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1. Introduction

Licensed Microwave (6-42 GHz) link deployment has and is projected to continue to grow in all industry segments that rely on receiving data from operations or delivering data to internal and external clients. The heavy and indiscriminate use of unlicensed frequencies coupled with a demand for higher capacity has driven many regulatory agencies to create new channel plans and open new frequencies for fixed PtP deployments. Demand and opportunity have driven a new chapter in what can be called the "Data Sheet Wars" proliferated by manufacturers throughout the world. This white paper will:

A. Separate the facts from the fiction of licensed microwave deployments
B. Provide the operator and engineer with the information they should consider to ensure their deployments meet or exceed both capacity and reliability needs.

2. It's A Zero-Sum Game

The very first thing that needs to be understood is that successful deployment of any wireless system is a Zero-Sum Game. This means that every decision that is made regarding the proposed link, there will be opposite consequence that will have to be mitigated in some form or fashion. No part of the process of engineering, procurement or operation of the link is immune to this fact. However, the two most common areas that need to be carefully planned for are link capacity and link distance. Diligent planning here will ensure that your next link will have the reliability and performance that is desired during operation.

3. Link Capacity

Link capacity requirements are continuing to grow. There are two laws that ultimately govern the capacity that a given link can achieve.

A. The Laws of Man are the local regulatory agency requirements that govern:
   a. What frequency bands are available. (effects range and reliability due to propagation characteristics of given bands)
   b. What channel bandwidths are available. (most dramatic effect on capacity)
   c. What EIRP (effective isotropically radiated power) can be used. (effects range and reliability)
   d. What type of equipment can be used. (effects choice and investment)
B. The Laws of Physics govern the application of technology to overcome the limitations imposed by the regulatory agencies. Some examples of the technology are:
   a. Modulation type (i.e. BPSK, QPSK, QAM etc)
   b. The propagation characteristics of different RF frequencies. (Lower frequencies like 6 GHz tend to propagate better over distance)
   c. The size of frequency bands. (Higher frequencies have more space to create channels in, therefore you can create larger channels increasing capacity)

As you can tell already, there are clear moments when the regulations and the physics are at odds. For example, you have a fairly long link you want to make with a large capacity requirement. The link distance and reliability needs will suggest the use of a lower frequency where you will encounter smaller channel sizes reducing capacity. This will tend to force the use of physics related features like high order modulations to gain back some capacity. This in turn will require the use of lower Tx power settings. Of course, this then leads to a need for a larger antenna to increase output and restore operational reliability!

Confusing? Yes! Frustrating? It can be, but the good news is that separating the facts from the data sheet and marketing fiction and employing the K.I.S.S engineering philosophy will clear up the confusion and reduce the frustration. Let's take a closer look at the facts about link capacity.

Fact Number 1 Channel Size Is Your Best Friend

The single biggest impact on link capacity will be your local regulatory agency. Specifically, it will be the regulations that govern channel size. Channel size is directly proportional to link capacity. For any channel size X with a capacity of Y, all you have to do to double the capacity is double the channel size so a 2X channel will provide a capacity of 2Y. You can clearly see this relationship in the following table taken from our LinX all outdoor licensed microwave system.

	ANSI Channel Bandwidth (MHz) / Capacity (Mbps)								
Modulation	10	20	29.65/30	40	50	60	80	150	160
QPSK	12	23	35	48	60	72	97	182	194
16 QAM	24	48	72	93	117	140	195	366	390
32 QAM	32	63	95	128	160	192	257	482	514
64 QAM	39	79	118	158	198	237	318	596	636
128 QAM	47	94	141	189	236	284	379	711	758
256 QAM	55	109	164	220	275	330	440	825	880
512 QAM	62	125	187	250	313	375	502	941	1004
1024 QAM	70	140	210	281	351	422	564	1057	1127
2048 QAM		155	233	312	390	468	624	1170	1248
4096 QAM			254	340	425	511	681	1276	1361

Capacity based on RFC2544 data, 1518byte packets, IFG & Pre-amble are excluded, without compression. Specifications are subject to change.

Notice that as you move from left to right in the table across channel size, the data rates increase in direct proportion to the channel size. Conversely as you move down any given channel size along the modulation rates, the net gain in capacity continually gets proportionally lower. Moving from QAM1024 to QAM2048 does NOT double capacity. In fact, the capacity gain is only about 10%. Also, keep in mind the zero-sum game. Increasing modulation requires the operator to DECREASE Tx power which impacts link distance and reliability.

Fact Number 2 Compression Just Makes You Feel Good

Most manufacturers, including LinxRF, have some type of header and payload compression you can employ to increase your bandwidth. Header compression is the most effective because header information can be more consistently compressed. Unfortunately, the header is a relatively small part of overall traffic and therefore the effect is not significant.

Payload compression is where you can seemingly achieve big gains, but the effectiveness is not very consistent. Compression works best when the information being compressed is predictable and uniform. Also, payload can contain information that is already highly compressed when introduced into your wireless link. Keep in mind that compression across the radio link introduces processing time as the data enters and leaves the link. This may induce latency and jitter effecting applications sensitive to timing like VoIP.

Now that we know the facts about capacity, we can see that the best technology to implement with regard to link capacity is that which increases channel capacity. The best tried and true way to do this is implementing 2+0 architecture.

4. Two approaches to 2+0

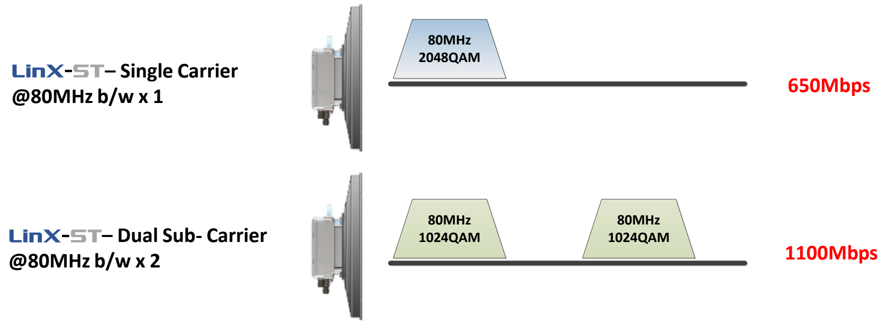
Traditionally a 2+0 link was deployed when capacity requirements could not be met with a single available channel. As the term suggests, deploying a 2+0 link will effectively double the capacity of a given microwave path. Up until recently the only way to achieve a 2+0 link was to literally double the amount of equipment. However today, technology allows for implementing these paths in two different ways.

a. Traditional 2+0

This requires using two radio terminals on each side of the link. On each side the two radio terminals would be mounted on a combiner or most commonly an orthomode transducer (OMT). This method increased cost for the path due to increase equipment needs. It also increased complexity for engineering purposes. Deployment of OMT's also introduces loss at each end of the link, decreasing reliability or requiring the use of a larger antenna increasing cost yet again. For indoor radio equipment, dual wave guide runs were required further driving up cost.

b. Stacked Sub Carrier 2+0

Technology now allows us to get more out of a single Tx/Rx chain. Two independent data sets can now be launched from a multi-core modem in to a single RF chain using two sets of frequency channels. Now you can deploy 2+0 links with ZERO additional hardware cost. As you can see below this technology dramatically increases your link capacity without the added complexity and cost of additional hardware.



Even with reverting to 1024QAM to enable stacked sub-carrier operation, this cutting edge technology provides more for your investment dollars.

5. LinxRF has beaten the Zero-Sum Game! ... No just kidding.

Although that would have been nice, even LinxRF cannot violate the Laws of Man or the Laws of Physics. The Zero-Sum Game is still in play.

When implementing sub-carrier operation, you will be limited to 1024QAM modulation. In addition, because you are effectively spreading the power output over an additional channel, the total Tx power will be 3dB less. This however does not affect the receiver side (passive gain). This may mean that a step up in antenna size will be needed to maintain a desired calculated availability. With regards to the local regulatory environment, you will need to license two separate channels. In addition, your coordinators need to ensure that the two channels fall within the range of a single set of diplexers.

6. Traditional 2+0 made easier and inexpensive with the LinX-DT

The LinX-DT integrates a multi-core modem with two independent Tx/Rx chains and integrated OMT into a single unit whose form factor and most importantly cost is little different from that of a single all outdoor unit. This allows you to deploy traditional 2+0 at a fraction of the cost and complexity of last generations radios systems.

7. Summary

- Facts
  - Channel Bandwidth (largely regulatory limited) is the best way to determine ultimate link capacity.
  - Modulation (largely limited by required link budgets given factors such as distance and weather) provides additional capacity after channel bandwidth.
  - Compression yields such small and inconsistent capacity gains that it would be best to not consider it when planning link capacity. Consider capacity increase due to compression to be a bonus.
  - If 1+0 links will not achieve your capacity and reliability requirements 2+0 operation should be considered.
  - 2+0 links can be achieved
    - Using LinX-ST and dual stacked subcarriers
      - ZERO additional equipment investment
      - Limited to 1024QAM Modulation
      - Must license two frequencies
      - Both frequencies must fit within single diplexer range
    - Must plan for 3 dB loss
    - Using LinX-DT
      - ZERO additional equipment investment
      - Use up to 4096QAM modulation
      - Must license two frequencies
      - Frequencies may be in different diplexer ranges within the band
      - For additional capacity LinX-DT can be operated with Quad Stacked subcarriers.

About LinxRF

LinxRF is a wholly owned subsidiary of Link Technologies Inc. We have over 100 years of wireless and wired network engineering experience in industries such as:

Coop and investor owned utilities
ISP and WISP operators
State transportation departments
Corporate networking
Oil and Gas
Mobile Telecom
Finance
Entertainment

If you desire further information or assistance with any of your networking requirements, please contact

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