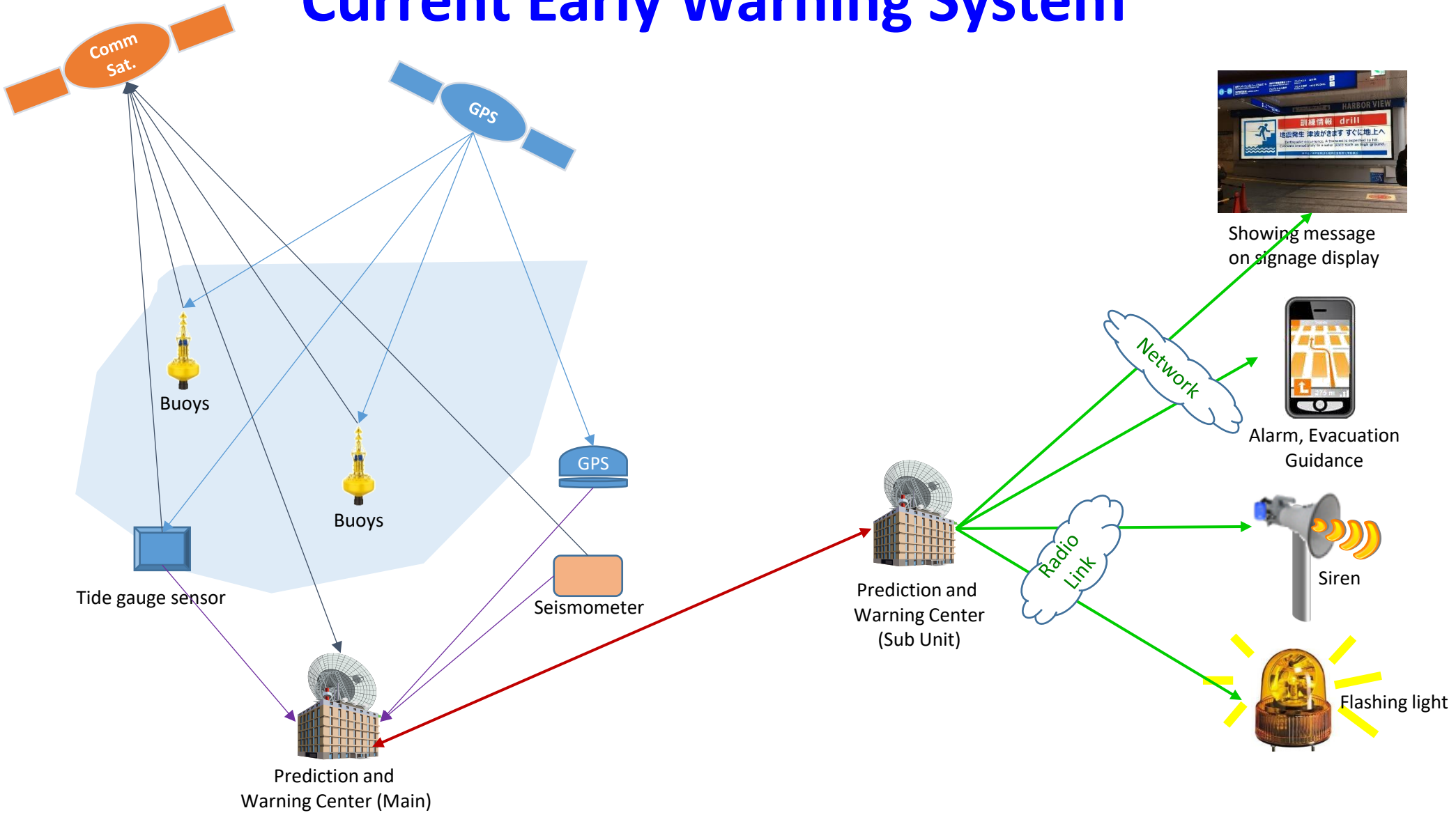


Link to Video:
https://www.daf.qld.gov.au/business-priorities/fisheries/monitoring-compliance

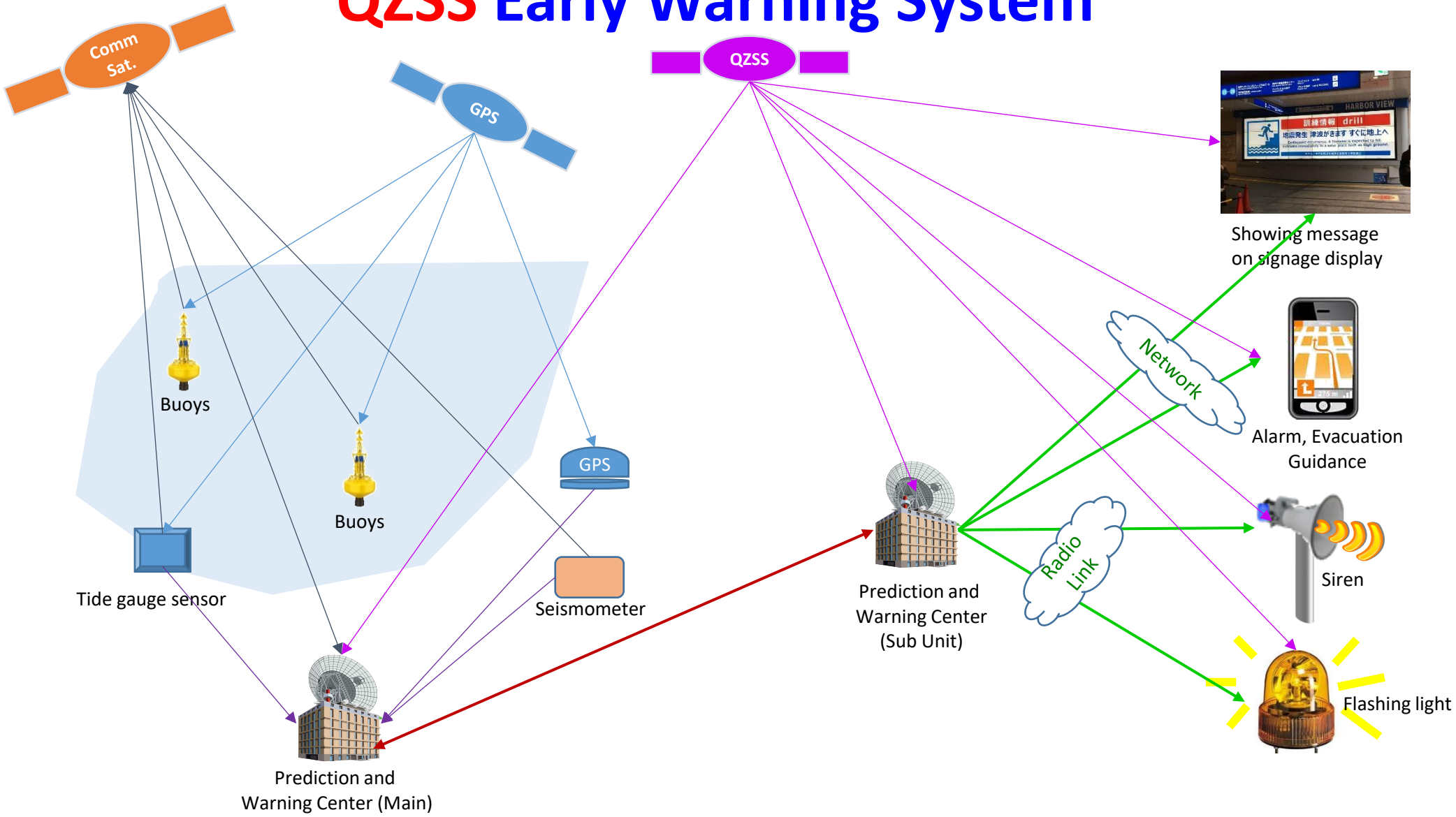
Early Warning System (EWS)

- Difficulty in reaching the people at risk or reaching to the "the Last Mile"
  - How to send alerts to people in the risk zones?
- Shutdown of power and communication systems due to Earthquake, Tsunami etc.
  - Alerts can't be sent effectively
    - Mobile phones, SMS, Internet, and Social Media may not work
  - Even if a mobile phone is working, due to bandwidth congestion, communications may not be established on time
    - Delayed arrival of alert message

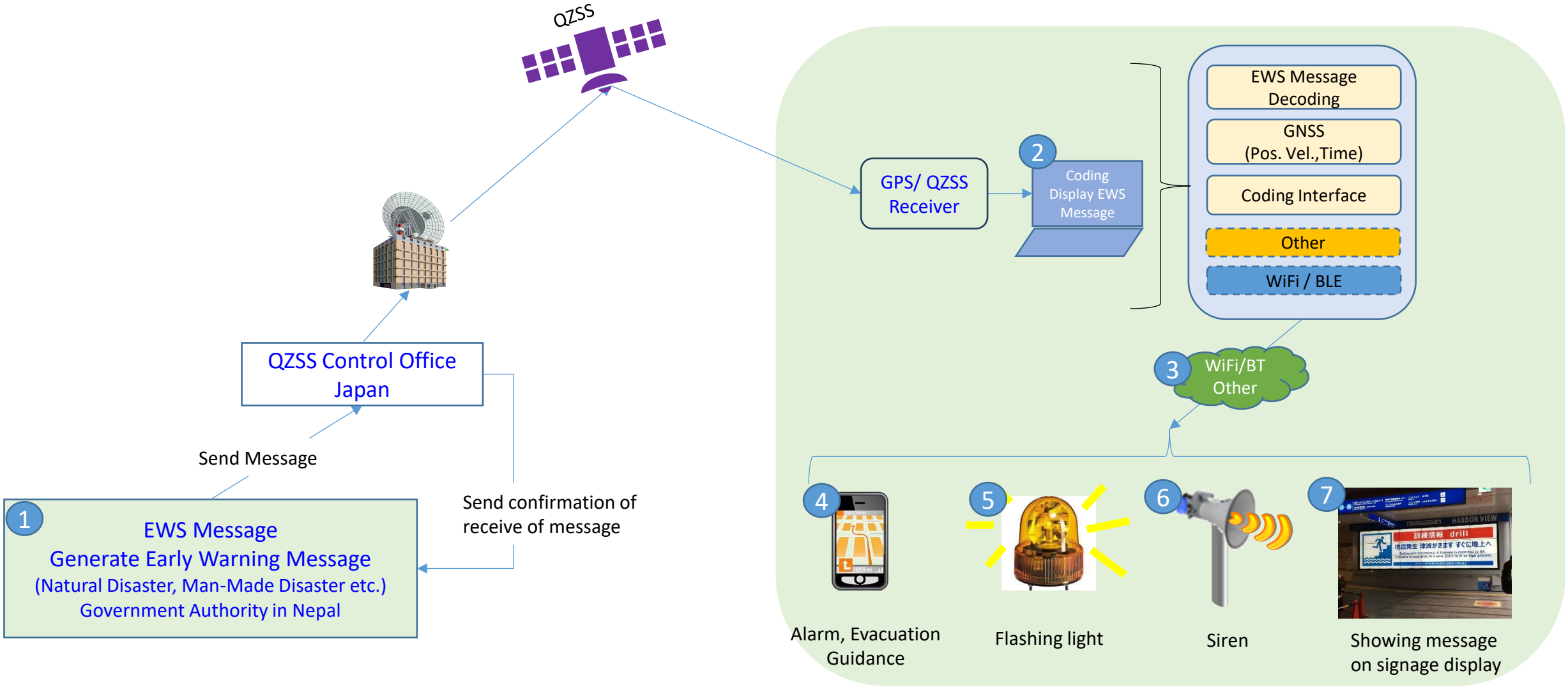
Current Early Warning System



QZSS Early Warning System



QZSS EWSS Demo: System Architecture



City Environment Monitoring

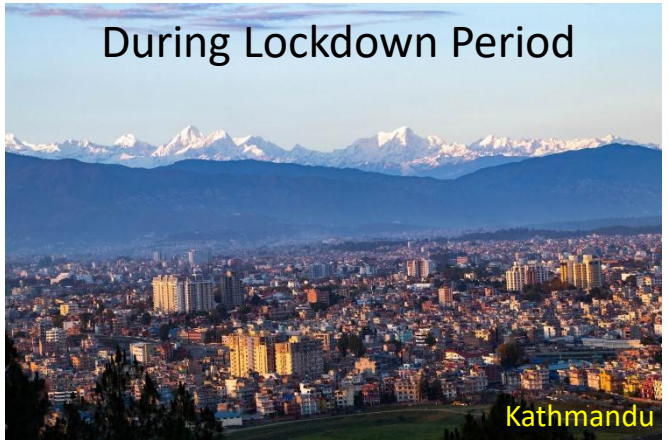


Photo Sources: https://www.nepalitimes.com/here-now/nepals-smoky-mountains/?fbclid=IwAR31xbeCKSSj9_gN0AU7BKMquQAzTg0Z6J-LUTmtsZu9o7o9ozsddu8Z5Vo

- Monitor City Air Quality
- Dynamic and Real-Time
- Use Low-Cost Sensor Systems
- Implement the Sensor in Public Buses

Prototype System