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Analysis of Progeny Part 15

Test Report

March 15, 2012

Table of Contents

Table of Contents i
1 Executive Summary 1
2 Device Selection Methodology 2
3 Test Procedure and Result Issues 5
4 Impact of Progeny on Part 15 Devices 9
5 Impact of Progeny on Commercial/Industrial Part 15 Technologies 11
6 Conclusion 14

1 Executive Summary

The engineering consulting firm of RKF Engineering Solutions, LLC (hereafter "RKF") has analyzed the report "Demonstration of Compliance with Section 90.353(d) of the Commission's Rules," filed by Progeny LMS, LLC ("Progeny"). Section 90.353(d) states that approval of an M-LMS system license will be "conditioned upon the licensee's ability to demonstrate through actual field tests that their systems do not cause unacceptable levels of interference to 47 CFR part 15 devices." RKF has examined the field test results, including a review of the devices tested and procedures employed, and has concluded that the field tests are insufficient and do not adequately demonstrate that the Progeny system does not cause unacceptable levels of interference to Part 15 devices. As well, the report has no showing of statistical significance that interference to Part 15 devices will not occur.

RKF's examination of the field testing report has identified several significant flaws in the test plan which cast doubt upon the amount of interference, and the effects of this interference, that Progeny proposed system would cause to Part 15 devices operating in the band. These flaws fall into two broad categories, with the first being the number and types of devices selected for testing and the second being the methodology and test locations employed to ensure that interference is not unacceptable. Moreover, the test procedures outlined in Progeny LMS's report are insufficiently documented and unclear, particularly for commercial/industrial devices.

Additionally, RKF's examination includes an analysis of the amount of interference that Progeny's M-LMS system would cause to Part 15 devices, which leads one to believe that further testing is likely to uncover significant interference to many types of broadly-deployed Part 15 devices. The analysis of the Progeny M-LMS system is based on the technical details provided in their report, and we note that many of the interference mitigation techniques (*e.g.* low data rate messages, activity factors, etc.) that Progeny proposes are not contemplated by current FCC regulations. Our analysis shows that even with these techniques, however, the amount of interference caused to certain Part 15 devices would be substantial.

2 Device Selection Methodology

The tests of the Progeny M-LMS system included a total of 17 devices: 12 consumer devices, such as baby monitors, cordless phones, and wireless speakers, and 5 commercial/industrial devices such as automated meter readers, RFID readers, and similar devices. The test report gives details on how the devices were selected. According to the report, the testing firm used the FCC Equipment Authorization Database to develop a list of potential Part 15 devices operating in the band, specifically looking for Part 15 devices that have been approved for use in the 902-928 MHz frequency band since January 1, 2005. This search resulted in a set of 867 devices (out of 5216 from a search

where date was not a criterion). The list of devices was then further reduced to 17[1] devices chosen at random.[2]

While this selection method might have some merit in certain circumstances, in this instance the method creates a significant risk of missing many Part 15 devices and, thereby, undermining the validity of the test results. By using only devices approved since 2005, the testing team missed a large number of legacy devices, many of which have multiple decade life span, were installed 15-20 years ago and are still operating in the field. Automated meter reading equipment, for example, has been deployed in the tens of millions across the country and many pieces of equipment have a lifetime of twenty years. Devices such as these would not have been included in the random sample and moreover, legacy devices may function and operate differently so to affect the results obtained by the testing.

Additionally, by narrowing the sample to 17 devices from a set of 867, the test team examined less than 2.5% of the devices that have been approved since 2005. And of these 17 devices, eight were either cordless phones or baby monitors, which by itself does not provide a sufficient representative sample of even those Part 15 devices used by consumers, let alone ISM devices. Additionally, the list of devices tested were heavily biased towards specific types of modulation and coding, such as FHSS, DSS and Analog FM, while many Part 15 devices commonly use types of coding that may encounter different problems with the Progeny waveform and hence should be tested. Even if the

[1] The appendix of the report describes a device selection methodology where Progeny took a random sample of 20 devices from the FCC EAS database and developed a further non-random sample of 15 devices. However, it is not clear how this pool of 35 devices was reduced to 17, or if the pools were even related.

[2] An 18th device was selected but could not be tested because Progeny could not control the master controller.

argument that only devices approved since 2005 are reasonable to examine were valid, examining 2.5% is not sufficient to support the conclusion that Part 15 devices will not experience harmful interference from the Progeny system. Furthermore, it is not clear how the 17 devices selected in this step were used. According to the test report appendix, a random sample of 20 devices from the list of 867 were “almost all” commercial/industrial devices. However, the list of devices tested included only 5 commercial/industrial devices. Assuming that those devices were taken from the group approved since 2005 and that all 867 devices were commercial/industrial, fewer than 0.6% of the approved Part 15 devices were tested for unacceptable interference.

In terms of the single AMR device tested, the Progeny test report does not mention whether this device operates as a two-way or fixed device. Moreover, the device uses a digital modulation, is wide-band, and operates on a single channel, while other 902-928 MHz AMR devices use FHSS modulation. These FHSS devices are designed to operate on a select spread of channels. As such, the AMR device tested is not representative of all AMR devices operating in the band, which represents another flaw in the device selection methodology.

Progeny did indicate that it had difficulty procuring OEM, legacy and commercial equipment, but there is no explanation that supports the conclusion that all Part 15 devices will not see unacceptable interference from their very limited sample size.

3 Test Procedure and Result Issues

The Progeny report described several details on the tests performed. However, the test procedure is missing some key details required to evaluate the effectiveness of the testing, particularly for commercial/industrial devices. The test report breaks the devices into two rough categories: “consumer” and “commercial” devices. The report makes the point that the consumer devices are configured as they would reasonably expect to be configured for typical operation. For example, with a baby monitor, the transmitter and receiver would be placed in different rooms of the same home. The test setup for commercial/industrial devices does not provide any details on where these devices were placed for the measurements, making it difficult to evaluate whether these devices were configured in a manner consistent with their typical use. For example, the report does not even mention whether the devices were placed indoors or outdoors, nor where the measurements were performed. The report mentions distance measurements along three “radials,” but the report does not state what the radials correspond to or which direction they went. The report has many photos of tests performed with consumer devices, but no photos of the commercial/industrial device tests. Without these details, it is difficult to ascertain whether or not a typical device would see interference from the tests performed.

What is clear is that the test plan failed for perform a number of important tests. The plan did not attempt to test existing Part 15 deployments, including the effects of the Progeny system on Part 15 devices collocated with the WAPS beacons. The plan also did not test the vehicular location portion of the Progeny system.

In terms of the testing that did occur, there are problems with the test locations for commercial/industrial devices. The Progeny test report states that tests of consumer devices were performed at nine different locations, but commercial devices were tested at only two locations, both of which were very similar. Both were office buildings located between 0.5 and 0.8 miles from the nearest WAPS beacon. While some commercial/industrial devices may be used exclusively in office buildings, not all devices would be. Many Part 15 devices, such as wireless security cameras, SCADA modems, industrial controls, transportation RFID tags, and AMR devices, are typically affixed to the outside or in the basement of a building, which may be a commercial or residential building. Similarly, many different Part 15 devices, *e.g.*, WISPs, mission-critical SCADA, AMR fixed devices, railroad cargo management communication devices, and traffic light controllers, are mounted on power poles (which may place them in line-of-sight to a WAPS beacon). Some AMR devices also are activated and read by utility personnel driving in a truck. None of these situations was tested by the test plan. Similarly, traffic light control systems are found only outside buildings and above ground, which may result in more interference than was tested at the two commercial/industrial device test locations mentioned in the report. By not testing these cases, not all of the typical use-cases for Part 15 commercial/industrial devices are captured by the test plan. Test of such devices (including collocated ones) would have increased the chances of determining possible interference effects of the Progeny system. Additionally, the two commercial test locations were near the same WAPS beacon. As such, the tests would not capture any significant differences between the

beacon equipment, which may impact the amount and frequency (*e.g.,* out-of-band emissions) observed with respect to the Part 15 devices.

An additional significant flaw in the test plan was the beacon Line of Sight (LOS). Table 8 in the report indicates that of the ten locations tested, *none* of the test locations had direct line of sight to a beacon. Two of the test locations – location D and J – had line of sight to the roof. This means that the strength of the interfering signal could potentially be significantly higher than under the tested conditions. For the test locations without line of sight to the WAPS beacons, the interfering signal will be significantly attenuated by diffraction and shadowing, leading to higher signal losses than LOS locations. It is unreasonable to expect that all Part 15 operation would occur in buildings which do not have line of sight to the nearest WAPS beacon.

Another significant issue in the testing concerns what Progeny refers to as the *break case*, where the devices were placed 50 feet away from a WAPS beacon and checked for interference. The report indicates that 7 out of 9 consumer devices detected measurable interference in this scenario, which manifested as a 'shhh' or 'beep' noise in the audio. However, none of the commercial/industrial devices were tested in this scenario. It is reasonable to assume that commercial/industrial devices, which frequently transmit at very low power levels and with low duty cycles, would suffer noticeable interference in this scenario, but by not performing this measurement it is impossible to know what form that interference would take. For some devices, it may result in significantly reduced range, while other devices may become unable to communicate at all. The report states that it is not reasonable for commercial devices to be operating under these conditions, but many 902-928 MHz devices have been widely deployed. AMR devices, for

example, are likely to have been deployed in the same building as the WAPS beacon and may be less than 50 feet away. Additionally, because AMR readers and WISPs are frequently mounted on cell towers, there is a potential for these Part 15 devices to be collocated with Progeny beacons. These devices were not tested in a collocated mode and may react poorly to interference when placed in such close proximity.

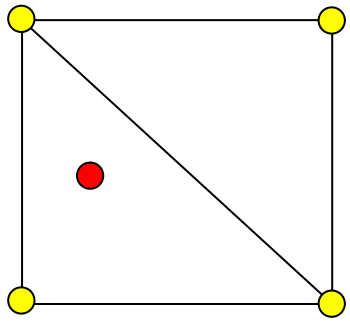
The reported measurements pose an additional source of concern. According to the test report, the commercial/industrial RFID and AMR devices were measured by measuring the range at which the device was still able to be read successfully. However, the measurements have very significant variance, and frequently the measurements are better for the system "off" and system "on" cases. It is not clear whether the measured range is a result of noise in the measurement process (as the report alleges) or was due to some other effect within the commercial device (*e.g.*, switching to another channel with better multipath or increasing the transmit power). The test report does not mention how many times tests were repeated or what the variance in the measurement distances could be. At the very least, measurements where the commercial devices performed better in the presence of the interfering signal deserves further exploration, as this could be a sign that the device has detected the interference and is employing a mitigation strategy such as increasing the transmit power. This mitigation may have an impact on the long-term health of the device, such as battery life, or the device's ability to co-exist with other Part 15 devices without interference.

The Progeny test report states that many devices tested could not be "forced" to use a channel which is co-frequency with the WAPS

beacons. However, it is not clear (particularly for the commercial/industrial devices) which devices could be forced and which could not. In particular for the single AMR device tested, the test report does not state whether the AMR device operates on a single channel and could be forced to use the same frequency as the WAPS beacons, or uses a dynamic transmit channel.[3]

4 Impact of Progeny on Part 15 Devices

To evaluate the impact of the Progeny M-LMS system on Part 15 devices, we performed an analysis using the Hata radio propagation model to develop a model network. We assumed that the WAPS beacons are placed on a grid of fixed dimension, where the dimension varies according to the Hata model. We chose a grid structure because the test report indicates that it is important for devices using the M-LMS system see four beacons. The Progeny report indicates that they can support a system loss of up to 165 dB, so the grid model was spaced accordingly such that every point in a grid square can see the beacons with at most 165 dB of loss.



[3] For instance, this AMR device has a transmitter that is programmable, but it is unclear how that function works for this device.

In this grid model (depicted above; yellow circles are beacons, red circle indicates a Progeny user), the dominant distance is the diagonal across the square. This diagonal must be sized such that at most 165 dB of loss occurs along this distance; otherwise, a user standing below the top-left beacon would not be able to receive signals from the lower-right beacon. According to the Hata model, we solved for 165 dB of loss in both the Urban and Suburban Hata models to get:

Hata Model Type	**Distance**
Urban	6.59 km
Suburban	12.9 km

These numbers were calculated for operations at for 928MHz, a 40m beacon height and a 1.6m tall user. We additionally assumed 12 dB[4] of building penetration, because the Progeny M-LMS system is intended to provide service indoors. Based on our calculations of the distances set forth above, we conclude that the test locations used for Progeny's testing of commercial devices do not follow the Urban Hata model. As such, Progeny may need to deploy its M-LMS beacons more densely than it did with its test system, and it will be difficult to generalize the test results to Progeny's actual operations.

Given these likely dense deployment distances, we also conclude that another potential source of interference from the Progeny beacons would come from overload. Although, as the test report describes, many Part 15 devices utilize sophisticated broadcast

[4] 12 dB is a fairly optimistic assumption for building penetration. Higher numbers would be needed to get deep into a building, which would necessarily require an even denser deployment than described above. This would only increase the amount of interference potential by Progeny. These numbers thus represent the minimal number of beacons Progeny would need to deploy their system.

techniques (such as frequency hopping), the Part 15 receivers need to be sensitive over a much larger bandwidth to effectively receive everything. As such, these devices are sensitive to overload, particularly since the M-LMS systems are such higher power than Part 15 devices. Overload numbers are frequently highly proprietary and confidential, but using a typical number for a digital wide-band system (> 5 MHz) of -35 dBm, a free-space propagation model, and the 30W beacon power described in the report, the Progeny system would cause an overload to any device within 0.25 km of the beacon. It's important to note that this overload is fundamental to any device operating in the band and will occur at *some* power level for any device, irrespective of the broadcast technique (e.g. frequency hopping) used. Overload will be a particularly significant concern for Part 15 devices which are co-located with WAPS beacons.

5 Impact of Progeny on Commercial/Industrial Part 15 Technologies

In terms of the number of deployed devices in the 902-928 MHz band, many commercial/industrial technologies have the potential to be most affected by the Progeny system. There are hundreds of millions of commercial devices deployed today and many of these have a very long lifetime (measured in decades). These two facts combine to make the interference to many commercial systems not a question of *if* it will have an effect, but more of what effect it will have on these systems.

The Part 15 testing performed with the current Progeny system has made the assumption that many commercial/industrial systems are:

- Used indoors and read by a mobile, hand-held or fixed network device that gives feedback on whether transmissions were successful.
- Operate at least 0.5 miles (0.8 km) away from the nearest WAPS beacon.
- Utilize frequency hopping or digital spread spectrum to avoid interference.

Unfortunately, none of these facts is true for all (or even most) commercial/industrial systems, and the potential number of devices that do not fit all three assumptions could number in the millions. Many commercial/industrial devices are pre-programmed to "bubble-up" at a fixed intervals, and the transmissions will be picked up by either a fixed receiver (attached to, for example, a telephone pole) or a vehicle-mounted unit. These devices are frequently attached to the outside of a structure and are equally likely to be used in commercial or residential environments. Commercial/industrial systems are so ubiquitous, in fact, that the tower where the WAPS beacon is deployed may very well include a commercial/industrial Part 15 device or two. Also, many of these Part 15 devices are centered, and only frequency hop, in the middle of the 902-928 MHz band; thus, M-LMS beacons located close to the center of the band (such as the Progeny system) would have a greater impact on these devices.

As described in the test report, Progeny has voluntarily chosen to utilize a low duty cycle (20%) to reduce interference and decrease the

probability of interfering with devices. However, the proposed Progeny system has a duty cycle that is deterministic and follows a fixed pattern (which repeats each second) for each beacon. Many commercial/industrial Part 15 devices in general, do not employ two-way communication and instead use a “fire+forget” model to communicate with a reader device. They avoid interference by transmitting on a fixed schedule, such as every four or seven or ‘x’ seconds. Since these patterns generally follow a fixed, integer second transmit schedule, and the Progeny beacons employ a similar repeating schedule, it’s possible that many devices will be active at the same time. If this occurs, the device will effectively be rendered inoperable because all of its transmissions would be simultaneous with the Progeny broadcasts and hence none of the data will be received. Moreover, many different commercial/industrial Part 15 devices that are broadcast-only have no way to report that they have received interference and will never change the broadcast schedule. The tests performed by Progeny did not include enough variety of commercial Part 15 devices to observe this sort of behavior, as they only tested four () commercial/industrial devices. This problem will only be exacerbated by a full deployment of the Progeny system. As described in the previous section, our analysis of the system indicates that beacons will be deployed with a separation of at most 6.5km to provide LMS service. However, measurement accuracy would improve with higher deployment densities and it is likely that additional base stations will be required to fill in where there are dead spots and to improve overall measurement accuracy. With a full Progeny deployment, as discussed above, commercial/industrial Part 15 devices may be seeing four (or

more) different beacons, each with a different 20% activity cycle, greatly increasing the chance of a simultaneous transmission.

6 Conclusion

RKF finds that the testing performed by Progeny as part of the 90.353(d) requirements cannot support the conclusion that Part 15 devices will not experience unacceptable interference from the Progeny network. There are many areas where the testing was insufficient, including:

1. An insufficient number of Part 15 devices were tested, and the devices tested were not fully representative of the Part 15 environment.
2. Significant details were missing from the test plan.
3. The test plan did not cover all expected uses for Part 15 devices.
4. Commercial/Industrial devices were not tested very close to the WAPS beacon.
5. No test locations had direct line-of-sight to a WAPS beacon.
6. Test deployment was not as dense as potential future deployments.

In conclusion, the report lacks sufficient evidence that the proposed system will not cause unacceptable levels of interference to Part 15 devices, and in fact, there is good reason to believe that the proposed service will cause unacceptable levels of interference to broad (and heavily deployed) classes of Part 15 devices.

CERTIFICATION OF PERSONS RESPONSIBLE

FOR PREPARING THE ENGINEERING INFORMATION

SUBMITTED IN THIS REPORT

I hereby certify that I am a technically qualified person responsible for the preparation of engineering information contained in this filing, that I am familiar with Part 15 of the Commission's rules, that I have prepared or reviewed the engineering information submitted in these reply comments, and that it is complete and accurate to the best of my knowledge. I am a registered Professional Engineer. My seal is attached.

By: _____

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I hereby certify that I am a technically qualified person responsible for the preparation of engineering information contained in this filing, that I am familiar with Part 15 of the Commission's rules, that I have prepared or reviewed the engineering information submitted in these

reply comments, and that it is complete and accurate to the best of my knowledge.

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