"Prevention of 4 Disasters and Their Single Recovery Networks based on Internet-of-Things with Airborne Capability (PATRIOT-41R-Net)"

[Year 2 of 2 Years; on the process of extension to March 2022]

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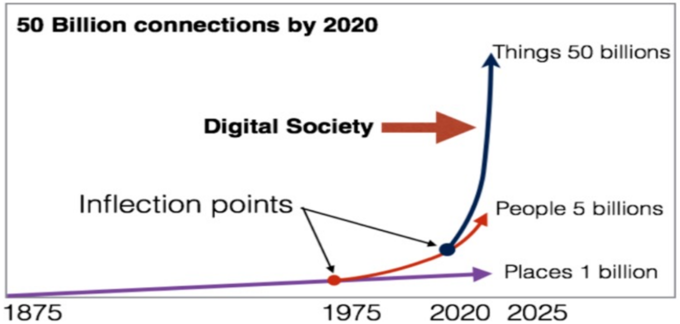
Project Review
March 31, 2022

Prevention of 4 Disasters and Their Single Recovery Networks based on Internet-of-Things with Airborne Capability (PATRIOT-41R-Net)

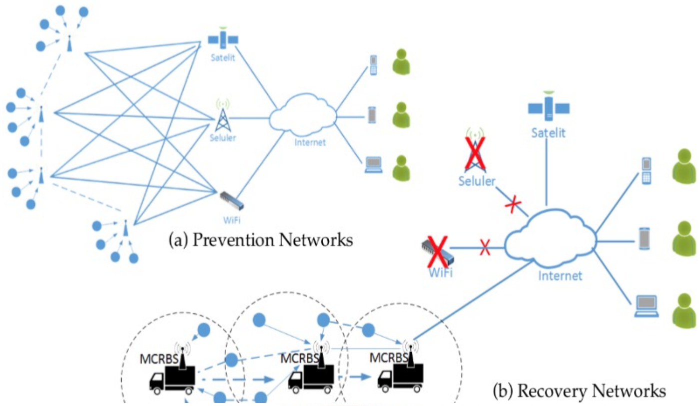
Background :

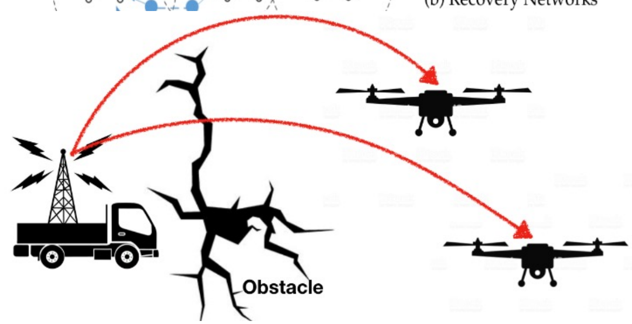
- After the disaster, telecommunication networks cannot be be recovered soon and are suffering from difficulties of covering large areas.
- The rescue team and mobile base station are suffering from difficulties in finding the victims although the victim's mobile phones are active but is out-of-network range.



Targets:

- This PATRIOT-41R-Net project makes an experiment, especially on drone and/or HAPS, at Padang City, Sumatera, Indonesia.
- APPS for smartphone and SMS services.
- Patent and publications for real-field experiment and real-field parameters in high reputed IEEE magazines or similar.





Speaker:

Assoc. Prof. Dr. Eng. Khoirul Anwar (Telkom University, Indonesia)

Prevention of 4 Disasters and Their Single Recovery Networks based on Internet-of-Things with Airborne Capability (PATRIOT-41R-Net)

Project Members :

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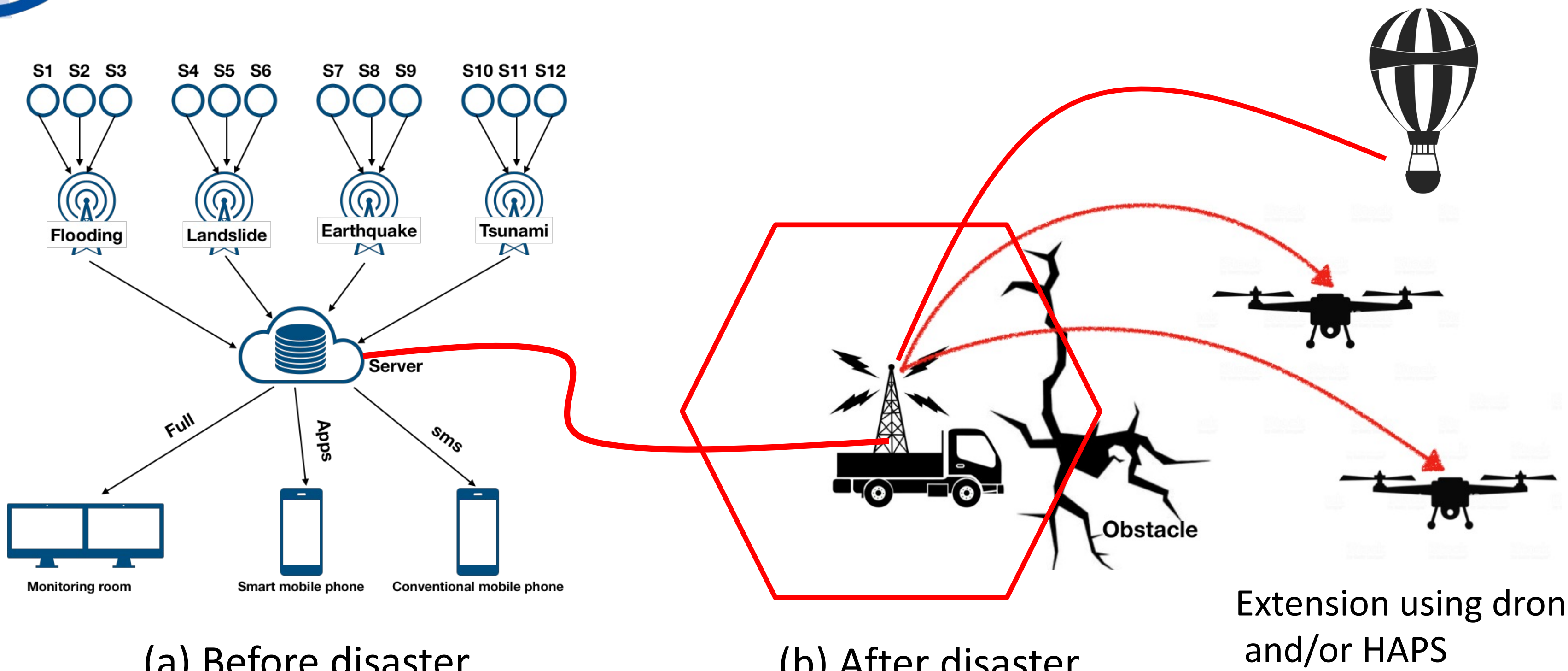
7. **Citra Dewi Anggraeni** (Telkom University, Indonesia)
8. **Oktaza Recy** (Telkom University, Indonesia)
9. **Dr. Hazilah Mad Kaidi** (UTM, Malaysia)
10. **Assoc. Prof. Dr. Liza Abdul Latiff** (UTM, Malaysia)
11. **Dr. Rudzidatul Akmam Dziyauddin** (UTM, Malaysia)
12. **Syed Aamer Hussain** (UTM, Malaysia)
13. **Joyeeta Rani Barai** (AIT, Thailand)
14. **Dyan Ahadiansyah** (Telkom University, Indonesia)
15. **M. Bagir Qauman** (Telkom University, Indonesia)
16. **M. Daffa Abdillah** (Telkom University, Indonesia)

Project Duration : **24 Months (July 2019 – June 2021, Extended to March 2022)**

Project Budget:

Budget Allocation	: USD 40,000
Used	: USD 23,660
Remaining:	: USD 16,340

Technology and Work Package (WP) Structure

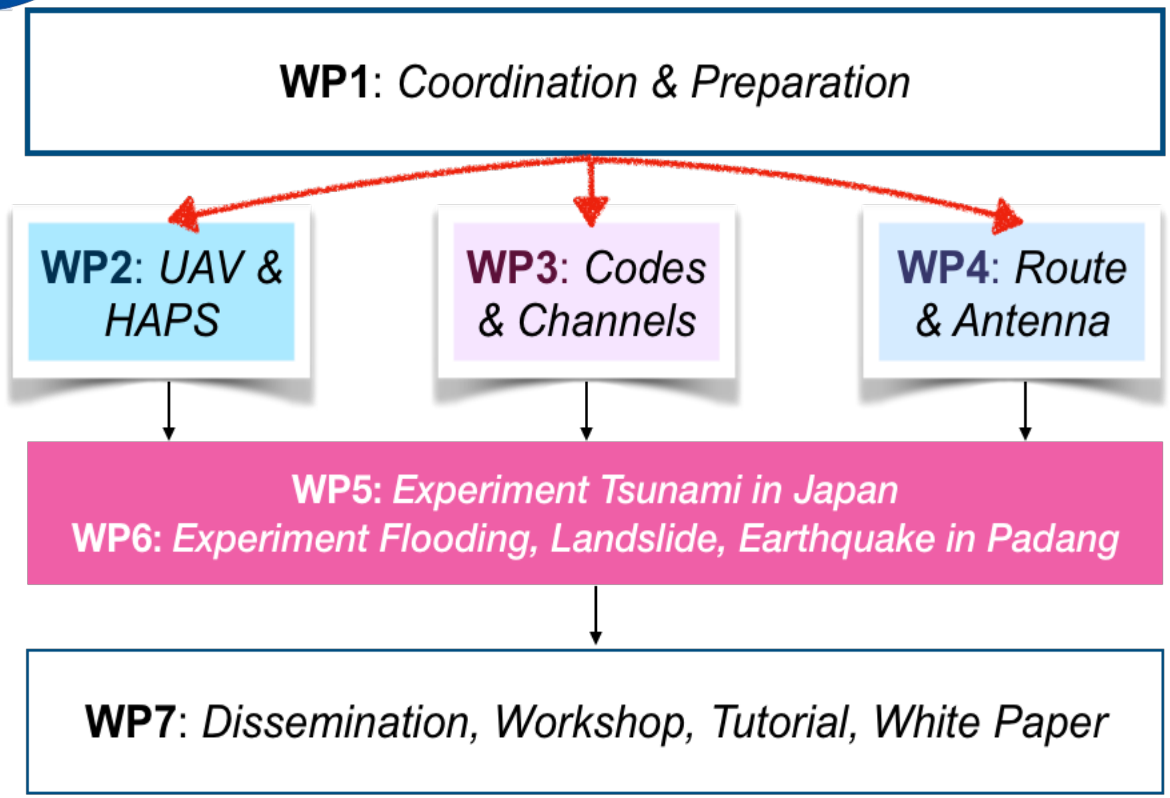


(a) Before disaster

(b) After disaster

- Network (a) monitors for damage prevention considering 4 disaster coditions: flooding, landslide, earthquake, tsunami.
- The rescue team and mobile base station use airborne capability provided by:
  - (i) Drone
  - (ii) High altitude platform system (HAPS)
  - To extend (1) network coverage and (2) find the victims having mobile devices emitting signals.

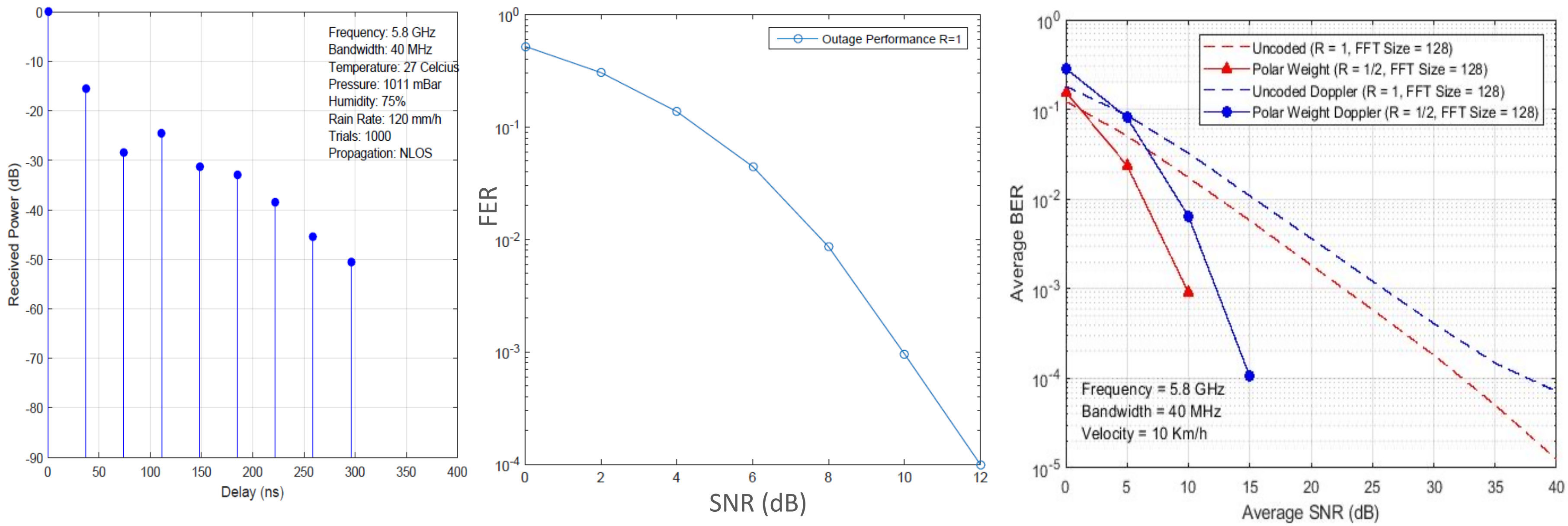
Work Packages (WP) Allocations *)



- WP1: Coordination and Preparation **(TelU, July 2019 – Jun 2021)**
- WP2: Experiment MCRBS, UAV Channels and HAPS **(TelU, AIT, Jul – Oct 2019)**
- WP3: Experiment Rateless Coding for UAV Channels **(JAIST, TelU Jul – Dec 2019)**
- WP4: Experiment for Routing and Antenna Dev. **(UTM, TelU, July – Dec 2019)**
- WP5: Experiment for Tsunami in Japan **(Tel-U, JAIST, HUST, Jan – Jun 2020)**
- WP6: Experiment for Flooding, Landslide, Earthquake in Indonesia **(TelU, AIT, July – Dec. 2020)**
- WP7: Dissemination, Workshop, Tutorial, Whitepaper **(ALL, Mar-Jun 2021)**

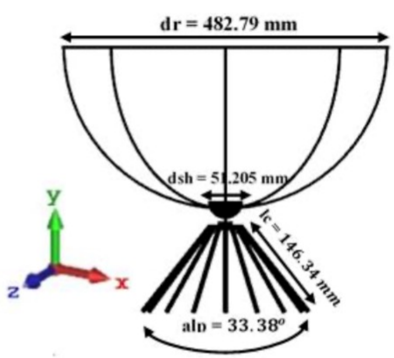
**) Agreed in Kick-Off Meeting 2019, Bandung, July 23, 2019.*

Current Progress 1: MCRBS

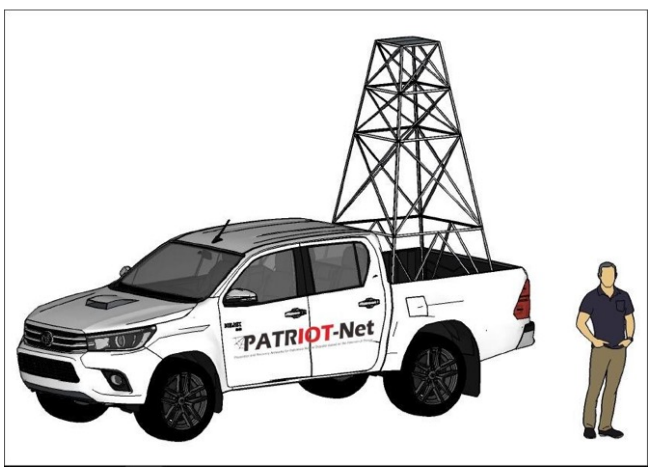


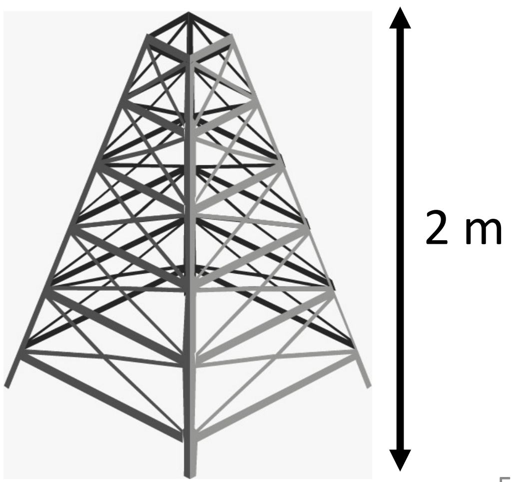
(a) (b) (c)

a. Power Delay Profile (PDP) for height of 0-10 m, b. Outage performance, (c) BER with Doppler



The type of outward curved asymmetric biconical (OCAB) antenna.





Current Progress 2: UAV Channel Model

Indonesia Unmanned Aerial Vehicle Channel Model

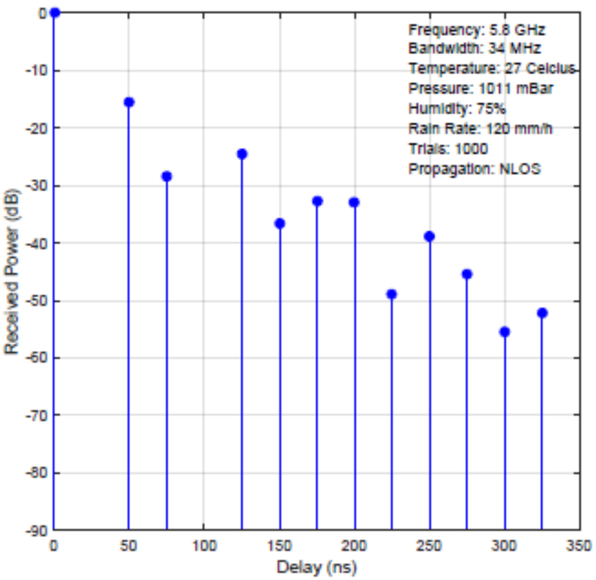


Figure: Power Delay Profile (PDP)

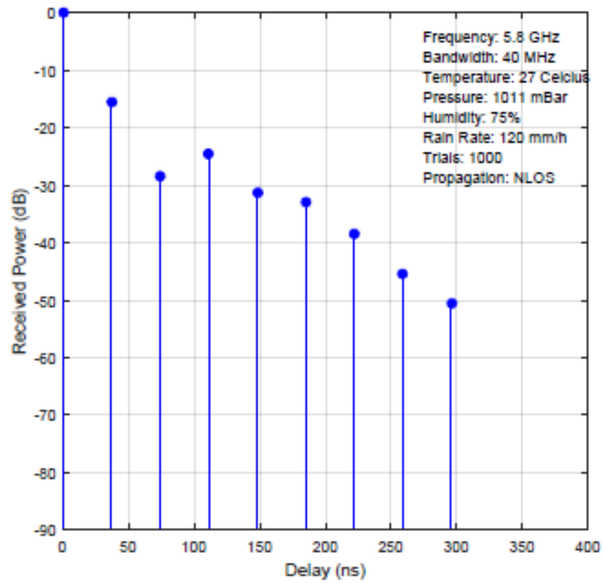


Figure: PDP mapped.

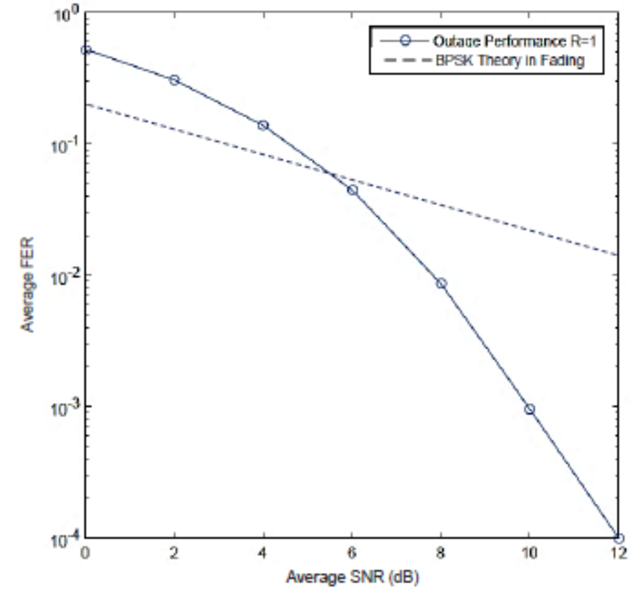


Figure: Outage Performance.

- The Indonesia UAV channel model is a representative PDP generated by NYUSIM using real-field parameters, such as average humidity of 70%, average temperature of 27°C, barometric pressure of 1011 mbar at average Altitude h=0-200 meters above sea level, and rain-rate *Q*=120 mm/hour with frequency F=5.8 GHz and bandwidth of 40 MHz.
- The proposed representative PDP of Indonesia UAV channel model has 9 paths. The proposed codes should be used to validate the outage performances.

Current Progress 3: Channel Coding for UAV (1/2)

In this project, we develop three kinds of channel coding:

1. Accumulate Raptor-like codes

- To extend the UAV communications, Semi-Rateless Accumulate Tornado Codes based on SR-QC-LDPC and Accumulator Codes are designed with adaptive capability to the channel.

2. Rateless Accumulate Tornado Codes

- In order to enhance the performance of UAV communications, Rateless Accumulate Tornado Codes based on Polar-LT-Accumulator Codes are designed.

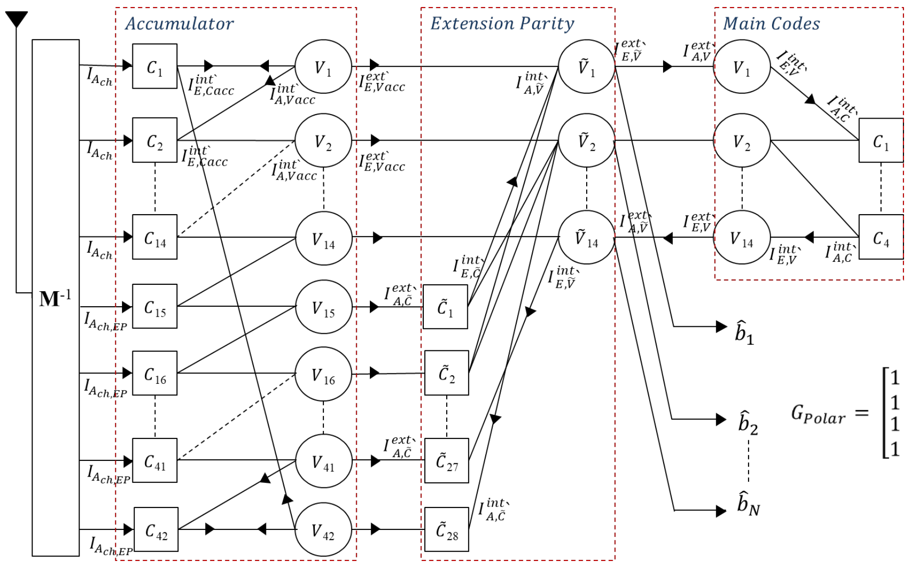


Figure 1. Construction of Accumulate Raptor-like codes.

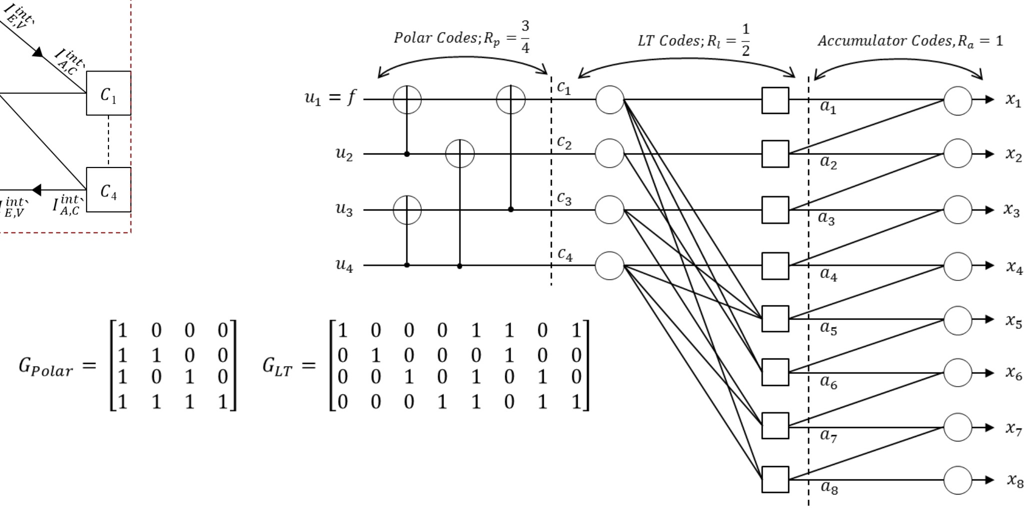


Figure 2. Construction of Rateless Accumulate Tornado Codes.

Current Progress 3: Channel Coding for UAV (2/2)

3. Rateless Polar-LT Codes

- Rateless Polar-LT codes have been designed for UAV and HAPS communications.
- Initial results confirmed that the proposed codes work well in minus SNR.
- Improvement is needed as well as the implementation to USRP and flying them to HAPS or drone.

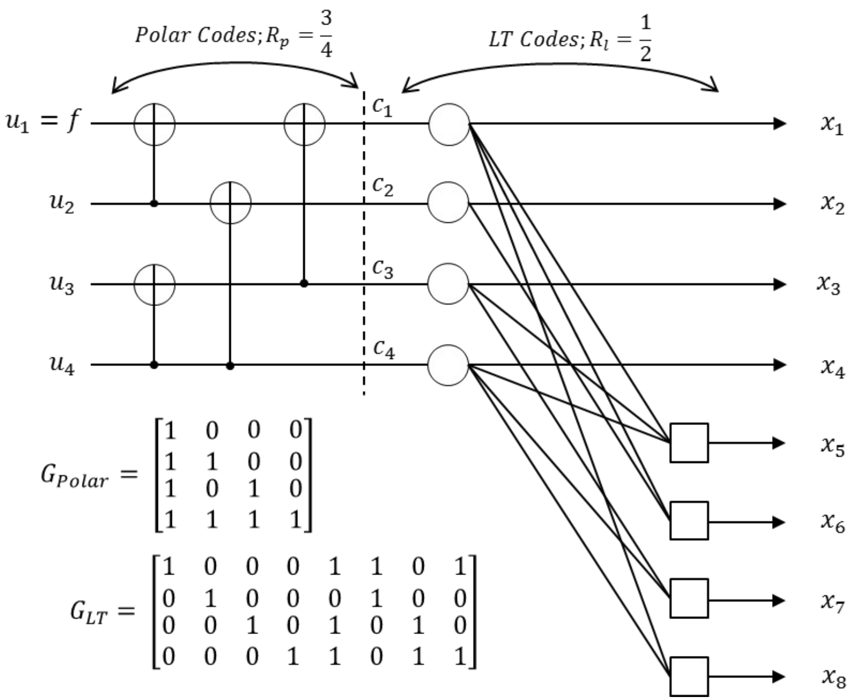
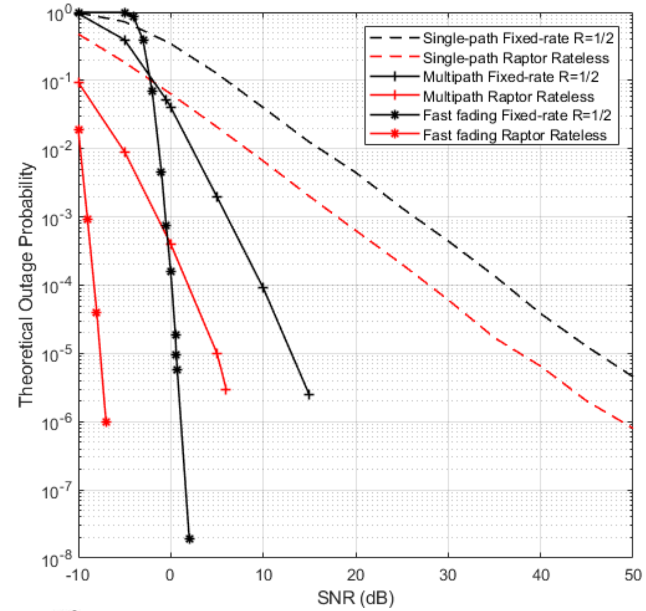
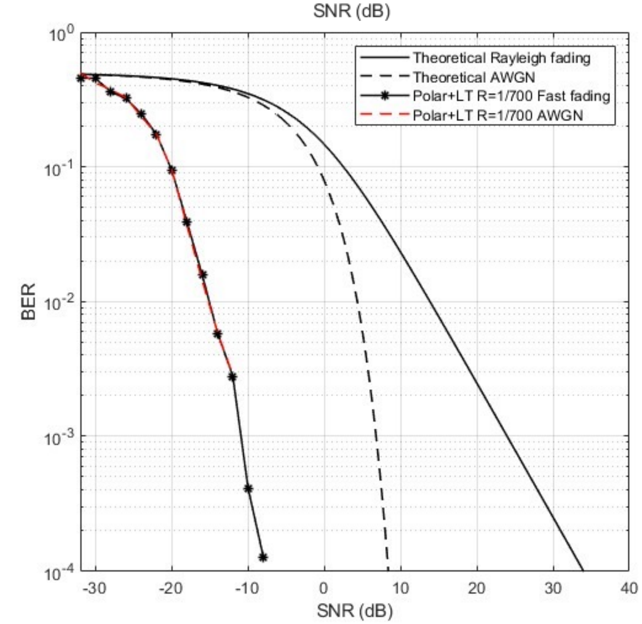


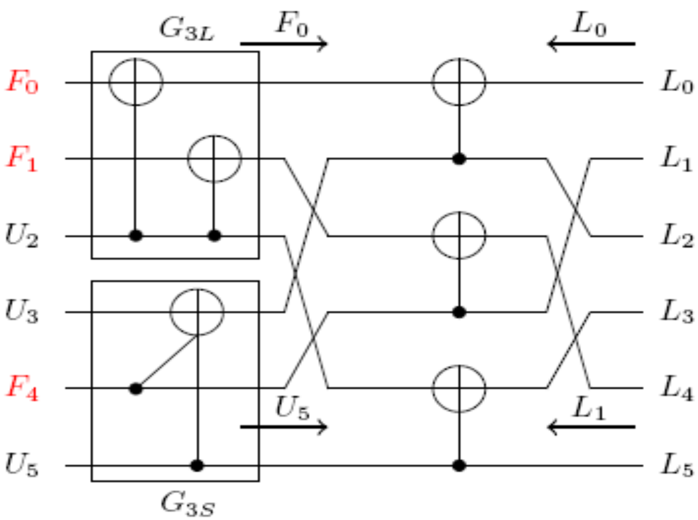
Figure 1. Construction of Rateless Polar-LT Codes.





Current Progress 4: Channel Coding for HAPS

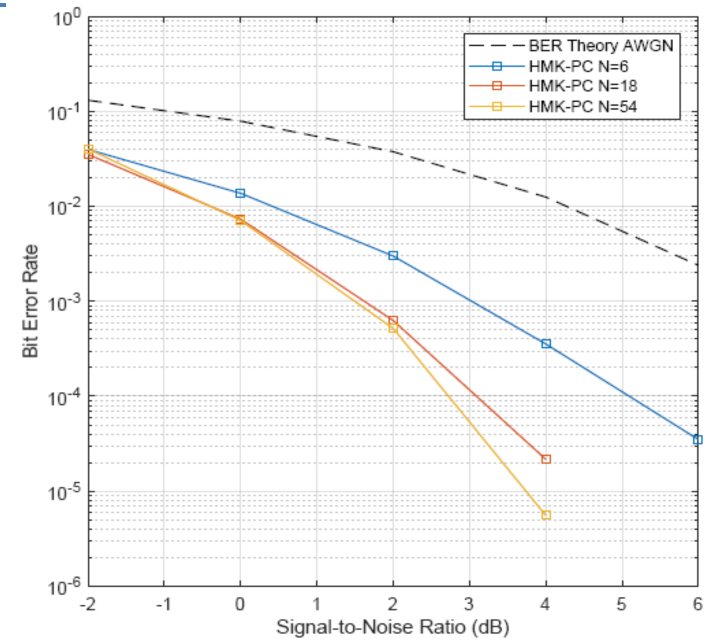
Hybrid Multi-Kernel Constucted Polar Codes.

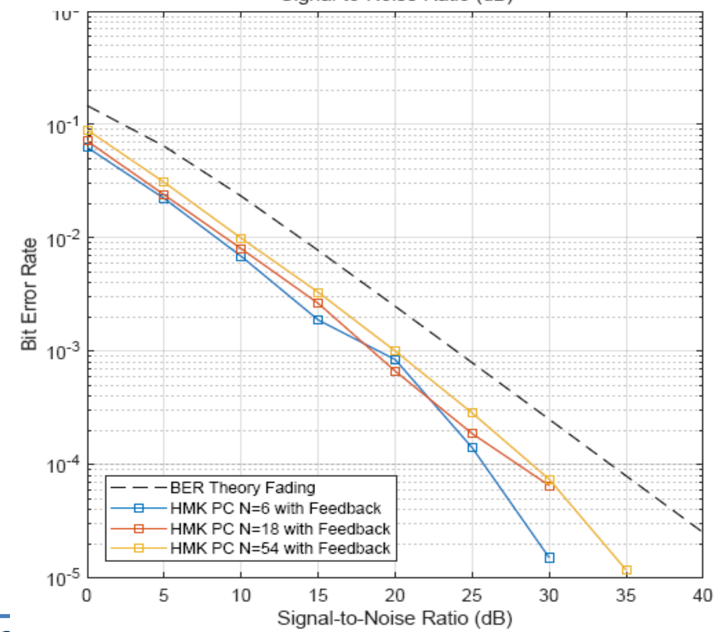


$$G_{6H} = T_2 \otimes T_{3H}$$

$$G_{6H} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 1 & 0 \\ 1 & 0 & 1 & 1 & 0 & 1 \end{bmatrix}$$

Figure 1. The Proposed Codes Constuctions: Hybrid Multi-Kernel Constucted Polar Codes.





- The proposed codes are designed a Hybrid Multi-Kernel Polar codes with different matrix for UAV communications,
- The initial results confrimed that the proposed codes are work well under BER Theory of AWGN and Fading channels,
- The proposed codes is going to be explore with List decoding algorithm.

Current Progress 5: Security with Polar Codes

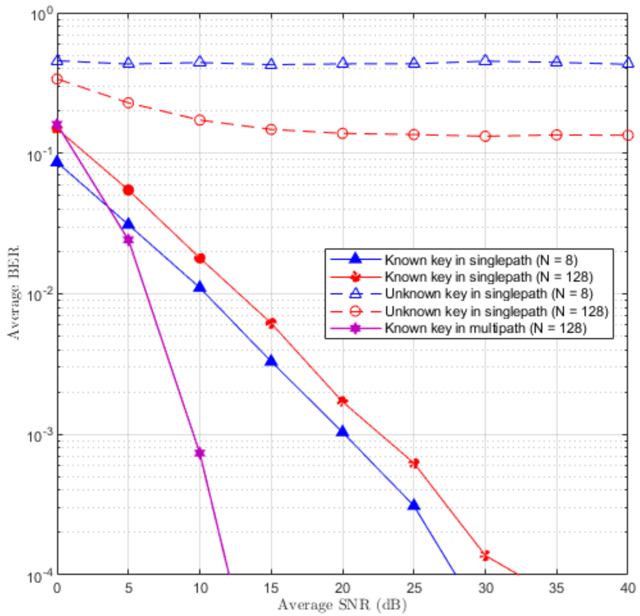


Figure 1. Security Polar in singlepath and multipath fading

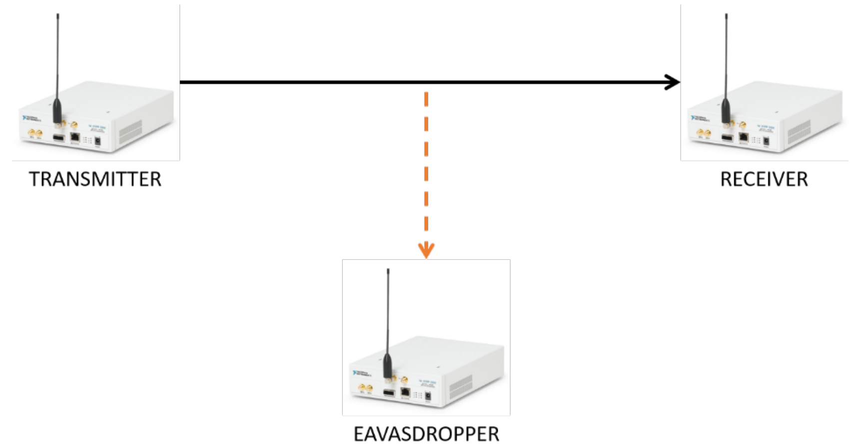


Figure 2. Polar security scenario with USRP

- We have obtained the simulation performance about the security of Polar codes in singlepath and multipath fading.
- We consider to use HAPS Channel model and OFDM to obtain the good performance of security Polar codes in fading.
- We obtained security of Polar codes in multipath have a better performance than singlepath fading in blocklength 128 by improvement of 13 dB at average BER of 10-3.
- We will evaluate the real-field performance of the propose Polar code-based physical layer security with USRP as illustrated in Fig. 2.

Current Progress 6: Security with Polar Codes

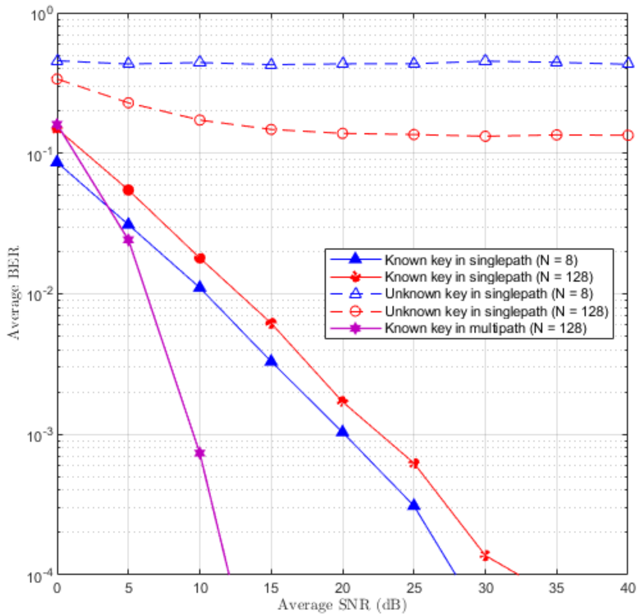
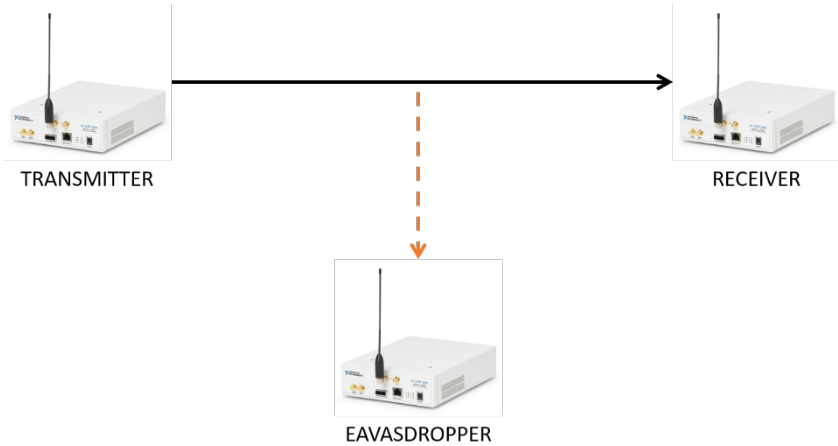


Figure 1. Security Polar in singlepath and multipath fading



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Current Progress 7: Paper SOFTT Citra

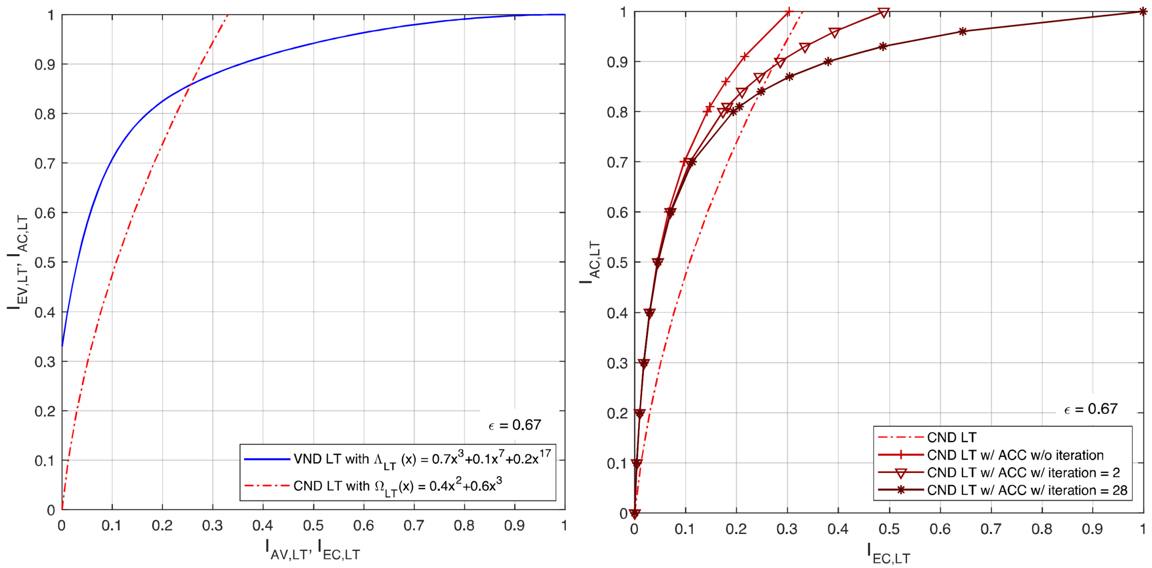
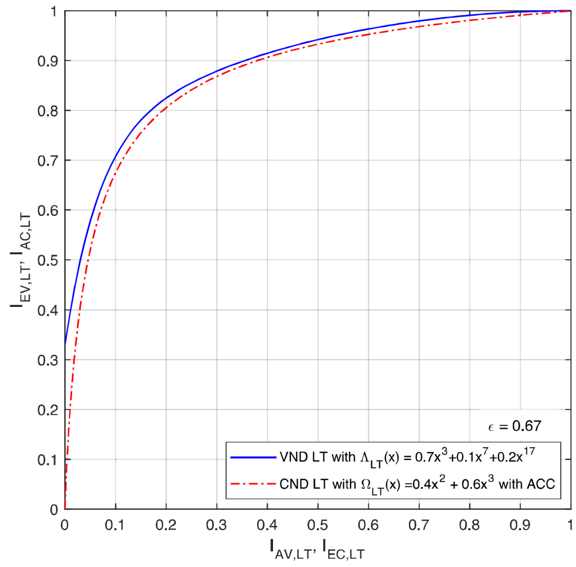
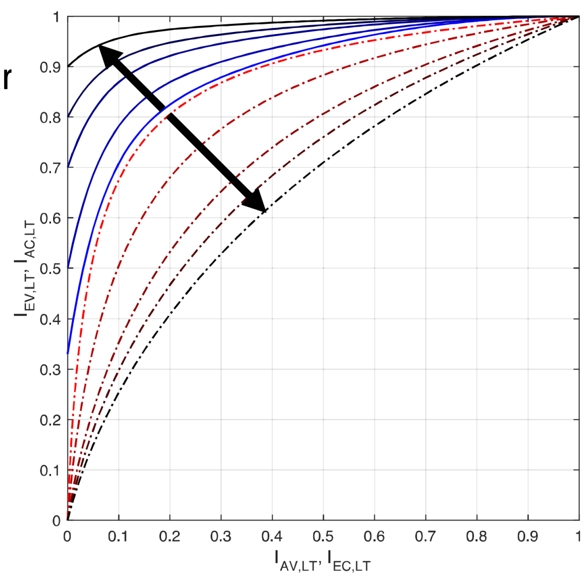


Figure 1. Security Polar in singlepath and multipath fading

Figure 2. Polar





- We have proposed ss

Current Progress 8: Simple Virtual Turbo Codes

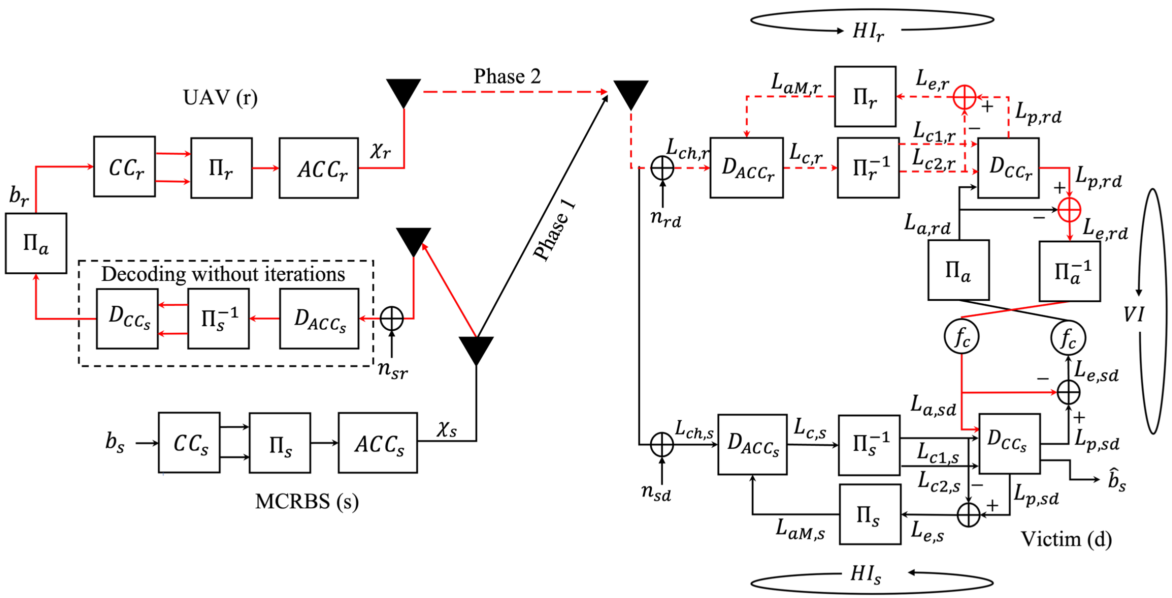
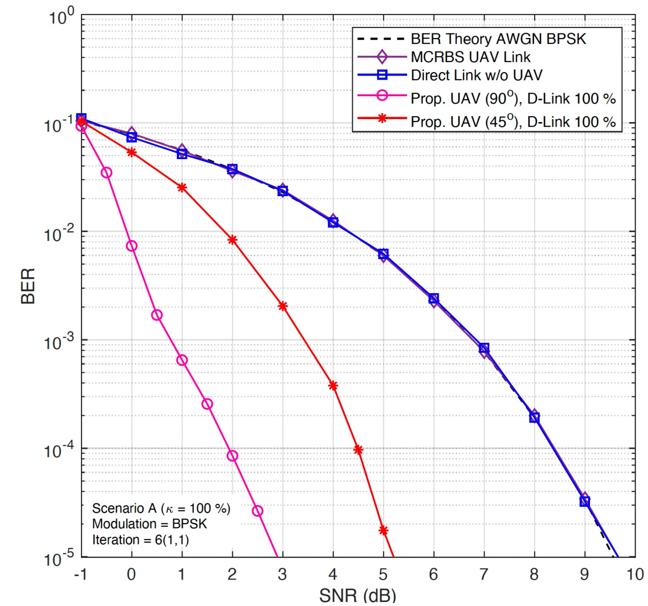
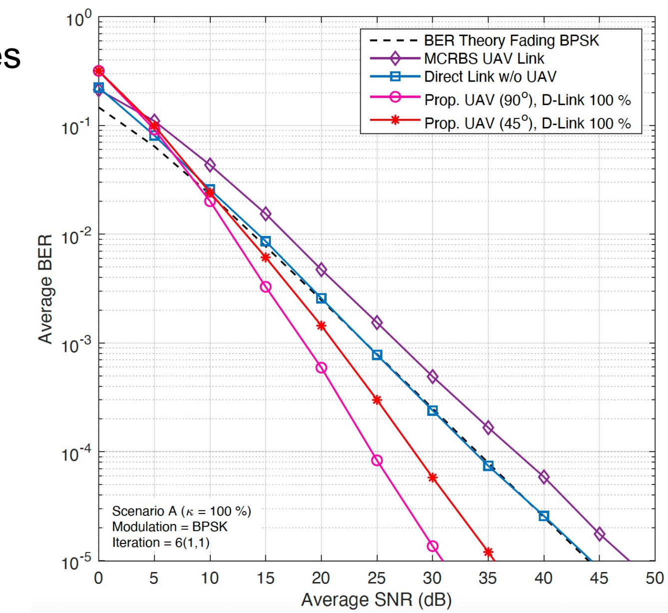


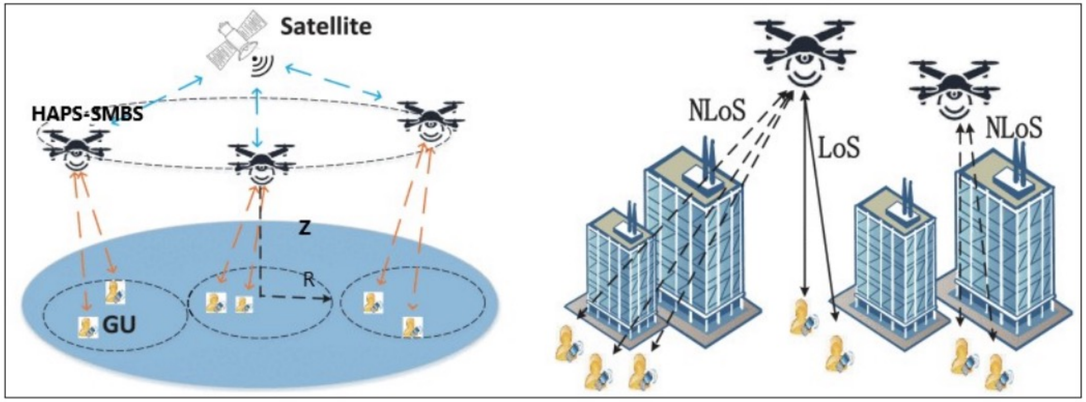
Figure 2. The Proposed Codes Constuctions: Simple Virtual Turbo Codes

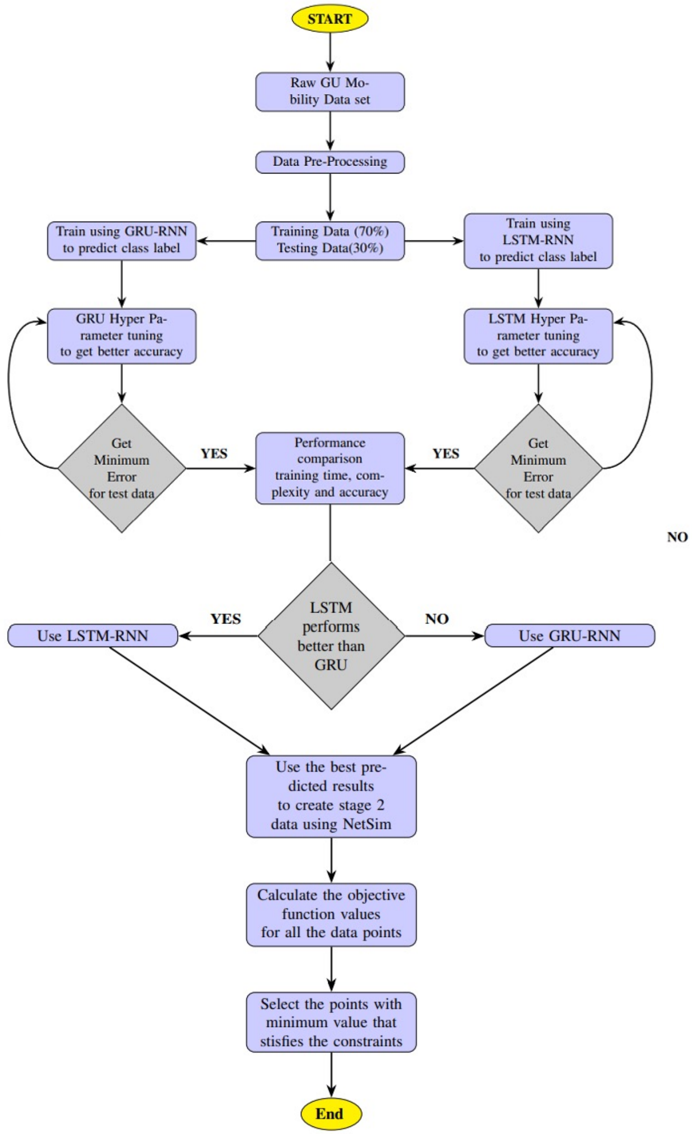




- We have proposed Turbo coding scheme that involving MCRBS and UAV, where the Turbo decoding combines signal from both MCRBS and UAV.
- We have obtained the simulation performance about simple virtual Turbo codes in AWGN and Rayleigh fading channels.
- The proposed UAV utilize: (i) 90° and 45° configurations, (ii) is used in fc(·) to update the LLR from the VI.

Current Progress 9: HAPS Positioning using Deep Learning



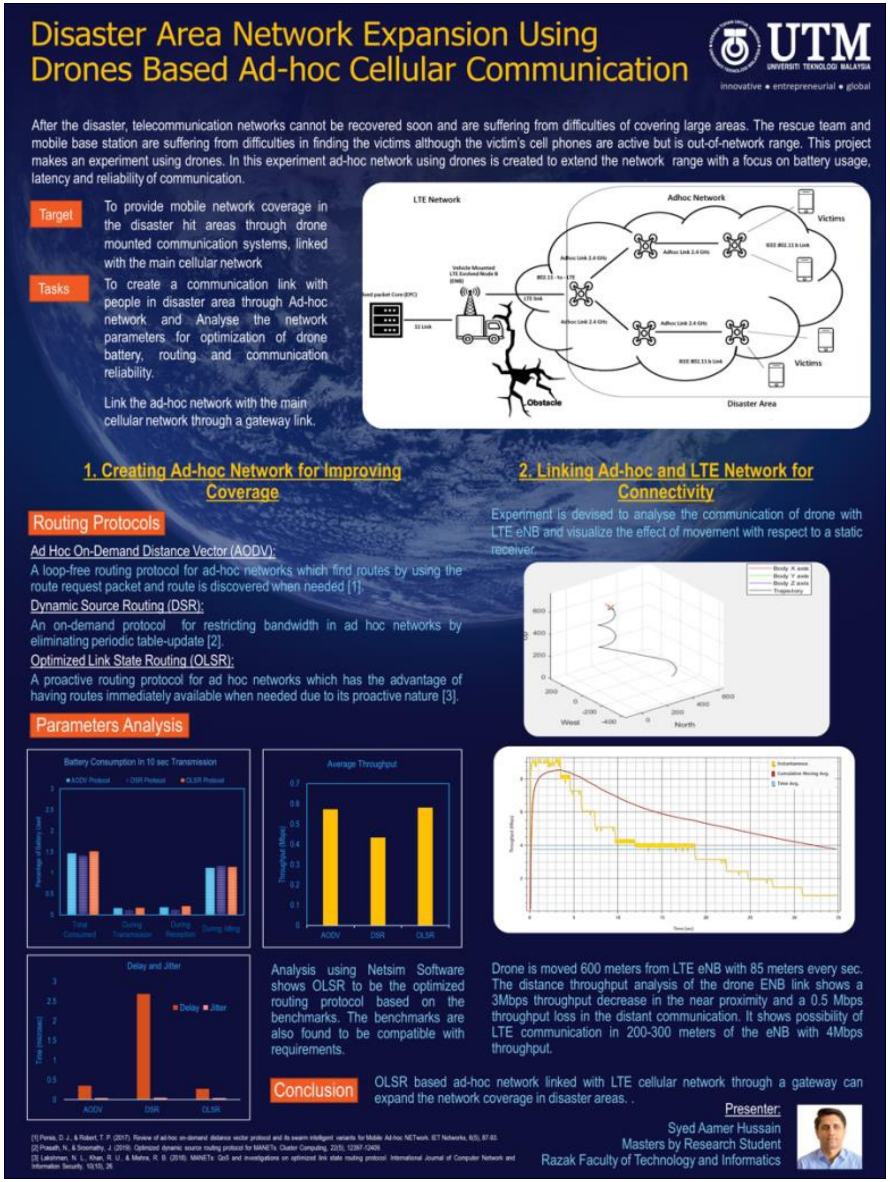


◉ Increasing the number of HAPS to provide connectivity for the users with different movements might work but that makes the network too much expensive and almost impractical. Hence, optimization of the available HAPS's positions can solve the problem cost effectively. Deep Machine Learning can be used to solve this problem. Moreover, if the positioning can be done a month ahead, it can be proved to be more efficient.

◉The results show that if the user locations are predicted accurately by solving the optimization problem, then it is possible to provide faster and reliable continuous 5G connection with better performance to the users in cases of both normal and disaster scenarios.

Current Progress 10: Ad-hoc Cellular Communication for Disaster

- The disaster area network with various protocols and architecture outlined in the preceding sections each has its own set of benefits and drawbacks.
- Choosing a proper network architecture with the appropriate protocol is a difficult undertaking that must take into account elements such as network size, network lifetime, types of data to be sent, topology, and mobility models.
- Message overhead is directly proportional to energy usage in the routing protocol. The greater the number of messages sent; the more energy is consumed. The battery in a node is difficult to replace due to the mobility nature of the nodes.
- To efficiently use the network, it is vital to extend the network lifetime by keeping the nodes operational if possible. The ability to quickly build ad hoc networks if infrastructure is destroyed or damaged is the main reason for their use.
- The analysis of the study regarding network protocols concluded that OLSR based ad-hoc network linked with LTE cellular network through a gateway can expand the network coverage in disaster areas.



Japan Visit (JAIST, 5GMF, and NICT)

Fig 1. MOU with JAIST, Ishikawa, Japan

Fig 2. Visiting ASEAN IVO project member, Brian Kurkoski at Ishikawa, Japan

Fig 3. Attending 5G International Symposium 2020

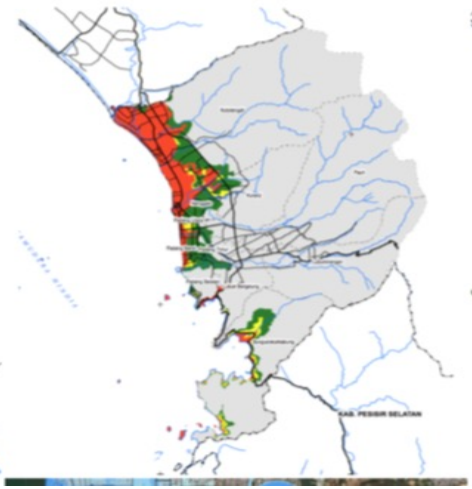
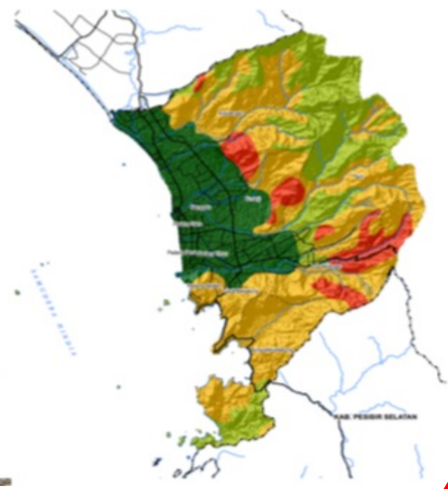
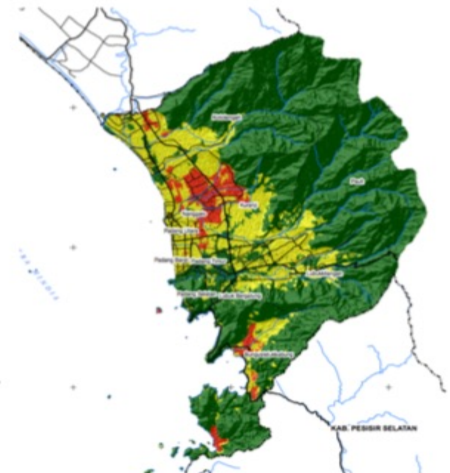
Fig 4. Meeting at NICT, Tokyo, Japan

Budget

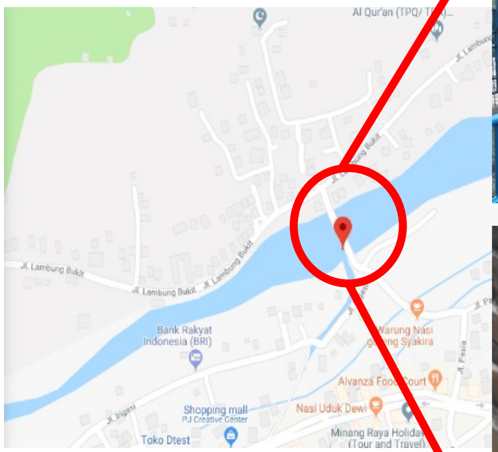
Budget used:

No.	Item	Amount		Balance	
1	Budget Allocation for PATRIOT-41R-Net from ASEAN-IVO			USD	40,000
2	Kick Off Meeting 2019 (Jul 23, 2019)	USD	188	USD	39,812
3	Kuala Lumpur International Meeting 2019 (Nov 17, 2019)	USD	2,400	USD	37,412
4	Japan Visit (Feb 17-21, 2020)	USD	2,012	USD	35,400
5	Equipment Purchasing: Drone	USD	3,599	USD	31,801
6	Tax Drone	USD	1,542	USD	30,259
7	Equipment Purchasing: 2 units USRP E312 & 1 unit Drone (RM 47.232,54)	USD	11,419	USD	18,840
8	NetSim Educational Software NetSim Standard v12.1 (or higher) Component 1	USD	1,250	USD	17,590
9	NetSim Educational Software NetSim Standard v12.1 (or higher) Component 10	USD	1,250	USD	16,340
		Remaining Budget		**USD**	**16,340**

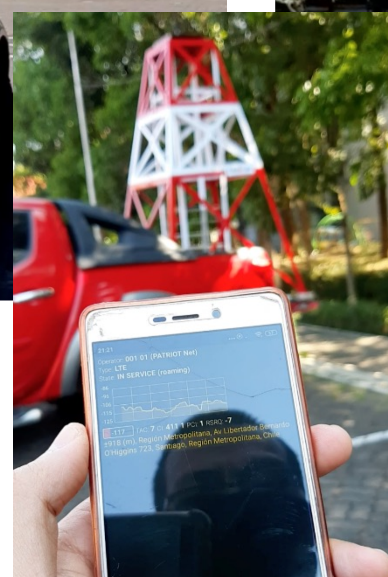
Locations of Experiment

Earthquake	Tsunami	Landslide	Flooding
			

No.	Sensor	Locations	Number of sensors
1.	Tsunami	1. Muaro Batang Anai 2. Teluk Bayur 3. Muaro Batang Kuranji 4. Muaro Penjalinan 5. Pelabuhan Bungus	6
2.	Gempa	6. Air Pacah 7. Gor H. Agus Salim 8. UNP 9. Lubuk Kilangan	4
3.	Banjir	10. Nanggalo 11. Pintu Air Gunung Nago 12. Rawang Mata Air	5
	Banjir Bandang	13. Batu Busuk 14. Limau Manis Selatan 15. Timbalun	
4.	Longsor	16. Bukit Gado-gado 17. Panorama Sitinjau Laut 18. Gates	12
		Jumlah	27



Experiment (1/3): MCRBS



- MCRBS with antenna having capability of multiple generation detection.
- We have proved to make connection with the mobile phone successfully.

Experiments (2/3): Drone

Drone deployment for disaster applications

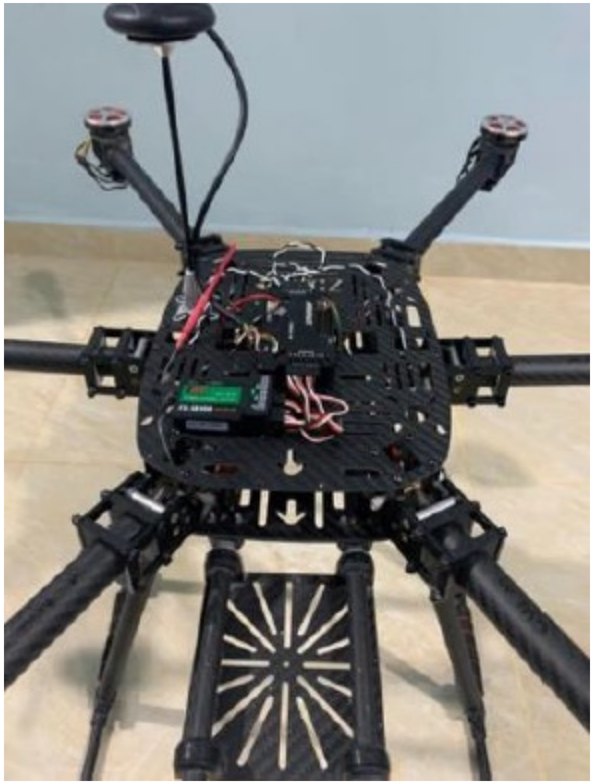


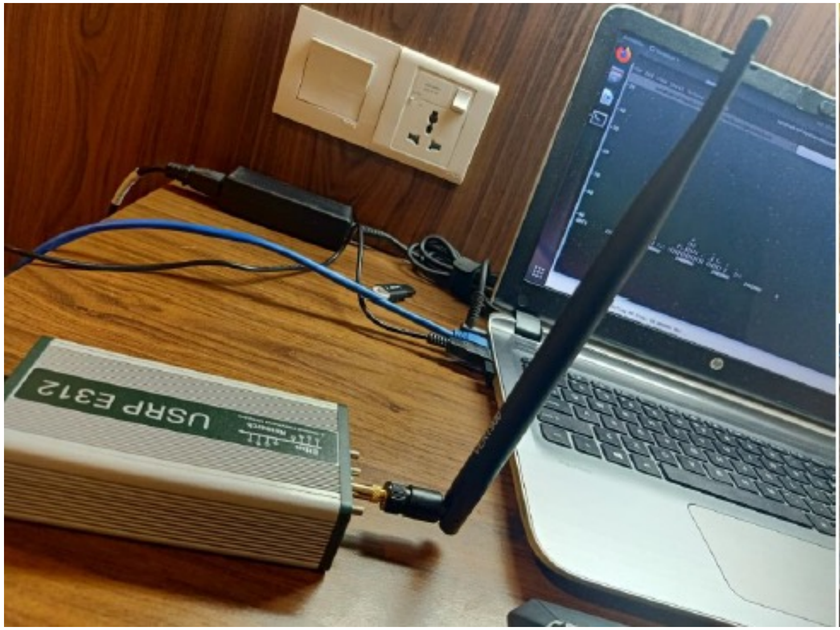





Experiments (3/3): Drone

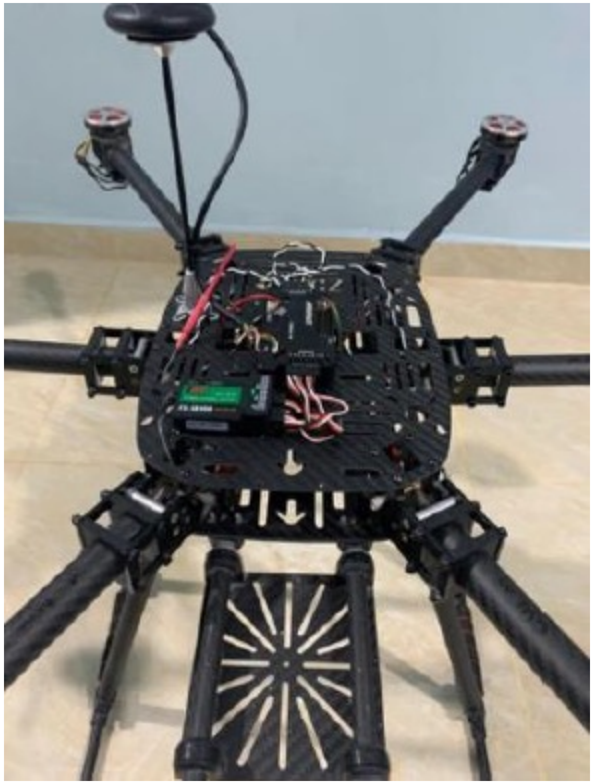
Experiment with Drone, USRP E312, and LabView Software

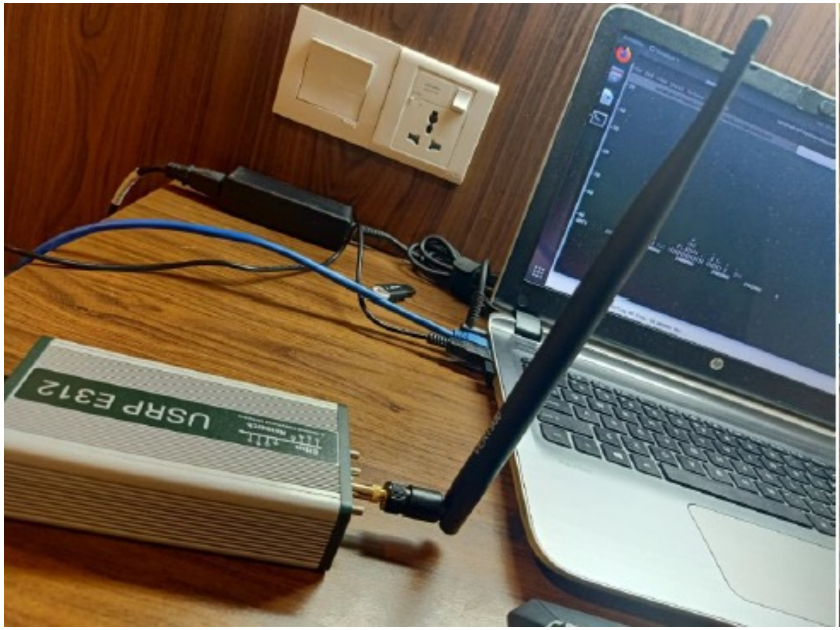




Experiments (4/3): Drone

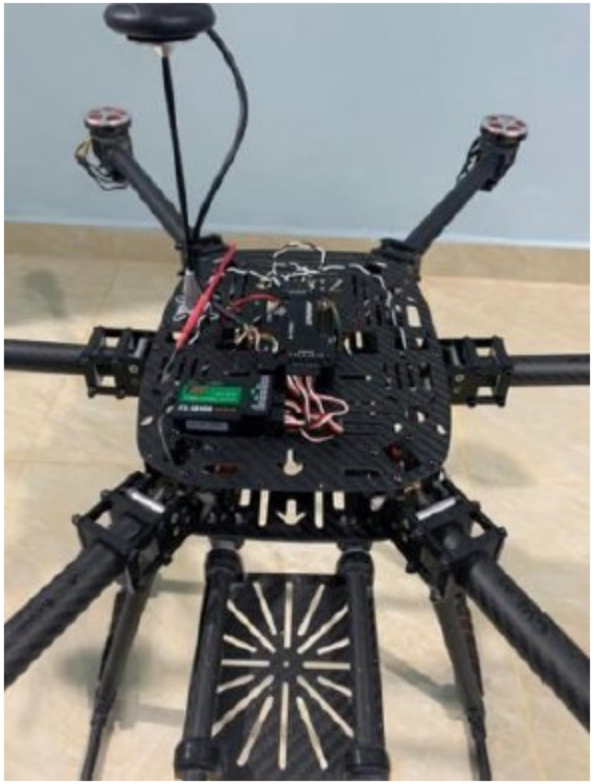
Experiment with Drone, USRP E312, and LabView Software

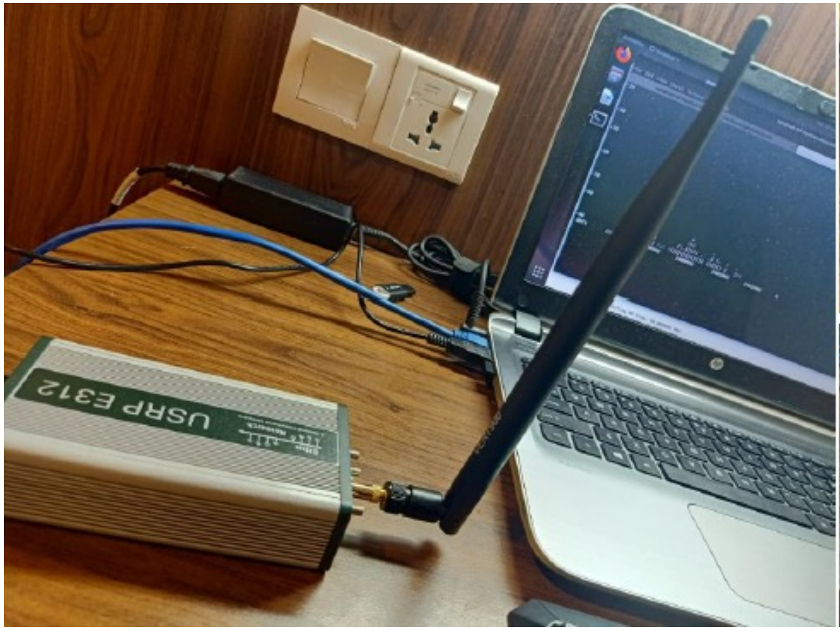




Experiments (5/3): Drone

Experiment with Drone, USRP E312, and LabView Software





ASEAN IVO

Experiments (6/3): Drone

Experiment with Drone, USRP E312, and LabView Software

Scientific Contributions Jul, 2019 – Nov, 2021: Conference (1/2)

Presentations at International Conferences:

No:	Paper title:	Author names	Affiliation	Conference name:	The date of the conference	The venue of the conference
1.	Extrinsic Information Transfer (EXIT) Analysis for Short Polar Codes	Fauzil Mufassa and Khoirul Anwar	Telkom University	3rd International Symposium on Future Telecommunication Technologies (SOFTT2019)	18-20/10/2019	UTM, Kuala Lumpur, Malaysia
2.	Biconical Antenna for Mobile Base Station for Post Disaster Area Wireless Communications	Dammar Adi Sujiansyah, Khoirul Anwar and Aloysius Adya Pramudita	Telkom University	SOFTT 2019	18-20/10/2019	UTM, Kuala Lumpur, Malaysia
3.	Cellular Communications-based Detection to Estimate Location of Victims Post-Disaster	Tides Anugraha, Khoirul Anwar and Sigit Jarot	Telkom University	SOFTT 2019	18-20/10/2019	UTM, Kuala Lumpur, Malaysia
4.	Interference Mitigation using Adaptive Beam- forming with RLS Algorithm for Coexistence between 5G and Fixed Satellite Services in C- Band	Cahya Budi Muhammad and Khoirul Anwar	Telkom University	IEEE ICERA 2019	12/2019	Yogyakarta, Indonesia
5.	On the Design of Optimal Soft Demapper for 5G NR Wireless Communication Systems	Alhamdi Syukra, Khoirul Anwar, and Desti Madya Saputri	Telkom University	The IEEE 10th Electrical Power, Electronics, Controls, Communications, and Informatics Seminar (EECIS) 2020	08/2020	Malang, Indonesia
6.	Experiment of Routing for Mobile Cognitive Radio Base Station (MCRBS)	Luthfi Fauzi, Khoirul Anwar, and Hafidudin,	Telkom University	The IEEE 10th Electrical Power, Electronics, Controls, Communications, and Informatics Seminar (EECIS) 2020	08/2020	Malang, Indonesia
7.	Hybrid Multikernel-Constructed Polar Codes for Short Blocklength Transmissions	Cita Aisah Nurbani, Khoirul Anwar, and Willy Anugrah Cahyadi	Telkom University	17th Int. Wireless Communications & Mobile Computing Conference (IWCMC 2021)	June 28 - July 02, 2021	Harbin, China

Scientific Contributions Jul, 2019 – Nov, 2021: Conference (2/2)

Presentations at International Conferences:

No:	Paper title:	Author names	Affiliation	Conference name:	The date of the conference	The venue of the conference
8.	Design of Polar Code Lattices of Finite Dimension	Obed Rhesa Ludwiniananda[1], Ning Liu[2], Khoirul Anwar[1], and Brian M. Kurkoski[2]	[1]Telkom University, [2]Japan Advanced Institute of Science and Technology	2021 IEEE International Symposium on Information Theory (ISIT 2021)	July 12-20, 2021	Melbourne, Victoria, Australia
9.	Encoding and Decoding Construction D' Lattices for Power-Constrained Communications	Fan Zhou[1], Arini Fitri[2], Khoirul Anwar[2], and Brian M. Kurkoski[1]	[1]Japan Advanced Institute of Science and Technology, [2]Telkom University	2021 IEEE International Symposium on Information Theory (ISIT 2021)	July 12-20, 2021	Melbourne, Victoria, Australia
10.	Design of Rateless Polar Accumulate Tornado Codes Using EXIT Chart for UAV Communications	Citra Dewi Anggraeni and Khoirul Anwar	Telkom University	The 2021 IEEE Symposium on Future Telecommunication Technologies (SOFTT)	December 06-07, 2021	Bandung, Indonesia (Virtual)
11.	Simple Virtual Turbo Codes for Unmanned Aerial Vehicle (UAV) Communications	Okzata Recy and Khoirul Anwar	Telkom University	The 2022 IEEE Symposium on Future Telecommunication Technologies (SOFTT)	November 14-16, 2022	Johor Bahru, Malaysia (Hybrid)

Scientific Contributions Jul, 2019 – Nov, 2021: Journal

Published in Journal Papers:

No:	Paper title:	Author names	Affiliation	Journal name:	The publisher of the Journal	The volume number and Pages
1.	Study on Error Correction Capability of Simple Concatenated Polar Codes	Robin Sinurat, Muhamad Rizki Maulana, Khoirul Anwar, and Nanang Ismail,	Telkom University	Accepted in International Journal on Advanced Science, Engineering and Information Technology (IJASEIT), February 2020.	INSIGHT - Indonesian Society for Knowledge and Human Development	Accepted
2.	Communication System for High Speed Flying Devices with Repetition Codes	Dwi Juniarto, Khoirul Anwar, Dharu Arseno	Telkom University	Journal of Measurement, Electronic, Communication, and Systems, April 2020. (https://journals.telkomuniversity.ac.id/jmecs).	Telkom University	Published
3.	Indonesia 5G Channel Model Under Foliage Effect	Khoirul Anwar, Evander Christy, and Rina Pudji Astuti,	Telkom University	Buletin Pos dan Telekomunikasi, Volume 17 No. 2 Dec. 2019, https://online.bpostel.com/index.php/bpostel/article/view/170201.	Kominfo	Published
4.	Study on Early Warning Systems (EWS) for Indonesia Digital	S. F. Nurbadri, K. Anwar, D. Arseno	Telkom University	Journal of Measurements, Electronics, Communications, and Systems (JMECS), August 2020.	Telkom University	Published
5.	HAPS-SMBS 3D Installation for 5G FANET Performance Optimization Using a DNN, WCOP and NetSim Based Scheme	Joyeeta Rani Barai and Attaphongse Taparugssanagorn	AIT, Thailand	International Journal of Sensor Networks (IJSNET)	International Journal of Sensor Networks	Submitted

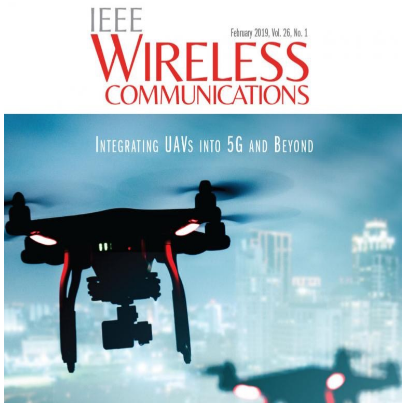
Scientific Contributions Jul, 2019 – Nov, 2021: Patent

Patent:

No:	Patent Title:	Inventor:	Affiliation:	Date of Submission:	Number of Patent:	Country:	Status:
1.	Antena Pita Lebar untuk Pemulihan Sinyal Komunikasi Pasca Bencana (Broadband Antenna for Network Recovery Post-Natural Disaster)	Khoirul Anwar and Dammar Adi Sujiansyah	Telkom University	July 07, 2021	P00202105209	Indonesia	Submitted
2	Teknik Pengkodean Kanal dengan Rate Adaptif untuk Teknologi Komunikasi Nirkabel	Khoirul Anwar and Citra Dewi Anggraeni	Telkom University	September 15, 2022	P00202209894	Indonesia	Submitted
3	Teknologi Telekomunikasi Relay untuk Wahana Terbang Tak Berawak*	Khoirul Anwar and Okzata Recy	Telkom University	To be submitted	To be submitted	Indonesia	To be submitted

Societal Impact of PATRIOT-41R-Net Project

- With this PATRIOT-41R-Net project, the people can have **direct access to the level of danger** in their living places.
- People will be **well prepared** about when they should leave or when they should keep staying.
- Furthermore, the government can have **accurate information** about what is happening due to the full information access provided in their monitoring room → can **inform people** with decision supported by accurate information source.
- Lesson learned from **real-field experiment** and real-field parameters for ASEAN countries.
- Submitted to **recommendation/standardization in** Asia Pacific Wireless Group and ITU.
- The impacts of PATRIOT-41R-Net project may also go indirectly to the economy of ASEAN people, especially when 4 sensors are **massively produced** by manufacture of in each country.
- The successful of this project will also impact to the **change of public policy rules.**



Conclusions

- This PATRIOT-41R-Net project proposes Airborne capability using drone and/or HAPS for disaster recovery networks.
- Airborne capability is performed using drone and/or HAPS to: (1) extend the network coverage and (2) find the victims.
- The rateless Polar-LT codes are developed to make networks communications stable and reliable.
- The project considers UAV channel modeling for reference of experiment.
- WP2, WP3, and WP5 are being tested in Year 1.
- WP4 and WP6 are to be experimented in Year 2.

Future works: Roadmap of PATRIOT-41R-Net

- **Year 1: July 2019 – June 2020**
  a. *Kick-Off Meeting, Bandung, Indonesia*
  b. ***Complete the Theoretical Derivations of the proposed technique.***
  c. ***Evaluating the Theoretical Performances***
  d. *Writing Patents*
  e. *Publication I of First Year (WP of Telkom University)*
  f. ***Performing WP1: Meeting I at KL, Malaysia***
  g. *Progress Report Meeting of Year 1*
  h. **Experiment of WP2: MCRBS**
  i. **Experiment of WP3: Coding**
  j. **WP1: Meeting II Online (Covid-19)**
  k. **Experiment of WP5: Tsunami, Researcher Exchange to NICT and JAIST, Japan (TelU, JAIST, HUST)**
  l. Publication II of First Year (Joint with Other Teams)

- **Year 2: July 2020 – June 2021**
  a. **Experiment of WP4: Routing (UTM, TelU)**
  b. Meeting III at Thailand (November 2020)
  c. Writing Patents
  d. **Experiment of WP6: Indonesia (TelU, AIT)**
  e. Publications of the Year 2
  f. Meeting IV at Vietnam
  g. Experiment of HAPS
  h. Progress Report Meeting of Year 2
  i. Meeting V at Indonesia
  j. **WP7: Tutorial/ Workshop/ Whitepaper**
  k. Writing A Final Report

*) underline: has been completed.