Comcast LoRa status
Comcast LoRa Network (machineQ) status

- Comcast keep deploying LoRaWAN network named as “machineQ” at key focused regions for overall nationwide sites (Total 18 cities) to facilitate the development, deployment and integration of IoT sensor technology and solutions. This well managed Network-as-a-Service offering is designed to meet the needs of your IoT solutions.

<table>
<thead>
<tr>
<th>ATLANTA, GA</th>
<th>AURORA, CO</th>
<th>BALTIMORE, MD</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSTON, MA</td>
<td>CHICAGO, IL</td>
<td>DENVER, CO</td>
</tr>
<tr>
<td>DETROIT, MI</td>
<td>INDIANAPOLIS, IN</td>
<td>MIAMI, FL</td>
</tr>
<tr>
<td>MINNEAPOLIS, MN</td>
<td>OAKLAND, CA</td>
<td>PHILADELPHIA, PA</td>
</tr>
<tr>
<td>PITTSBURGH, PA</td>
<td>SAN FRANCISCO, CA</td>
<td>SAN JOSE, CA</td>
</tr>
<tr>
<td>SEATTLE, WA</td>
<td>SAINT PAUL, MN</td>
<td>WASHINGTON DC</td>
</tr>
</tbody>
</table>
Use case of Comcast LoRa Network

- **Victor Digital Matter**
  - Application: GPS tracking
  - Oyster is a compact, rugged GPS tracking device that has been designed for tracking containers, trailers and other assets where super-long battery life is required without sacrificing the frequency of updates and performance.

- **Vlink HQ**
  - Application: Rodent & Pest Trap
  - Easy trap setup and application pairing allows you to get back to business quickly.
  - The quick, high-voltage shock offers a humane alternative to rodenticides.
  - Dual-entry trap design ensures a higher kill rate and increases interaction.

- **Neptune Technology**
  - Model name: L900
  - Application: Water AMI
  - Leverage powerful connectivity to stay lean and resourceful with innovations such as the R900 MIU, the MACH 10 solid state ultrasonic water meter, and the water industry’s first LoRa Alliance certified solution for wide-area AMI networks, the L900 MIU.

- **NetLink Controls**
  - Model name: netLiNK
  - Application: Dimming Lighting Control System
  - netLiNK Reach is teaming LPWAN based on the LoRaWAN protocol to provide a smart sensing and control infrastructure and an all in one auto sensing 120v-480v unit that meets the needs of any site under any circumstance.
## Use case of Comcast LoRa Network

<table>
<thead>
<tr>
<th>Website</th>
<th>Application</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="https://pansofik.com/">https://pansofik.com/</a></td>
<td>Building management system</td>
<td>Smart Building suite of sensor solutions of Pansofik provide real-time monitoring of building mechanical, environmental, electrical and plumbing data enabling building managers to improve tenant comfort and productivity while optimizing operations to lower utility costs by as much as 30%.</td>
</tr>
<tr>
<td><a href="https://www.instapio.com/">https://www.instapio.com/</a></td>
<td>Data Management Platform</td>
<td>Instapio leverages smart signals from the physical world just like cookies from the digital world to build real time consumer profiles for enterprises. Instapio’s proprietary technology and dataset brings real time visibility into consumers.</td>
</tr>
<tr>
<td><a href="https://www.pnicorp.com/">https://www.pnicorp.com/</a></td>
<td>Smart Parking system</td>
<td>PlacePod is an IoT enabled smart parking sensor for on-street and off-street municipal and private parking management. PlacePod solves the most mission-critical aspects of parking management: real-time vehicle detection and location of available parking spaces.</td>
</tr>
<tr>
<td><a href="https://carebandremembers.com/">https://carebandremembers.com/</a></td>
<td>Wearable band</td>
<td>CareBand is a wearable technology company dedicated to reducing deaths and injuries due to dementia-related wandering. CareBand provides real-time precise location tracking both indoors and outdoors, a nurse call button and automated analysis of activity patterns to help caregivers identify early changes in condition.</td>
</tr>
</tbody>
</table>
Use case of Comcast LoRa Network

**Shipley Energy**

https://www.shipleyenergy.com/
- Application: Liquid monitoring system
- Shipley Energy uses the sensor technology to monitor liquid level in propane, oil and diesel tanks. Our easy to use platform allows you to track, manage and respond to liquid levels across a wide-array of tanks and optimize routes to service those customer.

**mesur.io**

https://www.mesur.io/
- Application: Agriculture monitoring system
- We are used by agriculture managers to record and monitor soil moisture levels and temperature, to monitor and assist the process of determining when and where to irrigate and fertilizer their turf.

**SteamIQ**

http://steamiq.com/
- Application: Steam trap monitoring system
- SteamIQ is ubiquitous mechanical devices and their goal is simple: to allow steam to do work via a transfer of latent heat and than allow condensate to drain back to the boiler for reuse.

**ADVEEZ**

http://www.adveez.fr/
- Application: Asset management for airports
- ADVEEZ provides location mapping and usage tracking for cities, airports and other organizations with high-value assets. The module is packaged in a ruggedized housing with a replaceable 5-year battery.
What is ‘mQSPARK?’: It is a plug-and-play development kit for rapid prototyping of IoT solutions as a USB module that is easily plugged into your laptop to configure and power your solution.

How to configure it?: Once plugged into PC, the board can be connected to a power bank for mobility. The mQSpark works with the open source Arduino IDE platform, which allows developers to tap into a huge development community to speed up the process. Additionally, the mQSpark is compatible with the suite of Grove sensors, which have easy-to-use standardized connectors. (mQSpark includes a development board and up to 5 Grove connectors)
What is ‘mQFlex’?: It is a plug-and-play device for quick deployment across multiple IoT use cases. It is a robust LoRaWAN-compliant multi-usage device capable of monitoring temperature, acceleration, pressure, and humidity, and includes a gyroscope and magnetometer.

Key feature: It is compact and has a long battery life (3-5 years), which makes it a cost-effective solution to collect data and trigger threshold detection mechanisms in a wide variety of applications. The device is a low cost, rapid time-to-market solution that can support any business model from use case validation to mass implementation with its easy out-of-the-box configurable capabilities. mQFlex is the easiest way to trial a LoRa device and bring a realized solution to market. (Commercially available May 2018)
New Korea ISM Frequency Band & Regulation (917.1Mhz-923.3Mhz)
New Output Power Plan for Korea IoT Band

1. New Output power plan of each Center Frequency and channel in Korea regulation are defined like below chart.

<table>
<thead>
<tr>
<th>Channel</th>
<th>Frequency</th>
<th>Channel</th>
<th>Frequency</th>
<th>Channel</th>
<th>Frequency</th>
<th>Channel</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>917.1 Mhz</td>
<td>9</td>
<td>918.7 Mhz</td>
<td>17</td>
<td>920.3 Mhz</td>
<td>25</td>
<td>921.9 Mhz</td>
</tr>
<tr>
<td>2</td>
<td>917.3 Mhz</td>
<td>10</td>
<td>918.9 Mhz</td>
<td>18</td>
<td>920.5 Mhz</td>
<td>26</td>
<td>922.1 Mhz</td>
</tr>
<tr>
<td>3</td>
<td>917.5 Mhz</td>
<td>11</td>
<td>919.1 Mhz</td>
<td>19</td>
<td>920.7 Mhz</td>
<td>27</td>
<td>922.3 Mhz</td>
</tr>
<tr>
<td>4</td>
<td>917.7 Mhz</td>
<td>12</td>
<td>919.3 Mhz</td>
<td>20</td>
<td>920.9 Mhz</td>
<td>28</td>
<td>922.5 Mhz</td>
</tr>
<tr>
<td>5</td>
<td>917.9 Mhz</td>
<td>13</td>
<td>919.5 Mhz</td>
<td>21</td>
<td>921.1 Mhz</td>
<td>29</td>
<td>922.7 Mhz</td>
</tr>
<tr>
<td>6</td>
<td>918.1 Mhz</td>
<td>14</td>
<td>919.7 Mhz</td>
<td>22</td>
<td>921.3 Mhz</td>
<td>30</td>
<td>922.9 Mhz</td>
</tr>
<tr>
<td>7</td>
<td>918.3 Mhz</td>
<td>15</td>
<td>919.9 Mhz</td>
<td>23</td>
<td>921.5 Mhz</td>
<td>31</td>
<td>923.1 Mhz</td>
</tr>
<tr>
<td>8</td>
<td>918.5 Mhz</td>
<td>16</td>
<td>920.1 Mhz</td>
<td>24</td>
<td>921.7 Mhz</td>
<td>32</td>
<td>923.3 Mhz</td>
</tr>
</tbody>
</table>

- **Output power per each channel**
  - Under 3mW for UL & DL
  - Under 10mW for UL & DL
  - Under 200mW for Down Link
  - Under 10mW for Up Link
  - Under 25mW for Up Link

- The channels from #1 to #19 (Blue and Yellow) are fixed same output power for Up Link and Down Link with previous Regulation. Because Korea Telecom is using under 917Mhz for their LTE service. So for minimize effect to LTE channel of Korea Telecom, Government just allow to increase the output power from #20 channel.
- All of regulation specs are compatible with previous specs.
Korea Regulation for IoT Band

1. Center Frequency and channel are defined like below chart.

<table>
<thead>
<tr>
<th>Channel</th>
<th>Frequency</th>
<th>Channel</th>
<th>Frequency</th>
<th>Channel</th>
<th>Frequency</th>
<th>Channel</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
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<td>3</td>
<td>917.5 Mhz</td>
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<td>19</td>
<td>920.7 Mhz</td>
<td>27</td>
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</tr>
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<td>4</td>
<td>917.7 Mhz</td>
<td>12</td>
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<td>920.9 Mhz</td>
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<td>7</td>
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<td>31</td>
<td>923.1 Mhz</td>
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<td>24</td>
<td>921.7 Mhz</td>
<td>32</td>
<td>923.3 Mhz</td>
</tr>
</tbody>
</table>

2. Frequency Tolerance is required under $\pm 40 \times 10^{-6}$ from center frequency.
3. Output power is defined in slide 2 & 3.
4. In case of frequency hopping, it needs to use over 16 channels without overlap and occupy time is under 0.4sec per each channel.
5. In case of Listen Before Transmission, it needs to receive or scan the signal over 5ms before transmission and if the received power signal is under -65dBm, it can transmit the signal. And transmission should be stopped within 4s and then do not use this channel over 50ms.
6. If frequency hopping and listen before transmission are not used,
   in case of under 10mW, occupied time of special channel is within 2% of 20sec.
   in case of over 10mW to 25mW, occupied time of special channel is within 1% of 40sec.
   in case of over 25mW, occupied time of special channel is within 0.5% of 80sec.
<table>
<thead>
<tr>
<th>Spurious Emission</th>
<th>Frequency</th>
<th>Limit</th>
<th>RBW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 1GHz</td>
<td>&lt; -36dBm</td>
<td>100KHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Under 200KHz: 3KHz</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Under 400KHz : 30KHz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt; -76dBm (904~915MHz:)</td>
<td>100KHz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; 1GHz</td>
<td>&lt; -30dBm</td>
<td>1MHz</td>
</tr>
<tr>
<td>Spurious Rx</td>
<td>&lt; 1GHz</td>
<td>&lt; -54dBm</td>
<td>100KHz</td>
</tr>
<tr>
<td></td>
<td>&gt; 1GHz</td>
<td>&lt; -47dBm</td>
<td>1MHz</td>
</tr>
</tbody>
</table>
New Korea ISM Frequency Band & Regulation
(940.1Mhz-946.3Mhz)
New Korea ISM Frequency Band
(940.1Mhz ~ 946.3MHz)

1. Frequency Band : 940.1MHz ~ 946.3MHz
2. Frequency Tolerance is required under ±20×10⁻⁶ from center frequency
3. Output power is under 200mW for Up & Down Link both of them
4. Occupied time of special channel is within 0.1% of 1hour (3.6sec)
5. Do not have limitation of channel bandwidth (Will be modified)
6. Do not have LBT specification (Will be modified)

7. Spurious Emission Requirements

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Limit</th>
<th>RBW</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1GHz</td>
<td>&lt; -36dBm</td>
<td>100KHz</td>
</tr>
<tr>
<td>&lt; -64dBm (Average Power) (718Mhz<del>938MHz and 949.3Mhz</del>962Mhz)</td>
<td>100KHz</td>
<td></td>
</tr>
<tr>
<td>&gt; 1GHz</td>
<td>&lt; -30dBm</td>
<td>1MHz</td>
</tr>
</tbody>
</table>

8. Receiver Selectivity (Over value based on below table spec)

<table>
<thead>
<tr>
<th>Frequency(MHz)</th>
<th>Under 25KHz occupied frequency band</th>
<th>Over 25KHz occupied frequency band</th>
<th>BW(kHz) : Total bandwidth of Receiver</th>
<th>Standard sensitivity(dBm) : -107 = 10log BW/16</th>
</tr>
</thead>
<tbody>
<tr>
<td>940.1~946.3</td>
<td>54dB-10log BW/16</td>
<td>60dB-10log BW/16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>946.3~949.3</td>
<td>79dB-10log BW/16</td>
<td>85dB-10log BW/16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Welcome

SX1280/1
Launch 14 March 2017 @EMW

Ultimate Global 2.4 GHz Low Power, Long Range Communication Solution for Low and High Data Rate with Ranging Capability

Long Range Communication in 2.4 GHz
Enable Low & High Data Rate
Long Battery Lifetime
Ranging Engine
Reliable Connectivity
Platform for Solution

» **LoRa 2.4 GHz**
Long Range communication for low data rate in 2.4 GHz

» **BLE 2.4 GHz**
Physical layer compatibility for BLE (PHY layer only)

» **GFSK 2.4 GHz**
A compatibility asset for migration to FLRC or standard FSK use

» **FLRC 2.4 GHz**
A robust long range modulation for high data rate communication

» **Ranging Engine “ToF”**
RF link Security, P2P ranging and positioning solutions

---

Semtech Confidential
Key Features Overview

- **Long Range**
  - High sensitivity down to -132 dBm
  - +12.5 dBm output power with high efficiency PA
  - 144.5 dBm maximum link budget

- **Low Current**
  - <5.5 mA RX current (LoRa), 4.8mA (FSK)
  - 24 mA TX @ +12.5dBm
  - 215 nA Sleep mode

- **Supported Modulation**
  - LoRa – 476 bps up to 200 kbps (Long Range)
  - FLRC – 260 kbps up to 1.3 Mbps (Fast Long Range Communication)
  - (G)FSK/MSK – up to 2 Mbps
  - BLE PHY Layer compatibility

- **Robust Links**
  - Excellent blocking immunity
  - In-band interferer greater than 6MHz IIP3 = -6 dBm

- **Ranging Engine**
  - Time-of-flight functionality, 1 meter accuracy (LoS)
  - Build-in ranging data filtering

- **Low System Cost**
  - Minimal external BOM/matching
  - Package low foot print, 24-pin 4x4

- **Compliant with 2.4 GHz Regulations**
  - ETSI EN 300 440, FCC CFR 47 Part 15, ARIB STD-T66
Main Performance

- **Frequency Range:** 2.4 – 2.5 GHz

- **Bandwidths**
  - LoRa Signal BW: 203 kHz – 1625 kHz
  - FLRC/FSK RX channel BW: 0.3 MHz, 0.6 MHz, 1.2 MHz, 2.4 MHz
  - COMPLEX ADC Bandwidth up to 2.4 MHz DSB

- **Best Sensitivities**
  - LoRa:
    - -132 dBm @ 476 bps (PER = 1 %, 10 bytes)
    - -108 dBm @ 70 kbps (PER = 1 %, 10 bytes)
  - FLRC:
    - -106 dBm @ 260 kbps cr ½ (PER = 1 %, 10 bytes)
    - -101 dBm @ 1.0 Mbps cr ½ (PER = 1 %, 10 bytes)
  - (G)FSK/BLE:
    - -94 dBm @ 250 kbps (PER = 1 %, 10 bytes)
    - -90 dBm @ 1.0 Mbps (PER = 1 %, 10 bytes)

- **RX current modes**
  - Low current mode: 5.5 mA (default)
  - High sensitivity mode: 6.2 mA

- **TX output power**
  - From -18 dBm up to 12.5 dBm
  - 24 mA @ 12.5 dBm
  - 18 mA @ 10 dBm
  - 10 mA @ 0 dBm

- **Phase noise**
  - -117 dBC/Hz @ 1 MHz offset
  - -135 dBC/Hz @ 10 MHz offset

- **PLL**
  - Frequency step 198 Hz
  - Frequency deviation from 2KHz up to 1.5 MHz
Ranging Classes & Ranging Engine

**Peer to Peer (P2P)**

- **PRESENCE**
  - Here or Not?
- **PROXIMITY**
  - Relative Distance

- Point to point with limited information based on direction
- Need movement to determine direction information
- Read distance out of register in RAW data
- Requires algorithms based on uses cases

**PROXIMITY & P2P**

---

**Infrastructure**

- **POSITIONING**
  - "Indoor Localization"

- Infrastructure based with synchronization
- Infrastructure nodes interrogate device using Ranging
- Infrastructure nodes compute time of flight, counteract multipath/fading, and triangulation to determine exact location
- Third party algorithms required
Ranging Engine "ToF"

- Ranging operation is between a master and a slave, all exchanges initiated by master using LoRa modulation.

- Ranging Exchanges with Frequency Shift
  - ~25 measures are needed for an accuracy of approximately 2.5m
  - One measure takes between 1ms and 120ms (depending of data rate)

SF9 1600 MHz = 1 m Ranging Precision after 80 ranging exchanges
Parts, EVK

SX1280 (with ranging)

All 2.4 GHz features including Ranging Engine

✓ LoRa (Long Range)
✓ FLRC (Fast Long Range Communication)
✓ GFSK / FSK
✓ BLE PHY layer
✓ Ranging Engine “Time-of-flight”

> 4 km

SX1281 (no ranging)

Advanced Communication 2.4 GHz features

✓ LoRa (Long Range)
✓ FLRC (Fast Long Range Communication)
✓ GFSK / FSK
✓ BLE PHY layer

SX1280DVK1ZHP (Two units)

Evaluation Kit with touch screen available for $399

✓ Mbed based, Fast adoption
✓ Modems Ping Pong demo
✓ Modems PER demo
✓ Ranging Engine P2P demo
✓ Radio test modes

Eval Kit Touchscreen.png

Evaluation Kit with touch screen available for $399

✓ Mbed based, Fast adoption
✓ Modems Ping Pong demo
✓ Modems PER demo
✓ Ranging Engine P2P demo
✓ Radio test modes
2.4 GHz ISM band Advantages

- Smaller antenna design
- Worldwide band
Technologies Landscape (2.4 GHz)

<table>
<thead>
<tr>
<th></th>
<th>Zigbee</th>
<th>Bluetooth</th>
<th>BLE 5.0</th>
<th>WiFi</th>
<th>SX1280</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nodes</td>
<td>65’000+</td>
<td>255</td>
<td>Unlimited</td>
<td>256+</td>
<td>Unlimited</td>
</tr>
<tr>
<td>Range</td>
<td>10m</td>
<td>10m</td>
<td>100m</td>
<td>100m</td>
<td>&gt;4Km</td>
</tr>
<tr>
<td>Data Rate</td>
<td>20 kbps to 250 kbps</td>
<td>1 Mbps</td>
<td>125 kbps to 2 Mbps</td>
<td>10 Mbps to 1000 Mbps</td>
<td>500 bps to 2.6 Mbps</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>-100dBm</td>
<td>-98dBm</td>
<td>-106dBm</td>
<td>-95dBm</td>
<td>-130dBm</td>
</tr>
<tr>
<td>Life</td>
<td>Years</td>
<td>Month</td>
<td>Years</td>
<td>Days</td>
<td>Years</td>
</tr>
<tr>
<td>Network</td>
<td>Mesh</td>
<td>Mesh</td>
<td>Mesh</td>
<td>Mesh</td>
<td>Mesh/Star</td>
</tr>
<tr>
<td>Ranging</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- **UWB**
- **Wireless LAN WiFi**
- **Bluetooth® BLE / 5.0**
- **ZigBee**

**SX1280**
Enable Star Network for Smart Home Application (Low & High Data Rate)

- **(Transmission speed)**
  - 1000 Mbps
  - 100 Mbps
  - 10 Mbps
  - 1 Mbps
  - 2 Mbps
  - 500 bps
- **(Transmission distance)**
  - 1m
  - 10m
  - >100m
  - >4Km

**Nodes**
- 65’000+
- 255
- Unlimited
- 256+
- Unlimited

**Range**
- 10m
- 10m
- 100m
- 100m
- >4Km

**Data Rate**
- 20 kbps to 250 kbps
- 1 Mbps
- 125 kbps to 2 Mbps
- 10 Mbps to 1000 Mbps
- 500 bps to 2.6 Mbps

**Sensitivity**
- -100dBm
- -98dBm
- -106dBm
- -95dBm
- -130dBm

**Life**
- Years
- Month
- Years
- Days
- Years

**Network**
- Mesh
- Mesh
- Mesh
- Mesh
- Mesh/Star

**Ranging**
- No
- No
- No
- No
- Yes
2.4 GHz Market Applications

- Traditional 2.4 GHz
  - PC peripherals
  - Mobile – sports/health
  - Game controllers
  - Wearable / Medical
  - Hearing aids
  - Security Cameras

- Long Range 2.4 GHz
  - LoRa, FLRC
  - Security
  - Alarm
  - Smart Home
  - Industrial Control
  - Smart Toys
  - Shelf Label

- SX1280 Applications

- Ranging Engine
  - Find kids & pets
  - Outdoor Activities
  - Find & Secure car keys
  - Gaming & Adv. Toys
  - Retail find items
  - Social Networking

- Data Communication
  - Presence, Proximity
  - Low Prices
  - Intensive competition

- Key differentiator
- Long Range, High Data Rate
Focus on Smart Home “Emerging Market”

- **Smart Home** (Home Automation & Appliance)

  **What’s Smart Home is ?**
  - Security, Light control, Entertainment, Energy management, HVAC
  - Garden, Swimming pool, Doors, Windows Management
  - New appliances as of Fridge, Washing, Coffee Machines

- **Who are the players ?**
  - Multiple small companies are emerging with proprietary or standard protocols → We’ll target proprietary protocols first also target the leaders…
Measurement Method

Using SX1280 development kits
LORA Range Advantage
FLRC Range Advantage

- Same data rate
- Same time on air
- 2-3X Range Improvement
Ranging Radiated Precision

1 m RMS Ranging Precision

170 m Line of Sight

Spreading Factor

Bandwidth [kHz]

Radiated
Cable
## Ranging Radiated Accuracy

<table>
<thead>
<tr>
<th>SF</th>
<th>Frequency (kHz)</th>
<th>Accuracy (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF10</td>
<td>1600</td>
<td>0.65</td>
</tr>
<tr>
<td>SF9</td>
<td>1600</td>
<td>0.06</td>
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<tr>
<td>SF8</td>
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<td>0.88</td>
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<tr>
<td>SF7</td>
<td>1600</td>
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### 170 m Line of Sight
LET’S MAKE IT A SUCCESS TOGETHER

THANKS

SUCCESS