Broadcast Engineering the North

The Acquaintance

One sunny afternoon in September 2016, while driving in downtown Tuguegarao City, licensed Professional Electronics Engineer Grant Ramones noticed a makeshift broadcast antenna on top of a three-storey building that housed one of the oldest FM radio station in the city. The antenna was obviously used by the said FM station as an emergency radiator after a strong typhoon hit the area, bending the tower down and breaking the antenna elements. Being an experienced Broadcast Engineer, Ramones knew the antenna was not appropriate for FM broadcast applications. He searched for the web site of Forefront Radio Network (FRN), the company who owned and operated the FM station, and sent an email to the address on the web site, writing to them about his observations of the antenna and the reasons why the antenna was not fit for FM broadcast applications. He ended the email by providing his contact number.

Moments later, Ramones' phone rang. It was Mr. Jesus Galvente, the President and CEO of FRN. Galvente commended Ramones on his insights and asked to hear more. The conversation then continued with exchanges in views and opinions on radio broadcast operations and the future plans of the network. Galvente described his plans for the network, which were twofold: 1) to improve its listenership over other radio stations in areas where there was presence of an FRN station, and 2) to improve network profit. Particularly, the network planned to have simultaneous broadcast among all its FM stations – also known as "chain broadcasting." Chain broadcasting or simultaneous broadcasting required connecting all FRN provincial stations that were strategically operating in key places in northern Luzon. This plan was FRN's attempt to make big in the FM broadcast industry by making its reach far and wide. Chain broadcasting makes it possible to propagate a common network-wide programming, and it was one of the strategies that most broadcasting companies used to attract national advertisers to buy ads placements in their programs.

Another of Galvente's plans for the network was to reduce operating costs, particularly on the technical side, thereby augmenting profit. Achieving this would require some engineering interventions to reduce the power consumption in each station. The lengthy telephone conversation between Ramones and Galvante ended with an appointment to meet in person.

During the in-person meeting at Ramones' office, the network CEO discussed, in detail, the plans of the network that needed engineering solutions. Specifically, the CEO desired a detailed engineering design on how to implement network programming in all the FM stations of FRN. The network intended to place the mother studio[i] in Tuguegarao City because of its strategic location in northern Luzon. The technologies to be used had to be the most cost-effective among all presently available technologies. Furthermore, the network was experiencing financial difficulties due partly to high operating cost. The electric consumption of all the stations had been steadily increasing over the years. As a cost-cutting measure, for several years now, almost all FRN stations were transmitting at reduced transmitter power during their operation. As a consequence, the coverage area of these FRN stations was likewise reduced and listenership declined as a result. So, the network needed some engineering solutions and to establish practices to be observed to cut cost on power consumption without reducing the coverage area of the FRN stations.

At the end of the conversation, Galvante offered to hire Ramones to be the Broadcast Engineering Consultant of FRN. As Broadcast Engineering Consultant, Ramones would design engineering solutions to address the specific needs of the company. In a month's time, he would need to submit a written report on the design solutions to Mr. Galvante and give an oral presentation in front of the Board of Directors of the company. The engineer eagerly accepted the offer. But after the meeting ended, when Ramones was strategizing his next moves, many questions arose in his mind related to the problems posed by the network's President and CEO: With all the available technologies today, what would the most cost effective technology that served the purpose of connecting all the provincial stations of FRN for simultaneous broadcast, without sacrificing the high fidelity requirement in FM broadcasting? What engineering interventions would be needed -- as well as practices to observe -- to reduce power consumption in each station? As a service-driven and responsible engineer, Ramones had to consider the importance of professional, social and ethical responsibility, as well as the effects of these engineering solutions in a broader perspective in all his proposed solutions.

The Radio Broadcast Industry in the Philippines

Radio broadcasting in the Philippines started in 1922, with the operation of three 50-watt AM transmitters. These transmitters were given temporary permits to operate and were mainly intended for demonstration purposes. They were on air for about two years before the owner replaced them with a 100-watt transmitter to become station KZKZ. From then on, the number of radio stations continued to increase. By 2014, a total of 408 AM radio and 934 FM stations were operating in the country.[1]

Chain broadcasting in the Philippines started as early as the 1970s, initiated by the government-run Philippine Broadcasting Service (PBS) through its Radyo ng Bayan stations operating throughout the country from northern Luzon to Mindanao receiving government subsidy in their operations. The main program emanated from the mother station, DZRB in Manila at 918 kHz at the time. The transmissions of DZRB were received by the provincial stations and then rebroadcast at another frequency (at the frequency of each provincial station). Any of its provincial stations that could receive the transmissions of the Manila station directly would rebroadcast the programs of their mother station. Provincial stations farther away

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[i] Mother studio is also known as the main studio.

from Manila would receive and rebroadcast the transmissions of their sister stations nearer to Manila. This process of reception-transmission would continue until the farthest provincial station was able to receive and rebroadcast the program. However, in 1994 with the widespread use of satellite communication, Manila Broadcasting Company (MBC) spearheaded chain broadcasting via satellite.[2] There were 20 provincial radio stations located in key locations in the country relaying the common program emanating from the mother station DZRH stationed in Manila. These provincial stations receive the common program via satellite and rebroadcast the same in different frequencies where these provincial stations were operating on. DZRH basically covers the whole country in this manner. With the nationwide coverage of DZRH, national advertisers were attracted to buy ads placements. In the AM broadcast band, DZRH was the undisputed top rated station[ii] nationwide.[3] Because of the high fidelity sound offered by satellite systems, several radio networks (both AM and FM) followed the footsteps of MBC-DZRH in chain broadcasting. To name a few was DZMB-Manila, the FM sister station of DZRH, DZRJ of Rajah Broadcasting Network, etc.

The Forefront Radio Network (FRN)

Forefront Radio Network (FRN) was granted a franchise to construct, operate and maintain radio broadcasting and television stations in the Philippines in the 1960s. As of 2016, FRN owned and operated seven FM stations and two AM stations. The FM stations were located in six key cities and one urban municipality in northern Luzon. One of the two AM stations was inactive while the other one was carrying only the programs of its FM sister station. FRN previously owned and operated a UHF television station in the City of Baguio, but recently sold it to another broadcasting company. For now, the network concentrated on its operations with its seven FM stations. Table 1 below shows the specifics of the FRN FM stations that were operating in northern Luzon.

In the political subdivisions of the Philippines, northern Luzon was composed of three regions: Ilocos Region (Region 1), which comprised the provinces of the Ilocos Norte, Ilocos Sur, La Union and Pangasinan; Cagayan Valley Region (Region 2), which comprised the provinces of Cagayan, Isabela, Quirino, Nueva Vizcaya and Batanes; and Cordillera Administrative Region (CAR), which comprised the provinces of Kalinga, Apayao, Ifugao, Mountain Province, Abra, Benguet and the city of Baguio. This part of Luzon was simply referred to as "Norte" or "the north." All the stations, except the one in Solano, (Nueva Vizcaya) had authorized power of 5000 watts. The Solano station has an authorized power of 1000 watts, which was sufficient for the much smaller target area.

Table 1
The FRN Stations in Northern Luzon

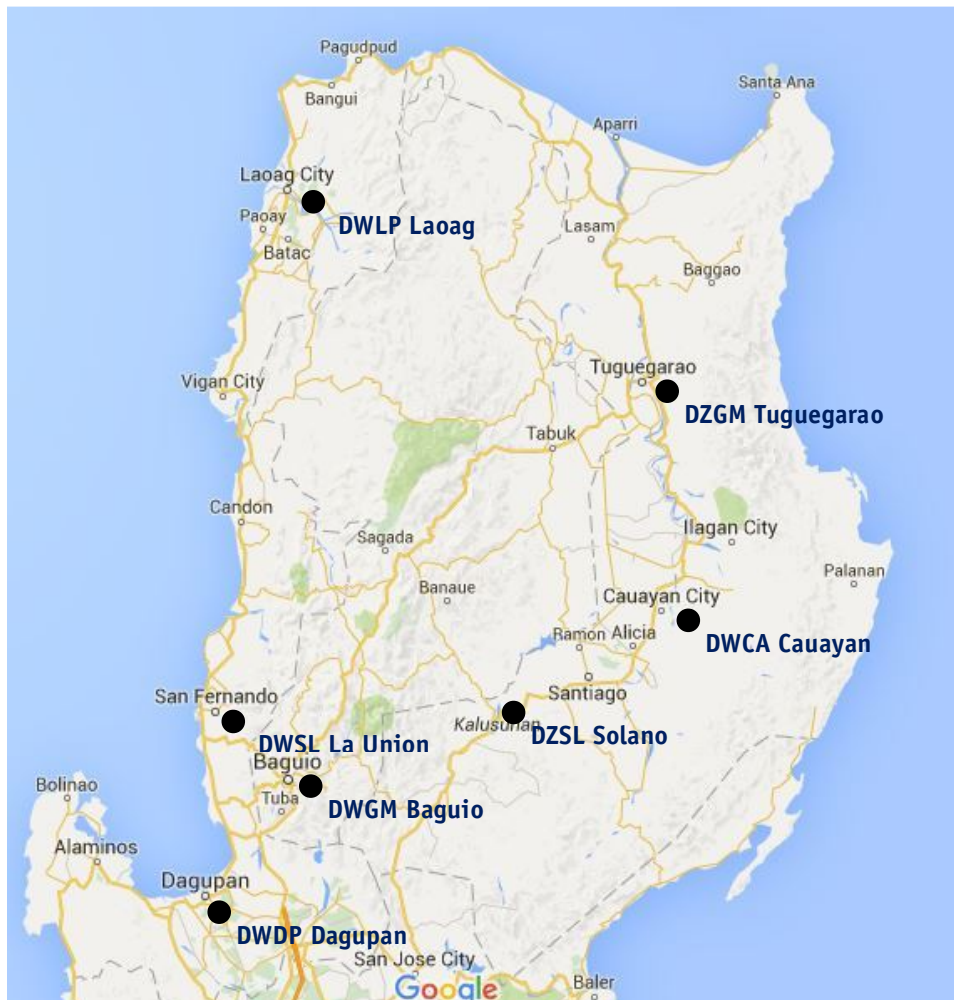| Call Sign	Frequency	Authorized Power	Location
DWGM	94.3 MHz	5 kW	Baguio City
DZGM	99.7 MHz	5kW	Tuguegarao City, Cagayan
DWCA	100.1 MHz	5 kW	Cauayan City, Isabela
DZSL	102.9 MHz	1 kW	Solano, Nueva Vizcaya
DWSL	102.7 MHz	5 kW	San Fernando, La Union
DWLP	96.3 MHz	5 kW	Laoag City, Ilocos Norte
DWDP	101.5	5 kW	Dagupan City, Pangasinan

[ii] No other radio network comes close to DZRH to having 20 relay stations nationwide.

In the early 80s, the revenue for FRN was good, and the profit was equally good. However, because of the chain broadcasting introduced in the 1990s, the competition was so intense that it resulted in a decline of national ads placements to local stations. The local stations just contented themselves with the local ads to support their operations. However, local advertisements were just not enough to support the operational expenses, especially if there were four or more local stations operating in a locality.

The Target Areas

Each FM station had its own target population, mainly targeting the whole population of the whole province. The whole province was therefore the primary service area of each station.[4] Adjoining provinces around the primary area were considered to be secondary service areas. The places where these FRN FM stations operated were acknowledged to be at least one of the following in their respective province or region: financial, commercial, educational, or government centers. The average population in these northern Luzon places was 155,127 based on the 2015 census, spread over an average land area of 135.133 square kilometers. Figure 1 shows the map of northern Luzon where the FRN stations were located.

Figure 1
Map showing the locations of all FRN FM stations in northern Luzon.

Source: https://www.google.com.ph/maps/@17.2352627,121.1204309,8z?hl=en&hl=en. Accessed November 27, 2016

DZGM Tuguegarao

DZGM was located in the premier Ibanag city of Tugegarao, a second class city in the province of Cagayan, Philippines. Tuguegarao was the capital city of the province and the regional government center of the Cagayan Valley Region (Region 2). The population of the city was 153,502, as of the 2015 census. Most of the inhabitants spoke Ybanag, Ilocano, Tagalog, Itawes and other Filipino dialects, including people of foreign descent. The economy of Tuguegarao City had gradually shifted away from agriculture to economic activities over the past few decades. This was due to the role of the city as the regional government and educational center and a major center of commerce in the region. Banks, universities and colleges, commercial and industrial establishments abounded in the city.[5] Because of the proximity of Tuguegarao in the province of Isabela, any FM station from the city could be heard in the northern part of the province.

Cagayan was the second largest province in Region 2, having a total land area of 9,002.70 square kilometres. This area was equivalent to about three percent (3%) of the total land area of the Philippines. The province had 28 towns and a city with a total population based on the 2015 census of approximately 1,111,045, giving an overall population density of about 123 people per square kilometer. While large areas remained uninhabited, very high population density was present in the cities of Tuguegarao, Solana, Tuao, Aparri and Claveria. The specific population in the different towns and a city in the province is listed in Table 2. Further, population density was relatively higher in the lowlands near the riverbanks compared to the uplands'. The relatively uninhabited uplands of the province were in the east by the Sierra Madre Mountain range and to the west by the Cordillera mountain range.[6] Figure 2 shows the locator map of Tuguegarao City and other municipalities in the province of Cagayan as well as the adjoining provinces.

Table 2
Population Distribution in the Province of Cagayan per Municipality/City based on the 2015 census.

City/Municipality	Population	City/Municipality	Population
Abulug	32,497	Lal-lo	44,506
Alcala	38,883	Lasam	39,135
Allacapan	33,571	Pamplona	23,596
Amulung	47,860	Peñablanca	48,584
Aparri	65,649	Piat	23,597
Baggao	82,782	Rizal	17,994
Ballesteros	34,299	Sanchez-Mira	24,541
Buguey	30,175	Santa Ana	32,906
Calayan	16,702	Santa Praxedes	4,154
Camalaniugan	24,923	Santa Teresita	19,038
Claveria	29,921	Santo Niño (Faire)	27,219
Enrile	35,834	Solana	82,502
Gattaran	56,661	Tuao	61,535
Gonzaga	38,892	Tuguegarao City	153,502
Iguig	27,862		
Total			**1,199,320**

Source: <http://www.cagayan.gov.ph/index.php/about-cagayan-home/10-city-and-towns/63-tuguegarao-city> Accessed November 27, 2016

Figure 2

Maps of Cagayan province showing the surrounding provinces, the municipalities/city in the province and the location of station DZGM.

Source: Cagayan Government, "Tuguegarao City" Accessed November 27, 2016 <http://www.cagayan.gov.ph/index.php/about-cagayan-home/10-city-and-towns/63-tuguegarao-city>
<https://en.wikipedia.org/wiki/Cagayan#/media/File:Ph_fil_cagayan.png>

DWCA Cauayan

The station was located in the city of Cauayan, a third class city and a fast-growing rural industrial center centrally located in the province of Isabela and in the entire stretch out of Cagayan Valley region. It was about 117 kilometers air distance south of Tuguegarao City in the province of Cagayan. The city of Cauayan had a land area of 336.4 square kilometers and a 2015 population of about 133,984. The people of the city spoke Ilocano, Tagalog, Gaddang and Ybanag. Major telecommunication companies that operated in the city included PLDT, DIGITEL, PILTEL, BAYANTEL, RCPI, PT&T, BUTEL, Globe, Smart and Sun Cellular Communications. There were four other FM stations operating in the city. Internet connections were provided by the NSCV internet connections plus the MYDSL and SmartBro broadband.[7]
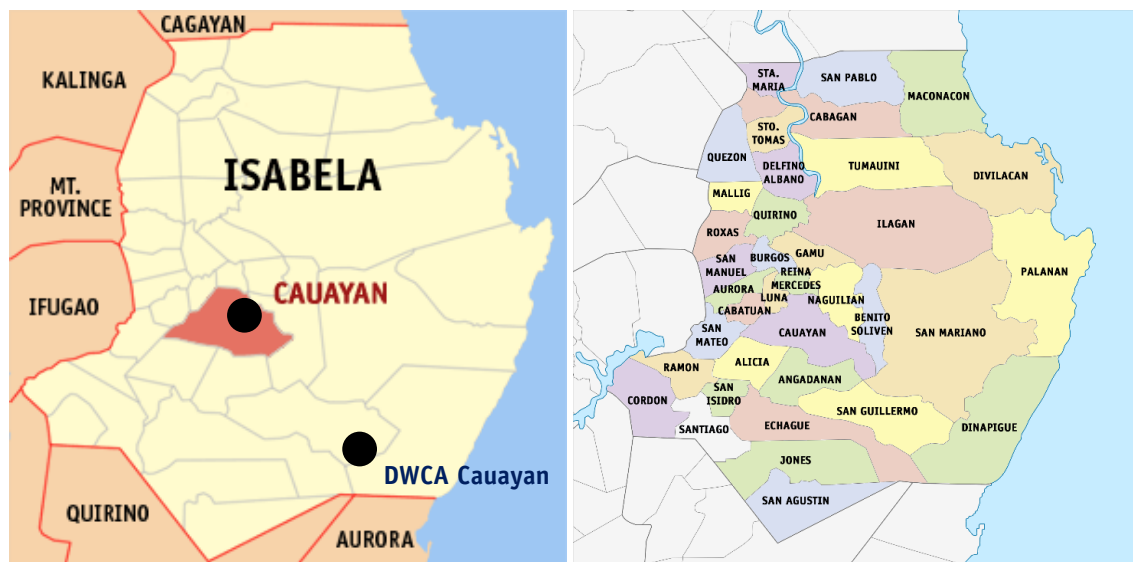
The province of Isabela was the largest province in the Cagayan Valley Region and the second largest in the Philippines. It had a total land area of 10,655 square kilometers, which accounted for about 40% of the region's total land area, with a 2015 population of 1,489,654. It was bounded on the north by Cagayan province; on the west by the Cordillera provinces Kalinga, Mountain Province and Ifugao; on the south by Nueva Vizcaya, Quirino and Aurora; and on the east by the Philippine Sea and the Pacific Ocean. Similar to the province of Cagayan, it was bounded to the east by the Sierra Madre mountain range and by the west the Cordillera mountain range. The population density was also high in the lowlands and dwindling in the highlands. The highlands were generally uncharted with thick forestlands and rugged terrain.[8] High population densities were recorded in the cities and towns of Santiago, Cauayan, Ilagan, Roxas and Alicia. Table 3 shows the population of the different towns and cities in the province. The locator maps of Cauayan City and other municipalities and cities in the province of Isabela as well as the surrounding provinces were shown in Figure 3.

Table 3
Population Distribution in the Province of Isabela per Municipality/City based on the 2015 Census.

Municipality/City	Population	Municipality/City	Population
Alicia	71,504	Naguilian	31,902
Angadanan	43,061	Palanan	17,260
Aurora	35,017	Quezon	25,860
Benito Soliven	29,624	Quirino	24,501
Burgos	23,784	Ramon	52,707
Cabagan	50,174	Reina Mercedes	26,998
Cabatuan	39,413	Roxas	61,773
Cauayan City	129,523	San Agustin	22,880
Cordon	42,926	San Guillermo	20,200
Delfin Albano (Magsaysay)	26,614	San Isidro	24,861
Dinapigue	5,005	San Manuel (Callang)	31,896
Divilacan	5,687	San Mariano	55,370
Echague	79,094	San Mateo	64,505
Gamu	29,904	San Pablo	25,384
Ilagan City	145,568	Santa Maria	25,382
Jones	45,666	Santiago City	134,830
Luna	19,326	Santo Tomas	23,005
Maconacon	4,253	Tumauini	67,650
Mallig	30,459		
Total			**1,593,566**

Source: < http://provinceofisabela.ph>. Accessed December 20, 2016.

Figure 3
Maps of Isabela province showing the surrounding provinces, the towns/cities in the province and the location of station DWCA.

Source: "Political map of Isabela, Philippines" Accessed November 27, 2016
https://commons.wikimedia.org/wiki/File:Political_map_of_Isabela,_Philippines.png

DZSL Solano

DZSL Solano was located in the first class municipality of Solano in the province of Nueva Vizcaya. Solano was the financial and commercial hub of the province. It has a land area of 139.8 square kilometers and a population of 59,517 based on the 2015 census.[9] The population density in the town was relatively high along the national highway and decreased from there. Solano was just about eight kilometers away from Bayombong, the capital town of Nueva Vizcaya.

Nueva Vizcaya was also one of the five provinces of Cagayan Valley Region located in the southernmost part of the region. The province was generally mountainous with three mountain ranges: the Cordillera on he west, the Sierra Madre on the east, and the Caraballo on the south. The Caraballo mountain range separated Region 2 from the Central Luzon Region (Region 3). The province had a population of 421,355 (2015 census) with a total land area of 3,975.67 square kilometers.[10] The population distribution in all municipalities in the province is presented in Table 4 below. Figure 4 shows the locator maps of the municipality of Solano and other municipalities in the province of Nueva Vizcaya as well as the surrounding provinces.

Table 4
Population Distribution in the Province of Nueva Vizcaya per Municipality based on the 2015 Census.

Municipality	Population	Municipality	Population
Alfonso Castañeda	7,940	Dupax del Sur	19,111
Ambaguio	15,250	Kasibu	37,705
Aritao	37,225	Kayapa	23,714
Bagabag	35,501	Quezon	21,056
Bambang	53,433	Santa Fe (Imugan)	16,180
Bayombong	61,512	Solano	59,517
Diadi	18,122	Villaverde (Ibung)	18,507
Dupax del Norte	27,514		
Total			**452,287**

Source: < https://en.wikipedia.org/wiki/Nueva_Vizcaya/> Accessed December 20, 2016.

Figure 4

Locator maps of Solano, Nueva Vizcaya where station DZSL was located. The maps also show the municipalities of the province and the nearby provinces.

Source: Mike Gonzalez, "Map of Nueva Vizcaya showing the location of Solano." Accessed November 26, 2016.
https://commons.wikimedia.org/wiki/Maps_of_Nueva_Vizcaya#/media/File:Ph_locator_nueva_vizcaya_solano.png

DWLP Laoag

DWLP Laoag was located in the City of Laoag. The city had a total population of 104,904 as per 2015 census and was growing at the rate of 1.12%. Laoag had a total land area of 127.4735 square kilometers. Approximately 930.847 hectares of the city were occupied by the urban core or the poblacion, while 11,816.501 hectares were occupied by the rural barangays. Laoag City was the capital of Ilocos Norte province and was the educational, commercial, information and communication center of the province and the rest of the Ilocos Region. The city was accessible through its international airport and international seaport and was identified as an economic zone in the Philippine Economic Zone Authority Law (R.A. 7916).[11]

Ilocos Norte was the northernmost province in the Ilocos Region (Region 1). It was located at the northwest Luzon, bordered by Cagayan to the northeast, Apayao to the east, Abra to the southeast and Ilocos Sur to the southwest. Ilocos Norte faced the West Philippine Sea to the west. To the east of the province was the cordillera mountain range where Apayao and Abra rested. Ilocos Norte had a population of 593,081 in the 2015 census spread over a total land area of 3,467.89 km^2.[12] The population density was relatively higher in the lowlands than in the highlands. Table 5 shows the population distribution of the province per municipality/city based on the 2015 census while Figure 5 shows the location of the city of Laoag in the province of Ilocos Norte and other areas around it.

Table 5
Population Distribution in the Province of Ilocos Norte per municipality/city
based on the 2015 Census.

Municipality/City	Population	Municipality/City	Population
Adams	1,792	Marcos	17,777
Bacarra	32,215	Nueva Era	9,506
Badoc	31,616	Pagudpud	23,770
Bangui	14,672	Paoay	24,866
Banna (Espiritu)	19,438	Pasuquin	28,980
Batac City	55,201	Piddig	21,497
Burgos	9,777	Pinili	17,300
Carasi	1,567	San Nicolas	36,736
Currimao	12,184	Sarrat	25,212
Dingras	38,562	Solsona	24,121
Dumalneg	2,947	Vintar	32,220
Laoag City	111,125		
Total			**593,081**

Source: < https://en.wikipedia.org/wiki/Ilocos_Norte> Accessed December 20, 2016.

Figure 5
Locator maps of Laoag City in Ilocos Norte where station DWLP was located. The maps also show the municipalities and cites in the province of Ilocos Norte and the adjoining provinces.

Source: "Laoag," Accessed December 1, 2016.
https://commons.wikimedia.org/wiki/Maps_of_Ilocos_Norte#/media/File:Ph_locator_ilocos_norte_laoag.png>

DWSL La Union

DWSL La Union was located in the City of San Fernando, a third-class component city and the capital of the province of La Union in the Philippines. San Fernando was the financial, commercial and industrial center of the province. It was also the government center of the Ilocos Region. In the 2015 census, it had a population of 121,812 people with a land area of 102.7 square kilometers. There were 32 banks operating in the city. In addition, Sun Cellular-Digitel, Globe Telecommunications. Inc. and PLDT operated in the area.[13]

Historically, La Union was a province carved from the nine towns of Pangasinan, three from Ilocos Sur and some villages in the Cordilleras. The name La Union indicated the union of towns from different provinces. The province was a progressive and developing province with a total population of 786,653 in the 2015 census in a land area of 1,497.70 square kilometers.[14] Higher population density was noticeable in the coastal towns of the province due mainly to the faster economic progress in these areas compared to the interior towns. Table 6 shows the population distribution of the province in its 19 municipalities and one city. The location of San Fernando City in the province of La Union and the surrounding areas are shown in Figure 6.

Table 6
Population Distribution in the Province of La Union per municipality/city
based on the 2015 Census.

Municipality/City	Population	Municipality/City	Population
Agoo	63,692	Naguilian	54,221
Aringay	47,458	Pugo	19,690
Bacnotan	42,078	Rosario	55,458
Bagulin	13,456	San Fernando City	121,812
Balaoan	39,188	San Gabriel	18,172
Bangar	35,947	San Juan	37,188
Bauang	75,032	Santo Tomas	39,092
Burgos	8,067	Santol	12,476
Caba	22,039	Sudipen	17,056
Luna	35,802	Tubao	28,729
Total		**786,653**	

Source: < https://en.wikipedia.org/wiki/La_Union>. Accessed December 20, 2016.

Figure 6

Locator maps of San Fernando City in La Union showing the location of station DWSL. The municipalities in the province are also shown together with the surrounding provinces.

Source: "La Union Labelled Map," Accessed December 1, 2016,
https://commons.wikimedia.org/wiki/Category:Maps_of_La_Union#/media/File:La_Union_Labelled_Map.png>

DWGM Baguio

DWGM is operated with a power of 5 kW with transmitter and studios located in the City of Baguio. The station had Baguio/Benguet as its primary service area. Baguio City was a highly urbanized city in the Cordillera Administrative region in the Philippines. The present system of social services delivery in the city was relatively well established considering its prominence as the Center of Education in the North. It was one of the Philippines' most profitable and best investment areas through the Baguio City Economic Zone, a Philippine Economic Zone Authority (PEZA) accredited business and industrial park. The city was also the center of investments and business opportunities in this part of northern Luzon. The city population was 345,366 based on the 2015 census, distributed in an area of 57.51 square kilometers. The developed part that lay in the northern half of the city corresponded to the plateau that rose to an elevation of 1,400 meters.[15]

Communication facilities were adequate in the city. These included print, broadcast, postal and telephone services operated by the government as well as the private sector. Flights were available daily through Asian Spirit and Air Philippines. The city had a road network of 315.867 kilometers for its circulation system.[16] Baguio City was located in the southwestern part of the province of Benguet as shown in Figure 7.

On the other hand, Benguet province with La Trinidad as capital was a landlocked province of the Philippines located in the southern tip of the Cordillera Administrative Region in the island of Luzon. It
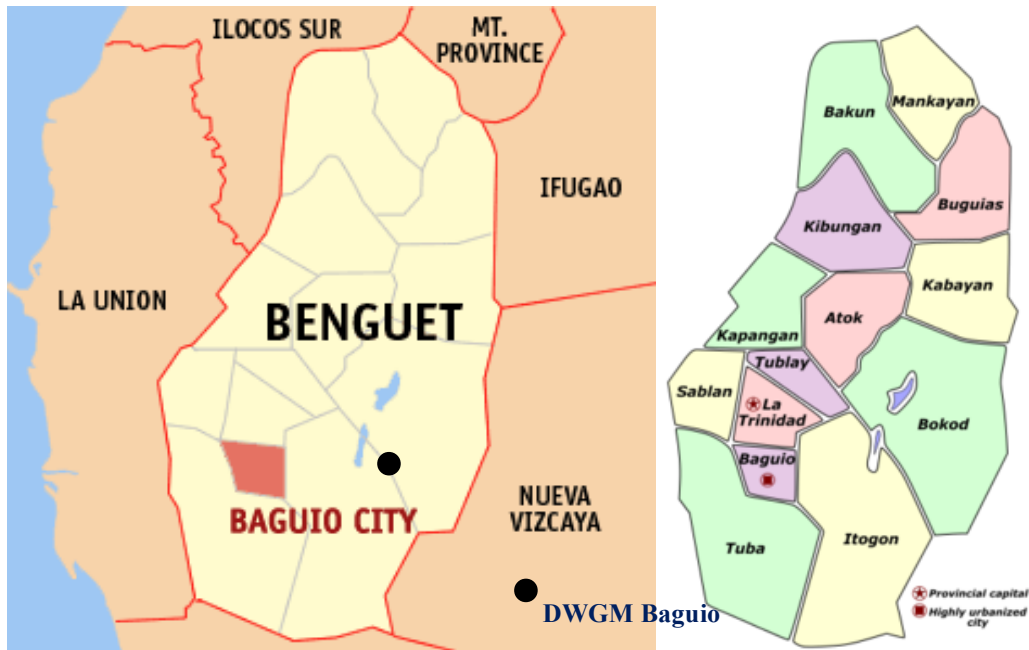
covered an area of 2,826.59 square kilometres (1,091.35 sq mi) to include Baguio City occupying the southwestern tip of the Cordillera Administrative Region. It had a population of 791,590 as of the 2015 census.[17] Table 7 shows the population distribution in the province. Figure 7 shows the location of Baguio City and the municipalities in the province of Benguet and the surrounding provinces.

Table 7
Population Distribution in the Province of
Benguet per Municipality/City based on the 2015 Census.

Municipality/City	Population	Municipality/City	Population
Atok	19,668	Kapangan	19,361
Baguio City	345,366	Kibungan	17,292
Bakun	15,357	La Trinidad	129,133
Bokod	13,756	Mankayan	35,953
Buguis	43,627	Sablan	11,457
Itogon	59,820	Tuba	47,648
Kabayan	15,260	Tublay	17,892
Total			**791,590**

Source: < https://en.wikipedia.org/wiki/Benguet>. Accessed December 20, 2016.

Figure 7
Locator map of Baguio City and the surrounding provinces.

Source: "Labelled Color Map of the Province of Benguet." Accessed December 1, 2016
https://commons.wikimedia.org/wiki/Category:Maps_of_Benguet#/media/File:Benguet_Labelled_Map.png>

DWDP Dagupan

DWDP had an authorized power of 5 kW. Its transmitter and studios were located in the City of Dagupan. Dagupan was a first class city that covered a total land area of 3,723 hectares (9,200 acres) with a population of 150,424 based on the 2015 census. Mother studios of the regional network for northern

Luzon of network giants GMA, ABS-CBN and TV5 were found in this city. The land in the city was primarily for agriculture with 35.98% of the total land area, fishpond, cropland, residential with 22.88%; other uses were commercial, industrial, institutional, government private, parks, and roads. Dagupan became a city in 1947 after World War II. Since the Spanish time, Dagupan had always been the center of education in the region as well as a major fishery, commercial and service, agricultural and industrial center. Presently, the city was an independent city from the province of Pangasinan[18].

The province of Pangasinan was located on the western area of the island of Luzon along the Lingayen Gulf and the West Philippine Sea. It was the sixth most populous province in the Philippines with a population of 2,956,726 inhabitants in the 2015 census and the eleventh most densely populated province. It had four cities and 44 municipalities in an area of 5,451.01 square kilometers. The population distribution of the province in its municipalities and cities are presented in Table 8. Further, all the municipalities and cities in the province were served by telecommunications services with a relatively high telephone density over other provinces in the north.[19] Figure 8 shows the location of the city of Dagupan in the province of Pangasinan and the surrounding areas.

Table 8
Population Distribution in the Province of
Pangasinan per Municipality/City based on the 2010 Census.

Municipality/City	Population	Municipality/City	Population
Agno	27,508	Malasiqui	123,566
Aguilar	39,529	Manaoag	64,578
Alaminos	85,025	Mangaldan	98,905
Alcala	41,077	Mangatarem	69,969
Anda	37,011	Mapandan	34,439
Asingan	56,353	Natividad	22,713
Balungao	26,678	Pozorrubio	66,111
Bani	45,758	Rosales	59,687
Basista	30,385	San Carlos	175,103
Bautista	30,193	San Fabian	77,899
Bayambang	111,521	San Jacinto	37,737
Binalonan	52,832	San Manuel	46,875
Binmaley	78,702	San Nicolas	34,108
Bolinao	74,545	San Quintin	32,626
Bugallon	64,253	Santa Barbara	76,637
Burgos	18,315	Santa Maria	31,091
Calasiao	91,109	Santo Tomas	14,406
Dagupan	163,676	Sison	43,979
Dasol	26,991	Sual	31,216
Infanta	23,455	Tayug	40,018
Labrador	21,149	Umingan	67,534
Laoac	29,456	Urbiztondo	47,831
Lingayen	98,740	Urdaneta	125,451
Mabini	24,011	Villasis	59,111
TOTAL			**2,779,862**

Source: < https://en.wikipedia.org/wiki/Pangasinan>. Accessed December 20, 2016.

Figure 8
Locator Map of Dagupan City in the Province of Pangasinan and surrounding provinces.

Source: "Dugapan," Maps of Pangasinan," Accessed December 2, 2016
https://commons.wikimedia.org/wiki/Maps_of_Pangasinan#/media/File:Ph_locator_pangasinan_dagupan.png >

The Challenge

Engr. Ramones was left with the challenge of presenting a detailed solution to address the engineering needs of FRN. Particularly, he need to identify of the most cost effective method of bringing the common program from the studios of DZGM Tuguegarao to the other six RFN stations. This included providing a detailed plan of implementation of the identified method or methods. Another challenge Engr. Ramones had to solve was to reduce the power consumption of each station, thereby reducing the operating cost. The reduction could be from the transmitter side and/or from the studios.

Endnotes

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