DESIGN OF TRAFFIC SIGNAL TIMING AND TRAFFIC IMPACTS OF THE RE-INTRODUCTION OF TRAFFIC SIGNAL CONTROL AT THE INTERSECTION OF THE UNIVERSITY AVENUE AND COMMONWEALTH AVENUE

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Background

• the “Big Rotunda” or U-Turn scheme, was implemented by the Metro Manila Development Authority (MMDA) in 2003

→to relieve the worsening traffic congestion by increasing travel speed along major roads in Metro Manila, including Commonwealth Avenue

→ it is also part of the Clearway Scheme which is a form of corridor management scheme that closes intersections (including those equipped with signal lights) and/or replaces left turns with U-turn movements (World Bank, 2004)

→ in June 2003, 48 slots have been constructed in Quezon Avenue, EDSA (C-4), Commonwealth Avenue, Marcos Highway and Sen. Gil Puyat (Buendia) Avenue that involved closure of several intersections including the intersection of Commonwealth Avenue and University Avenue

Background

• the traffic scheme allowed continuous traffic on major roads and not allowed traffic crossing from minor roads (through and left turn)

→converts these movements to RTUT (right turn + u-turn)
→formation of weaving sections from minor road to the u-turn slot

• impact studies

→ average travel speed increased in Commonwealth Ave. (10-44%) (MMDA Traffic Engg Center, 2003)
→fuel savings of 42.84 to 51.45 million according to MMDA in 2008 (focused on travel time savings)
→ number of accidents in Katipunan Avenue increased significantly with the introduction of the U-Turn Scheme and an increase in accidents related to the u-turn slots (Madrigal and Palmiano, 2004)

Background

• although Clearway Scheme is considered in traffic engineering as a short-term solution, it became a permanent scheme that substituted major interchange projects

• long-term effects:

→motorists have been conditioned:
→ to disregard traffic signals and its authority
→ to become more aggressive because:
→ vehicles at the minor road would have to weave and make that u-turn maneuver as high-speed through traffic at the major road remains uninterrupted
→ vehicles at the major road would think they have the priority and would continuously prevent minor vehicles from weaving

Background

- Commonwealth's conversion into a racetrack was encouraged by these thoroughfares being made even more "thorough" by reducing traffic lights in favor of U-turn islands, with inadequate provisions for pedestrians (Prof. Tan, Philippine Daily Inquirer, 2008)

- the UP-ICE study and the article of Tan (2008) were one in saying that widening of roads encouraged motorists to speed up

- Two road crashes that involved overspeeding of public utility vehicles along major thoroughfares in Metro Manila caught attention of the public:
  - →2008: overspeeding bus collided with the car of **Dr. Sarabia** along EDSA
  - →2011: a bus collided with the taxi that resulted to the death of **UP Professor Chit Estela-Simbulan** in the vicinity of u-turn slot at Commonwealth Avenue in front of the UP-Ayala Land Technohub

Significance of the Study

- in the light of the fatal road crashes in the University, the UP Diliman Transportation Committee under the UPD Office of the Vice Chancellor for Community Affairs (OVCCA), decided to propose a traffic study for the re-introduction of traffic signal control at Commonwealth Avenue

- the proposal for traffic study was submitted to the UPD Office of the Vice Chancellor for Research and Development (OVCRD) Source of Solutions (SOS) Grants and was approved in January 2012

Objectives

General Objective: the general objective of the study (UPD OVCRD SOS Grant) is to evaluate the impacts on traffic flow, road safety and the environment of the re-introduction of traffic signal control at the intersection of University Avenue and Commonwealth Avenue

Specific Objectives of this Paper

- design of appropriate traffic signal timing and phasing of the intersection with the re-introduction of the traffic signal at the intersection

- other objectives: preliminary assessment of safety and environment of the intersection under the u-turn scheme

Study Area

Traffic Surveys and Air Quality Monitoring

Traffic Surveys: 13 March 2012 (Tuesday)
Air Quality Survey: 12-13 March 2012 (Monday-Tuesday)

1) Traffic Volume Count Survey

- 16-hour classified traffic volume count (6:00 AM – 10:00 PM), March 13
  - Commonwealth Avenue (Philcoa overpass)
  - University Avenue (intersection with Commonwealth Avenue)
  - Commonwealth Avenue (Technohub U-turn Slot)

2) Vehicle License Plate (LP) Survey

- 16-hour vehicle license plate survey (6:00 AM – 10:00 PM), March 13
  - UP-AIT U-turn Slot
  - Ylanan Road Gate

3) Air Quality Monitoring

- 12 March (8:00 PM) – 13 March (10:00 PM)
  - Commonwealth Avenue (eastbound/Jollibee Philcoa Parking Lot)
  - measurement of concentration of CO, NO, NO_2, PM_{10}

1) Traffic Volume Count Survey

16-hour classified traffic volume count (6:00 AM – 10:00 PM), March 13 (Tue)

- Commonwealth Avenue at Philcoa, westbound (M1) and eastbound (M2)
- Right turn to University Ave. (M3), Right turn from University Ave. (M4)
- Right turn from University Avenue and u-turn at Technohub U-turn Slot (M5)

2) Vehicle License Plate (LP) Survey

16-hour License Plate Survey (6:00 AM – 10:00 PM), March 13 (Tue)

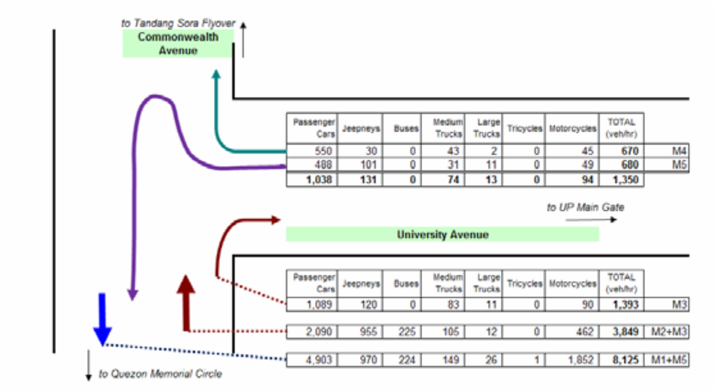
- Vehicles making a u-turn at UP-AIT U-turn Slot (LP1)
- Vehicles entering at the Ylanan Road Gate of UP Diliman (LP2)

3) Air Quality Monitoring

Monitoring of concentration of CO, NO, NO_2, PM_{10} every 10 minutes:
12 March (8:00 PM) – 13 March (10:00 PM)

- Commonwealth Avenue at Philcoa Jollibee Parking Lot (**AQ**)
- Monitoring equipment: Horiba Air Pollution Monitoring System and E-BAM

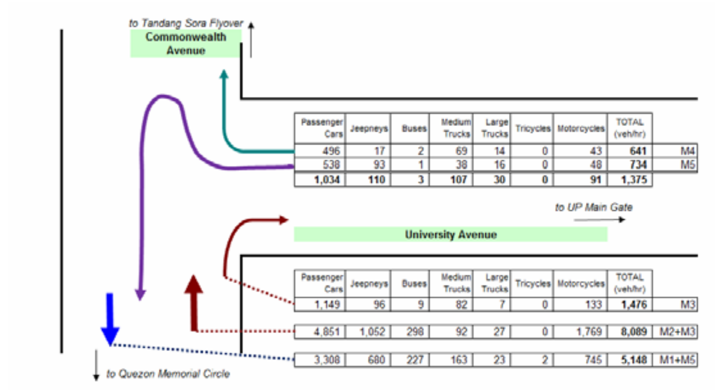
Morning Peak Hour (8-9 AM)
Traffic Volume Summary
(Commonwealth Avenue-University Avenue)



Passenger Cars	Jeepneys	Buses	Medium Trucks	Large Trucks	Tricycles	Motorcycles	TOTAL (veh/hr)	
550	30	0	43	2	0	45	**670**	M4
488	101	0	31	11	0	49	**680**	M5
1,038	**131**	**0**	**74**	**13**	**0**	**94**	**1,350**	

Passenger Cars	Jeepneys	Buses	Medium Trucks	Large Trucks	Tricycles	Motorcycles	TOTAL (veh/hr)	
1,089	120	0	83	11	0	90	**1,393**	M3
2,090	955	225	105	12	0	462	**3,849**	M2+M3
4,903	970	224	149	26	1	1,852	**8,125**	M1+M5

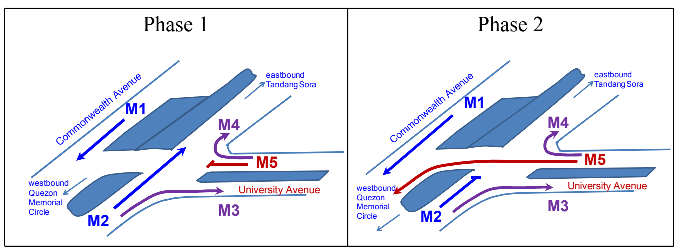
Afternoon Peak Hour (5-6 PM)
Traffic Volume Summary
(Commonwealth Avenue-University Avenue)



Passenger Cars	Jeepneys	Buses	Medium Trucks	Large Trucks	Tricycles	Motorcycles	TOTAL (veh/hr)	
496	17	2	69	14	0	43	**641**	M4
538	93	1	38	16	0	48	**734**	M5
1,034	**110**	**3**	**107**	**30**	**0**	**91**	**1,375**	

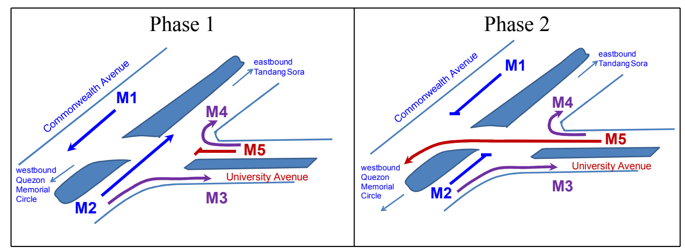
Passenger Cars	Jeepneys	Buses	Medium Trucks	Large Trucks	Tricycles	Motorcycles	TOTAL (veh/hr)	
1,149	96	9	82	7	0	133	**1,476**	M3
4,851	1,052	298	92	27	0	1,769	**8,089**	M2+M3
3,308	680	227	163	23	2	745	**5,148**	M1+M5

Phasing/Stage Plan



Phasing Plan of Case 1
Uninterrupted Westbound Traffic Along Commonwealth Avenue

Phasing/Stage Plan



Phasing Plan of Case 2
Interrupted Westbound Traffic Along Commonwealth Avenue

Data Input – Traffic Volume *q* and normalization to passenger car units or pcu/hour

The hourly traffic volume q, in passenger car units per hour, is given by

$$q = \sum PCU_i (q_i)$$

where q_i = hourly traffic volume of vehicle type *i*
PCU_i = PCU value of vehicle type *i*

PCU values are assumed to be the following:

passenger car = 1.0
jeepneys and medium trucks = 1.5
motorcycles = 0.50
tricycles = 0.80
buses and large trucks = 2.2

Data Input – Saturation Flow Rate, *s*

The saturation flow rate, s, in passenger car units per hour, is based on the number of lanes of each approach:

		no. of lanes	saturation flow rate, *s* (pcu/hr)
Commonwealth Avenue	Westbound (East approach), straight-through	5	9,000
		7	12,600
	Eastbound (West approach), straight-through	7	12,600
	Eastbound (West approach), right-turn	3	4,800
University Avenue	Westbound (East approach), left-turn	2	3,200

Note: straight-through saturation flow rate = 1,800 pcu/hr/lane
left-turn saturation flow rate = 1,600 pcu/hr/lane

Feasibility of Signalization

Based on the two cases of phasing/stages of signalization, the following are Computed:

y-value of each traffic movement *i*

$$y_i = q_i/s_i$$

where q_i= traffic flow of movement *i (pcu/hr)*
s_i = saturation flow rate of movement *i (pcu/hr)*

y_{cr} = maximum y_i of each phase/stage

$Y = \Sigma\, y_{cr}$ of all phases/stages

Lost Time

- in both cases, the proposed traffic signal control will be a two-phase/stage signal control
- the total lost time *L* is given as

$L = 2*(SL) + 2*(AR) = 8$ seconds

where *SL* (starting loss) = 2 sec
AR (all-red) = 2 sec

Optimum Cycle Length

- Webster's Formula for C_{opt}

$$C_{opt} = \frac{1.5L + 5}{1 - Y}$$

Where: L – total lost time
Y – sum of critical y-values

Source: Sigua, R. G. (2008) Fundamentals of Traffic Engineering, The University of the Philippines Press.

Allocation of Green Times

- in proportion to the y-values, green time is estimated as:

$$g_i = \frac{y_i}{Y} \times (C_o - L)$$

Capacity of Movement or Approach

$$Capacity = s \times \frac{g}{c}$$

s – saturation flow rate
g – effective green
c – cycle length

Source: Sigua, R. G. (2008) Fundamentals of Traffic Engineering, The University of the Philippines Press.

Intersection Degree of Congestion, *X*

$$X = \frac{CY}{g} = \frac{CY}{C - L}$$

Source: Sigua, R. G. (2008) Fundamentals of Traffic Engineering, The University of the Philippines Press.

Hourly Critical *y*-value (y_{cr}) and Optimum Cycle Length of Case 1

Hour of Day	Movement Traffic Volume (pcu/hr)		y-value $y_i = q_i/s_i$		Y	Optimum Cycle Length C_o (sec.)
	q_2	q_5	y_2	y_5		
6-7 AM	1,720	443	0.14	0.14	0.27	23.4
7-8 AM	2,257	791	0.18	0.25	0.43	29.6
8-9 AM	2,970	735	0.24	0.23	0.47	31.8
9-10 AM	2,616	980	0.21	0.31	0.51	35.0
10-11 AM	2,881	1,101	0.23	0.34	**0.57**	39.8
11 AM-12 NN	2,940	825	0.23	0.26	0.49	33.4
12-1 PM	3,550	717	0.28	0.22	0.51	34.4
1-2 PM	3,831	816	0.30	0.26	0.56	38.6
2-3 PM	3,954	963	0.31	0.30	0.61	44.1
3-4 PM	3,740	830	0.30	0.26	0.56	38.3
4-5 PM	5,275	766	0.42	0.24	0.66	49.7
5-6 PM	6,649	796	0.53	0.25	**0.78**	76.0
6-7 PM	5,798	808	0.46	0.25	0.71	59.2
7-8 PM	5,792	638	0.46	0.20	0.66	49.8
8-9 PM	4,635	515	0.37	0.16	0.53	36.1
9-10 PM	4,543	493	0.36	0.15	0.51	35.0

→all Y < 1.0: signalization is feasible for Case 1 (uninterrupted westbound straight-through traffic movement along Commonwealth Avenue with reduction in the number of lanes to 5)

Hourly Critical *y*-value (y_{cr}) and Optimum Cycle Length of Case 2

Hour of Day	Movement Traffic Volume (pcu/hr)			*y*-value $y_i = q_i/s_i$			Y	Optimum Cycle Length, C_o (sec.)
	q_1	q_2	q_5	y_1	y_2	y_5		
6-7 AM	6,771	1,720	443	0.54	0.14	0.14	0.68	52.4
7-8 AM	7,108	2,257	791	0.56	0.18	0.25	0.81	90.0
8-9 AM	7,324	2,970	735	0.58	0.24	0.23	0.81	89.9
9-10 AM	5,578	2,616	980	0.44	0.21	0.31	0.75	67.7
10-11 AM	5,293	2,881	1,101	0.42	0.23	0.34	0.76	72.1
11 AM-12 NN	4,471	2,940	825	0.35	0.23	0.26	0.61	43.9
12-1 PM	4,240	3,550	717	0.34	0.28	0.22	0.56	38.7
1-2 PM	4,436	3,831	816	0.35	0.30	0.26	0.61	43.3
2-3 PM	4,657	3,954	963	0.37	0.31	0.30	0.67	51.6
3-4 PM	5,023	3,740	830	0.40	0.30	0.26	0.66	49.7
4-5 PM	4,438	5,275	766	0.35	0.42	0.24	0.66	49.7
5-6 PM	4,701	6,649	796	0.37	0.53	0.25	0.78	76.0
6-7 PM	4,112	5,798	808	0.33	0.46	0.25	0.71	59.2
7-8 PM	3,654	5,792	638	0.29	0.46	0.20	0.66	49.8
8-9 PM	3,121	4,635	515	0.25	0.37	0.16	0.53	36.1
9-10 PM	2,933	4,543	493	0.23	0.36	0.15	0.51	35.0

→all Y < 1.0: signalization is feasible for Case 2 (interrupted westbound straight-through traffic movement along Commonwealth Avenue without reduction in the number of lanes)

Comparison of Intersection Degrees of Congestion of Case 1 and Case 2

Hour of Day	Cycle Length (rounded off), C (sec.)		Intersection Degree of Congestion, X		
	Case 1	Case 2	Case 1		Case 2
6-7 AM	25	55	0.40	<	0.79
7-8 AM	30	90	0.58	<	0.89
8-9 AM	35	90	0.60	<	0.89
9-10 AM	40	70	0.64	<	0.85
10-11 AM	40	75	0.72	<	0.86
11 AM-12 NN	35	45	0.64	<	0.75
12-1 PM	35	40	0.66	<	0.70
1-2 PM	40	45	0.70	<	0.74
2-3 PM	45	55	0.75	<	0.78
3-4 PM	40	50	0.70	<	0.78
4-5 PM	50	50	0.78	=	0.78
5-6 PM	80	80	0.86	=	0.86
6-7 PM	60	60	0.82	=	0.82
7-8 PM	50	50	0.78	=	0.78
8-9 PM	40	40	0.66	=	0.66
9-10 PM	40	35	0.64	<	0.67

→ all *X* < 1.0 (highest X = 0.89 at morning peak hour, 7-8 AM & 8-9 AM)

→ Case 1 (uninterrupted westbound traffic flow of Commonwealth) is more desirable as it has more hours (11 hours) with lesser degree of congestion than Case 2

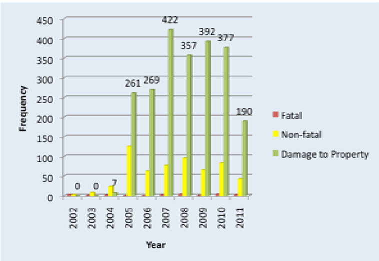
Preliminary data on road crashes/accidents

Accidents by Type, 2002-2011

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Fatal	3	1	2	0	0	3	4	1	4	3
Non-fatal	3	8	23	126	63	77	96	66	83	43
Damage to Property	0	0	7	261	269	422	357	392	377	190
Total	6	9	32	387	332	502	457	459	464	236

Source: Metro Manila Accident Reporting and Analysis System (MMARAS), Metro Manila Development Authority

Note: MMARAS started in 2004 and data before this year is incomplete



Source: Busok, A. C. and : Calivo, C. D. (2012) Assessment of Traffic Signalization at the University Avenue-Commonwealth Avenue Intersection, Undergraduate Research Project, Institute of Civil Engineering, College of Engineering, UP Diliman

Location of road crashes/accidents

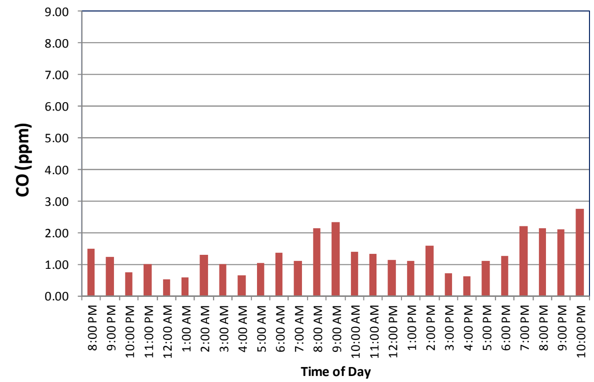
Source: Busok, A. C. and : Calivo, C. D. (2012) Assessment of Traffic Signalization at the University Avenue-Commonwealth Avenue Intersection, Undergraduate Research Project, Institute of Civil Engineering, College of Engineering, UP Diliman

Air Quality Monitoring at Commonwealth Ave. (Jollibee Philcoa) March 12-13, 2012

Set-up of Horiba Air Quality Monitoring System (CO, NO_2) and E-BAM (PM_{10})

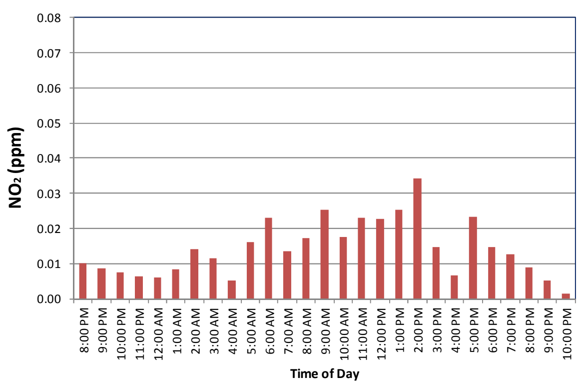
Air Quality Monitoring at Commonwealth (Jollibee Philcoa)

Carbon Monoxide (CO): Hourly Concentration from March 12 (8 PM) to March 13 (10 PM)



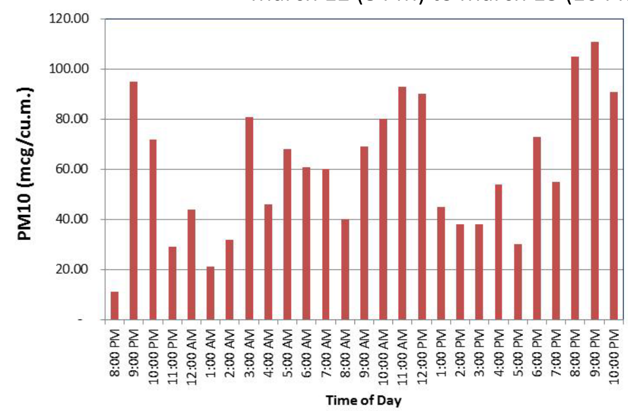
Air Quality Monitoring at Commonwealth (Jollibee Philcoa)

Nitrogen Dioxide (NO2): Hourly Concentration from March 12 (8 PM) to March 13 (10 PM)



Air Quality Monitoring at Commonwealth (Jollibee Philcoa)

Particulate Matter (PM10): Hourly Concentration from March 12 (8 PM) to March 13 (10 PM)



National Ambient Air Quality Guideline Values (Clean Air Act)

Pollutants	Short Term[a]			Long Term[b]		
	μg/Ncm	ppm	Averaging Time	μg/Ncm	ppm	Averaging Time
Suspended Particulate Matter[c] – TSP	230[d]		24 hours	90		1 year[e]
PM-10	150[f]		24 hours	60		1 year[e]
Sulfur Dioxide[c]	180	0.07	24 hours	80	0.03	1 year
Nitrogen Dioxide	150	0.08	24 hours			
Photochemical Oxidants as Ozone	140 60	0.07 0.03	1 hour 8 hours			
Carbon Monoxide	35 mg/Ncm 10 mg/Ncm	30 9	1 hour 8 hours			
Lead[g]	1.5		3 months[g]	1.0		1 year

[a] Maximum limits represented by ninety-eight percentile (98%) values not to exceed more than once a year.
[b] Arithmetic mean.
[c] SO_2 and Suspended Particulate matter are sampled once every six days when using the manual methods.
A minimum of twelve sampling days per quarter or forty-eight sampling days each year is required for these methods.
Daily sampling may be done in the future once continuous analyzers are procured and become available.
[d] Limits for Total Suspended Particulate Matter with mass median diameter less than 25-50 μm.
[e] Annual Geometric Mean.
[f] Provisional limits for Suspended Particulate Matter with mass median diameter less than 10 μm and below until sufficient monitoring data are gathered to base a proper guideline.
[g] Evaluation of this guideline is carried out for 24-hour averaging time and averaged over three moving calendar months.
The monitored average value for any three months shall not exceed the guideline value.

Conclusions

- traffic signal phasing and timing have been designed for the intersection of Commonwealth Avenue and University Avenue if traffic signal control were to be introduced

  → maximum intersection degree of congestion $X = 0.86$
  → maximum cycle length $C = 90$ seconds

- Case 1 (uninterrupted westbound traffic flow of Commonwealth) is more desirable as it has more hours (11 hours) with lesser degree of congestion than Case 2

- Total number of road crashes has increased from 2005 to 2007 and significantly decreased in 2011
- air pollutant concentration of gaseous pollutants (CO, NO_2 and PM_{10}) are still within the guideline values

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- Busok, Aimah C. and Calivo, Chrislene D.
  (B. S. Civil Engineering, 2012, Institute of Civil Engineering, College of Engineering, UP Diliman)
- BP Integrated Staff