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Hardware Development —

Best Practices to Provide Successful Outcomes

White Paper

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12/02/09	V1.5	Updated with new terminology, removed IEEE requirement information as longer necessary
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12/08/11	V1.9	General updates of contacts.
01/19/2012	V2	General update of contacts and web sites.
11/22/2013	V3	General content and contact updates, new header.

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1. Abstract

New entrants to wireless device design and manufacturing face the challenge of technical certification before gaining access to AT&T's wireless network, the nation's fastest and most reliable 4G LTE network.[1] AT&T's policy of open access welcomes devices and applications that broaden the choices of our wireless customers to reach people, information, and entertainment anytime and almost every place. That's why AT&T seeks to help original equipment manufacturers (OEM) certify new products. The certification process is designed to provide the fastest, safest, and surest path to market for emerging devices while protecting the AT&T network and customers.

1.1 Audience

This white paper is designed for new developers and entrepreneurs who plan to bring a wirelessly enabled device to market on AT&T's wireless network as well as those OEMs who need additional information on the AT&T technical approval process.

1.1.1 Goals of This White Paper

This white paper provides readers with guidance on how to best navigate the various certification requirements — like FCC and PTCRB — for accessing AT&T's wireless network. Ultimately, by helping you move through the list of needed certifications, AT&T wants to provide guidance around some common pitfalls that can cause delays for first-time device developers.

Note: The focus of this document is on Data only and data + voice devices.

2. Introduction

As the demand for data usage expands, AT&T expects growth in the emerging device category. According to Strategy Analytics, sales of U.S. wireless embedded consumer electronic devices are expected to exceed 105 million by 2017. Emerging devices are devices that AT&T might not stock, or independently sell to consumers, but that have received technical approval from our Network Ready Lab. These devices may support either consumer or enterprise mobile applications. Whether or not sold by AT&T, the Network Ready approval assures the OEM that the end-user will have an optimal mobile broadband experience on AT&T's network.

[1] 4G LTE speed claim based on national carriers' average 4G LTE download speeds. Reliability claim based on data transfer completion rates on nationwide 4G LTE networks. 4G LTE availability varies.

Tablets and tracking devices with integrated wireless modems are some common examples of emerging devices. Many special-purpose solutions also will drive the development of emerging devices. Examples of some of these special-purpose solutions include: vending machines signaling for stock replenishments, home electric meters sending usage data to utility companies for billing purposes, parking meters signaling time expirations, specialty handheld devices used by courier service personnel, and even court-ordered GPS ankle bracelets used for tracking offenders under house arrest.

3. Open Access is Key

With tens of thousands of applications and over 1,800 devices approved to run on our network, AT&T operates one of the largest and the most open wireless networks in the United States. AT&T supports a variety of wireless data technologies including EDGE, HSPA+ and LTE.

Our customers can choose from a broad selection of wireless device choices, at affordable prices, with fast and reliable access the information from virtually anywhere. To meet these demands AT&T works with many wireless platform makers by offering them open access to our network. We work with some of the most popular technology innovators, such as Android™, Apple®, BlackBerry®, Windows® Phone, and many others.

Chances are that if you're reading this white paper, you probably have a great idea for a wireless solution based on a special-purpose application, hosted on an innovative wireless device, with some possible cloud computing implications to consider. It might make use of simple, data-only telemetrics between machines, often called machine-to-machine (M2M) communications. Or it might involve both data and voice communications, which can be much more complex.

Either way, we are sure you're interested in learning how to get your device through the required certifications needed to connect to AT&T's network – mainly FCC, PTCRB, and AT&T Technical Acceptance - so you can get it into the marketplace as fast as possible.

4. Ensuring the Best Mobile Broadband Experience

We also assume that you want a great mobile broadband experience for your customers, just like AT&T does with its own branded devices. Quality of service is a priority for AT&T. If your device works properly on AT&T's network, our mutual customers can receive an exceptional user experience. The Network Ready certification and testing program is designed to make sure that your device performs as expected, with no harm to end-users or to the AT&T network. It lets both of us capture support information and device details needed to support customers after you've deployed.

To help you succeed from both a technical and business standpoint, we've interviewed a number of people in the certification process, including both inside AT&T's own certification lab and outside experts, as well as some of our most successful special purpose device manufacturers.

5. Best Practices to Guide You

From our conversations with device developers and module manufacturers, we've compiled what we believe are the best practices in how to design and engineer a wireless device with an emphasis on making the certification process as painless and fast as possible. In the following sections of this white paper, we will share with you what we've learned. We've included information on how to engineer for success, a primer on the certifications needed, guidelines for success, and some pointers and resources to help you with your go-to-market strategy.

Although we will cover a lot of information in this white paper, please keep in mind that it is only an overview and not a specific blueprint for designing a wireless device, developing a test plan, or guarantee for certification. We hope that you will find this information useful and valuable. You'll find that we will repeat four main themes throughout this paper that you should keep foremost in your thinking as you prepare to design and engineer your device:

- **Use an AT&T approved module in your device.** AT&T strongly encourages that you use approved wireless radio modules in your device. AT&T approved modules are those that have already received Network Ready approval and therefore have the best foundation for receiving FCC, PTCRB, and AT&T approvals because they are designed to perform optimally on AT&T's network. These are core sub-assemblies from a variety of third-party manufacturers. A wide range of approved modules are available for just about every purpose you can imagine. They are engineered and manufactured to the highest standards, not only to provide most, if not all, of the key functionality your device will need but also to help you pass the required certifications much more quickly, and at a lower cost than using a module or chipset that has not been approved by AT&T. For a complete list of AT&T approved modules and module manufacturers, visit: http://www.att.com/modules

- **Use high-quality, off-the-shelf components as much as possible.** Sub-optimal performance and radio interference from your antenna and power supply are two common pitfalls you can avoid if you select these components from proven manufacturers. Our experience has shown that cost-cutting at the expense of quality or using unproven components will lead to costly delays. High-quality, off-the-shelf components typically have more technical support options and are usually more widely available.

- **Contact AT&T early in your design and engineering stages.** AT&T is here to help you succeed and we invite you to contact us as early as possible in your design and engineering stages. The earlier you take certification compliance into account, the more likely that you'll get through certification faster and with the least amount of cost.

- **Make friends with your suppliers and testing service providers.** Your suppliers and testing service providers have a wealth of knowledge about the complexities of wireless design and engineering. Don't be shy about tapping into their expertise. AT&T has also teamed up with leading equipment

makers like Sierra, Telit, Huawei, and SIMCom to help lower barriers to 3G and 4G adoption with exclusive pricing for HSPA, HSPA+, and LTE technology available through the Mobile Broadband Accelerator Program. These and other module makers provide complete value-added engineering consulting services to help you select the right module for your device, and they can evaluate your designs and engineering to prepare you for certification testing. Many third-party test labs also will provide pretesting services to help you achieve successful certification for your product.

- **Identify experts early to assist in unfamiliar areas.** AT&T encourages you to seek out expertise for areas that you are not familiar with, beyond module and component suppliers. Consulting partners are available who can assist with antenna design, module integration, testing, and project management. Bob Witter at Device Solutions explains "Knowledge of the entire process and availability of engineering subject matter experts significantly reduces the time from concept to technical acceptance."

5.1 Engineering for Success

In researching this paper, we spoke with a number of device developers; among them was the lead engineering team from Psion, Inc. (http://www.psion.com/us/), a top provider of rugged yet highly sophisticated AT&T approved mobile computing solutions to a range of industries worldwide. What we heard from them about device engineering best practices echoed what others we spoke with said: "Build what your customers will buy."

> **"Build what your customers will buy."**
>
> *— Psion, Inc. Product Development Team*

That advice seems straightforward enough. Yet we encounter many device developers who have what they believe is a good idea, but they never validated its value with their customers or prospects before jumping into feature specifications and systems design. What follows is a discussion of the different kinds of devices you may be considering. We also provide more tips on "engineering for success" and a look at AT&T approved modules which can help accelerate your time-to-market.

5.1.1 Best Engineering Practices

This section offers insights from interviews conducted by AT&T with several of its device makers about the principles they use to engineer their devices for optimal performance and streamlined technical approval process.

What's clear from our discussions is that selecting the right suppliers for each key component is a critical first step in their procurement, because the suppliers themselves can provide helpful advice on which component model will provide the best engineering outcome and best overall price performance.

10 Keys to Success

1. Understand clearly the product requirements of the market and your customers.
2. Determine early on if your device is data-only or data-with-voice.
3. Choose an AT&T approved module.
4. Take a systems approach to RF.
5. Draft your certification plan early and include it in your development plan.
6. Contact AT&T and your choice of a third-party test lab early and establish open relationships with both.
7. Share and tightly coordinate your plans with carefully selected technology partners, especially your module, antenna, and power suppliers.
8. Adhere to industry standards.
9. Establish performance criteria at the highest levels possible.
10. Test, test, test.

—Psion, Inc. engineering team

6. Hardware Considerations

6.1 Approved Modules: Accelerating Time-to-Market

AT&T strongly encourages the use of AT&T approved modules. For a complete list of AT&T module suppliers, refer to Appendix A.

Why should you use AT&T approved modules? First off, we want you to succeed. AT&T approved modules take much of the complex "heavy-lifting" tasks out of RF design and engineering, because these modules are made to the highest performance standards by experienced and proven vendors. Their features typically include multiple interfaces, high-quality PCB mounting capabilities and other highly optimized capabilities developed over years of experience.

Modules for every device. AT&T approved modules from our highly qualified suppliers are available for just about every device — automotive, facility management, fleet management, healthcare, logistics, metering and remote monitoring, security, mobile computing and telephony, traffic management, and vending machines.

General purpose modules include a range of multi-band functionality. Many of them feature built-in Java platforms for onboard application development. Special purpose tracking modules can provide GPS capabilities integrated with their core radio features. Automotive modules are purpose-built for rugged, long-lasting performance.

Invaluable guidance. Some of the module makers listed in Appendix A can provide value-added professional services, as well. For example, their engineering specialists can help you develop your device requirements in such a way as to create a tight correlation between your market and your

technical specifications. They can offer an in-depth review of your initial design schematic plus your PCB design and help you source proven, off-the-shelf components. Last, they can provide pre-certification testing services and can introduce you to well-qualified, eager-to-help, third-party testing labs.

Cinterion Software Application Engineer Loic Bonvarlet, who helps lead Cinterion Wireless Modules U.S. presence, says he and his colleagues can help steer developers away from poor design by reviewing their schematics early. "While we can't ensure that your design will ultimately pass PTCRB testing," he says, "we're experienced enough to tell you if it won't. And if that's the case, we can help you with suggestions to make it work."

> **"If you don't use a highly reliable module maker, you stand a high chance of failure"**
>
> *— Psion, Inc. Product Development Team*

Maan Ghanma is the CEO of CETECOM in the USA, a major PTRCB qualified testing lab. Maan has over 20 years of experience and was responsible for PTCRB certification testing at CETECOM for many years. He stated that "Many module integrators, especially newcomers, are unaware of GSM's extreme RF sensitivities. We also see them unaware of the RF effects of the various interconnect lines such as LANs, wireless, electrical — they all act as RF radiators, especially in the lower 30 MHz to 1 GHz frequencies. We can help them sort all this out and design in various RF blocking schemes."

Faster time-to-market. AT&T approved modules will save you enormous time and effort in your device development which, in turn, can result in faster certification at the least cost. The absolute last thing anyone bringing a device to market wants to discover in late-stage testing is a shortcoming in its systems design and engineering that sends the project back even a few steps, much less to its starting point.

6.1.1 Additional Module Considerations

Physical Dimensions of the Device

The physical dimensions of a wireless device (also referred to as the footprint) should be carefully considered if you are embedding a module in your device. For example, it is important to determine if you have sufficient space on the inside of the device for the module. If you have ample space on the inside, determine if there are any potential interference risks of the module on the device. Your development team should also keep the following questions in mind as you design and prototype your device. Does your device require special grounding for the RF sections? Does your device require isolation of audio, signaling and the circuitry? What type of antenna and battery will your device

require? Internal antennas and certain types of battery designs will take up space that needs to be understood as you design your device. Understanding your devices physical dimensions can help you avoid potential interference impacts, costly delays, and mistakes.

Using non-AT&T Approved Modules

There is no cost to manufacturers for AT&T Network Ready testing for Integrated Devices that utilize an AT&T Approved Module. However, you could incur non-AT&T costs to resolve any issues that are discovered during the testing process. Integrated devices that do not utilize an AT&T Approved Module are subject to a fee from AT&T of $175K as well as a longer approval process.

6.1.2 Mobile Broadband Accelerator Program

The Mobile Broadband Accelerator Program helps lower the barriers to 3G/4G adoption by expanding our lineup of Network Ready 3G/4G modules to include lower cost, high performance options, offering next generation consumer electronics and machine-to-machine (M2M) device makers access to a more efficient path to production. We've teamed up with leading equipment makers like Sierra, Telit, Huawei and SIMCom to offer a suite of mobile broadband modules.

6.1.3 AT&T Connection Kits for Device Developers

Designed in cooperation with our partners, AT&T Connection Kits for Device Developers provide a dedicated environment for developers to test and refine device design and performance, using real network feedback.

AT&T has two versions to choose from at https://att.m2m.com - the Benchmark Kit, and the Modules Kit. Each kit features a selection of AT&T approved modules.

6.2 Antennas

Device antennas can either be external or internal and must be multiband. External antennas are typically less expensive, less complex, and tend toward greater efficiencies. They also are easier to certify due to having less interference with other device components and line connections.

Internal antennas can come in a variety of sizes, bands and efficiencies to provide design and engineering flexibility. That kind of flexibility is vital to success because so many factors can influence transmission efficiencies and generate RF interference such as the device's housing materials, its line connections, and its PCB trace paths and lengths. Of course, antenna efficiency also factors into determining your device's power requirements.

Devices with either internal antennas or external antennas which are to be located less than 20cm form the device, are required to have radiated RF Performance / OTA (Over The Air) Antenna Performance (TRP/TIS) testing done for both 850 MHz and 1900 MHz bands by a CTIA accredited lab

prior to entering for AT&T certification. Total Radiated Power (TRP) is your devices' transmit power, and its receiver sensitivity, called Total Isotropic Sensitivity (TIS). TRP/TIS must meet or exceed specified values.

For more information, refer to the technical brief called Antenna Fundamentals.

6.3 Power Sources and Management

Your device will need power and its source will depend on your application. External power supplied via AC or DC current are typically associated with fixed devices like those used in facilities and security management, although automotive and transport applications may charge themselves from the vehicles' on-board generators. Other mobile device applications, whether mounted or hand-held, will be powered by rechargeable batteries. Batteries used in these devices are typically lithium-ion.

The items consuming the most power on mobile devices are: backlit displays, voice activity, data transmission, data reception, and computations. Typically sending data consumes more power than receiving it. Power requirements for data-only M2M Devices can be somewhat predictable, depending on the specificity of other applications. In contrast, power needs of data-with-voice devices can vary greatly depending on their implied use by humans, plus computational and user interface demands of the device application(s).

Like with any mobile device, devices can lose power due to battery depletion or failure. Although there have been some significant advances in battery designs and to their discharge rates, applications should allow for a graceful recovery as well as periodic data synchronization to minimize data loss.

6.4 The Human Interface: Keyboards and Touch Screens

If your device will involve human interaction, you must carefully consider how your users will interact with it – the user interface. You have to provide ways to navigate its features and input as well as access data and information. Whereas many phones have a variety of keyboard designs, the standard for non-stocked devices is a QWERTY keyboard. For devices that often include signature capture or filling out forms, it is very common for devices to support a touch screen. These screens can add design complexity, but many mobile solutions require this functionality.

6.5 Security

The topic of network security is beyond the scope of this paper. Please refer to the Enterprise Reference Library for comprehensive information.

Security of both the AT&T network and customer data is a fundamental issue that you must consider from end-to-end, with the strength of the proverbial chain only as strong as its weakest link. We think about that chain in five segments: the device, airlink, carrier networks and IT systems, connectivity outside the carrier, and corporate IT systems inside its enterprise.

Of the five segments, the device is typically the weakest segment in the security chain because it's the only component in the entire security architecture that the average user can corrupt – intentionally or not – via unsafe downloads, disabling local client protections, turning off local authentication, removing or disabling virus protection and so forth.

What's more, if devices are lost or stolen, they could give attackers access to data stored locally on the device. Should the device have business applications on it, attackers could hack into corporate IT systems.

For all these reasons, you must design and engineer your device with measures to protect, monitor, control and enforce policies on it. At the same time, you want to avoid making its security so impenetrable that usability is adversely affected or users try to defeat its security features simply to use the device. Again, the Enterprise Reference Library can provide much more information on this important topic.

6.6 Ruggedization

Many AT&T approved devices are subject to harsh environments: outdoors with temperature extremes, humidity, precipitation, weather-induced electrostatic EMI, industrial environments subject to varying degrees of dust, dirt, temperature extremes, humidity, machine-induced vibration, EMI, and mobile environments that can combine some of the previous environments. If the devices are intended for human use, they need useful, ergonomic interfaces that are also designed to withstand these environments, not to mention frequent bumps and occasional drops.

Ruggedization is not an aftermarket option for these types of devices. It must be designed into the device from the start, given a clear understanding of user and application requirements. Obviously black-box telemetry devices placed in fixed-position (such as hotel vending machines) don't need the same degree of engineered ruggedness as a multipurpose device used by mobile field workers (or the

military). In fact, “MIL_SPEC” (or MIL_STD) refers to a long list of U.S. military specifications for all kinds of gear to ensure their ability to withstand the extreme rigors on and off the battlefield.

Special care should be taken when designing any device that could be deployed in potentially explosive atmospheres. That’s wherever a spark, hot surface or any other thermal or electrical ignition source could trigger an explosion. If this is the case, you must concern yourself with ensuring that your device is “intrinsically safe” according to standards that apply to any equipment capable of generating one or more of such defined potentially explosive ignition sources such as electrical sparks, arcs, flames, hot surfaces, static electricity, friction and so forth. Devices certified as “I-Safe” are designed to be unable to release sufficient thermal or electrical energy to ignite flammable gas, dust or other particulates.

Note: AT&T does not require your device to be certified as intrinsically safe, but your market and customers may demand that. Details on this can be found at: http://www.iprocessmart.com/techsmart/tech_standards.htm.

Tough enough? The design and engineering of “ruggedized” devices can purposefully fall short of MIL-SPEC standards, yet still provide devices tough enough to withstand extraordinary environments and outlast the average life span of similar devices. What’s required, however, is an extensive knowledge and experience in the use of materials, components, sealing techniques, PCB construction, fasteners and connectors, heat flows, maintainability, and much more — not counting RF, power, and ultimately FCC, PTCRB, and AT&T certification.

Ruggedness as an aggregate of all these considerations must be tested in multidimensional ways, including single components, sub-assemblies, and final assemblies. Devices must be subject to temperature extremes, drop-shock and vibration tests, water, and dust tests. Various standards exist including the IP Code defined in the international standard IEC 60529 for moisture and particulate ingress into electronic devices. A complimentary copy of the standard’s contents and scope can be found at http://www.nema.org/Standards/Pages/American-National-Standard-for-Degrees-of-Protection-Provided-by-Enclosures.aspx. You can also purchase the entire documented standard at this location.

If customer or prospect feedback suggests some level of ruggedization of your device is needed and your company lacks the know-how and experience, your module manufacturer may be able to provide recommendations of third-parties who do have ruggedization design and engineering capabilities.

6.7 M2M vs. Human Interaction

Machine-to-machine (M2M) devices communicate wirelessly with other devices without any human interaction. One excellent example of M2M devices is sensors in a mesh wireless network, like seed

modules in a series of vending machines placed throughout a large office building, campus, hotel, or resort. In this example from device maker Cantaloupe Systems — http://www.cantaloupesys.com, each device can communicate with the other to find the one that has the strongest signal to AT&T's Wireless Wide Area Network (WWAN). It then conveys the status — inventory, cash and mechanical health — of any or all of the vending machines to an unattended central monitoring station to generate a service dispatch order to check the vending unit the next morning.

That's just one example of a simple, black-box device, which contains all the electronic components needed to do the job. Hundreds of other M2M applications exist, spanning such areas as building access control, environmental monitoring, fleet tracking, healthcare, appliances, asset tracking, and meter reading. These can be silent sentinels, transmitting as few as 100 kilobytes a month in data, or in the case of video surveillance, which can transmit many megabytes per second and involve humans who monitor the video in real time.

6.8 Data-Only vs. Data-with-Voice

AT&T's current Network Ready device certification process does not apply to voice-only devices. Instead it qualifies data-only devices like those from Cantaloupe Systems or data devices that have voice features, like those from Psion, Inc.. Some of the Psion, Inc. devices are multipurpose, hand-held enterprise computers that can combine voice communications with bar-code scanning capabilities, GPS mapping and location-based features, an on-board camera and more. Because of the voice component, requirements like E911 emergency calling and Adaptive Multi-Rate (AMR) voice compression features are required for AT&T certification.

Data-only devices are simpler to design and engineer than data-with-voice. With its greater complexities, data and voice devices can pose bigger engineering challenges, such as adequate power supplies, user interfaces, radio interference shielding, component densities, and antenna performance. Later on we'll discuss how these added complexities can affect your device's certification. They'll also have to comply with all applicable regulatory and safety requirements such as emergency dialing.

6.9 Network Considerations

AT&T's wireless data network is based on the 3rd Generation Partnership Project (3GPP) family of technologies that includes EDGE, HSPA+ and LTE, some of the most widely-used wireless data technologies in the world. 3GPP technologies enable continued enhancement of mobile broadband speeds as we evolve to the next generation of technologies.

As part of our Project Velocity IP (VIP), a three year multi-billion dollar investment plan announced in November of 2012, we plan to expand and enhance our wireline and wireless IP broadband networks. We've already made great progress and are ahead of schedule in deploying our 4G LTE network. AT&T 4G LTE expected to cover nearly 270M people by year end 2013 and is now available in 424 markets. We currently cover over 300M POPS with HSPA+.

While we continue to expand our coverage throughout the country and continue to invest aggressively as part of our mission to deliver the number 1 mobile broadband experience, if your wireless device is mobile, AT&T's cell coverage for it might be provided by GPRS, EDGE, HSPA, HSPA+ or LTE depending on its location and the module in the device.

7. Third-party Testing Labs

Third-party testing labs adhere to the most meticulous standards for testing FCC, PTCRB, and other AT&T network qualification requirements. They work with device vendors to determine the best initial test strategies and understand the minimum requirements that AT&T expects for lab entry. They can assist with controlling R&D and acceptance costs and help save time to carrier acceptance. They provide device validation services that include device testing and quality assurance. Their staff members can also offer guidance that can help you better navigate the certification maze. For example CETECOM, a major PTRCB qualified testing lab, is a member of many wireless standards working groups and has expertise in identifying and controlling "spurious emissions" of RF that can plague wireless device designs and engineering.

In addition, AT&T offers the Mobile Broadband Accelerator (MBA) Labs Program to provide a speedy certification process that allows products to reach customers more quickly. An online onboarding system lets manufacturers create a new certification request that will be shared directly with their MBA lab of choice. Once testing is completed, reports and documentation to the devices are electronically submitted to AT&Ts onboarding tool. AT&T's Network Ready Lab (NRL) then conducts additional testing to ensure that specific requirements for the AT&T network are met. This process achieves quicker technical acceptance in up to three weeks sooner. It also prevents manufacturers from incurring extra costs for additional testing. Currently there are six participating labs: CETECOM, Underwriter's Laboratories (UL), 7Layers, AT4 Wireless, Bureau Veritas and Sporton Lab.

8. Certification Primer: Critical Means to Successful Ends

8.1 Certification Overview

AT&T developed its thorough Network Ready process for devices both to protect our network's integrity and optimization as well as to ensure that our customers – and your customers – benefit from the best possible mobile broadband experience with our network.

At AT&T, our goal is to help you get your device certified and then to market as fast as possible. We encourage you to contact us early in your development process, so we can help you learn much more about what is required. Like any journey, the more you know about the terrain you face, the less likely you'll encounter the unexpected. More information about preparing for device certification is available on the EDO website by clicking the link: Preparing for Certification.

For further guidance on meeting AT&T's prerequisite certifications, which are highlighted in the following subsections, we consulted with David Bissonette, who heads United States Business Development at 7Layers, Inc., a global, full-service testing lab. According to Bissonette, new device integrators can be delayed by any of the three major areas below if they don't plan ahead:

- **Component selection and RF design.** First, he says, components should be sourced from high-quality manufacturers. In conjunction with quality components and sound engineering design practices, the product going for FCC / PTCRB certification should minimize RF noise / harmonics that could cause radiated spurious emissions.

  "A manufacturer's stated specifications can be a far cry from its performance characteristics and if you've already bought a 10,000-unit inventory, you may be out some serious capital," he warns. "And that's not to mention having to go through all the time, trouble and expense to re-qualify another manufacturer and reengineering their component into your device."

  Of all the components, one of the most critical and often overlooked is the antenna system. Bissonette points out that RF Performance / OTA (Over the Air) Antenna Performance testing is a relatively new requirement to the industry, with performance benchmarks being set and a knowledge foundation being built across antenna manufacturers. He advises that device manufacturers select a more expensive (better engineered) antenna than what they otherwise might choose for cost reasons, to help ensure its RF performance characteristics conform to the specifications. Do not underestimate the engineering that goes into antenna design and RF performance.

  He also suggests that your device design have a well-shielded RF section, again to minimize spurious emissions, which he describes as among the most devilish of details that are difficult and costly to reengineer during the testing process. Impedance matching and overall system

impedance effects must be considered in the design.

- **RF engineering expertise.** Bissonette describes RF engineering as a special electrical engineering discipline that borders on a "black magic" that requires years of experience. Whether you hire this competency in someone as an employee or as a consultant, he said it is vital to RF success.

  Radio frequency consultant companies deliver turn-key design services and are experts in hardware and software solutions. A complete list of RF consultants is available on the EDO website by clicking the link: Finalize Specifications.

- **Underestimating certification costs.** In Table 1, we offer some ranges of costs and timelines for the various certification testing phases. Bissonette says that many, if not most of his new clients, underestimate the expense by an order of magnitude or more. He recommends that manufacturers add additional funds in their project budget to account for certification testing failures and the required costs for retesting. He suggests figuring at least a 25 percent additional cost contingency.

Keep in mind that, in some cases, AT&T certification is not required. If your device is using an "end terminal" (e.g., an already certified USB wireless modem) that connects to another device such as a laptop, you don't need to seek our certification. Remember, however, that if your device falls into this category, it may still require FCC and PTCRB certifications. This is one more reason to learn more about AT&T's device certification requirements.

In the next section, we provide you with more details on the device certification requirements and the process for achieving it.

8.2 AT&T Device Certification Prerequisites

Before we can accept your device into the AT&T Network Ready labs, you must submit the following governmental and regulatory certification requirements documentation:

- FCC Certification (refer to section 8.2.1)
- PTCRB Certification (refer to section 8.2.2)
- RF Performance / OTA (Over the Air) Antenna Performance (TRP/TIS) testing
- All relevant regulatory and safety certifications for a device with voice features, such as emergency dialing and hearing aid compatibility (refer to section 8.2.4)

A key to passing certification tests is planning and extensive pre-testing. AT&T encourages you to seek out partners with expertise in preparing and passing certification tests. Consulting partners are available who can guide you through the entire process

8.2.1 FCC Certification Highlights

The Federal Communications Commission (FCC) is charged with regulating interstate and international communications in the United States. As part of its charter, the FCC regulates the use of wireless spectrum and approves all devices that operate within the country. Wireless data communication devices are required to meet the appropriate FCC requirements, which include the following:

- Part 15 (Radio Frequency Devices)
- Part 22 (Cellular Telephones)
- Part 24 (Personal Communications Systems)
- Part 27 (Broadband Radio Service)

Upon completing these requirements, the device will be issued an FCC Identification (ID) number. Complete details regarding FCC testing requirements can be found at: www.fcc.gov.

If your device uses an AT&T approved module which has already received FCC approval, you must still obtain current FCC certification for the device itself. If it does not have its own FCC ID number, please provide us with a copy of a letter of conformity/waiver from the FCC or an agency on behalf of the FCC.

Note: If your device is a relatively simple mobile application that complies with the module FCC Grant Notes, typically you can leverage the FCC Identification (FCC ID) of the module. You will need to know what privileges the FCC grants the module (from its certificate) because sometimes it is limited to certain antennas. Talk to your module supplier about this possibility and how you can get a conformity letter, if you use the module's FCC identification in lieu of getting FCC identification for your device itself.

8.2.2 PTCRB Certification Highlights

In addition to FCC approval, your device must obtain PTCRB certification. PTCRB is a certification created by and required by all North American GSM operators.

You can visit the PTCRB website at www.ptcrb.org to find the list of PTCRB accredited labs and the certification requirements. There are 2 documents specific to PTCRB certification, NAPRD03 is the

technical requirements for certification and the PPMD covers the process for following PTCRB certification. The PTCRB website is also where you go to create a new certification request for PTCRB approval.

AT&T must follow industry requirements for PTCRB testing to ensure that your device complies with the appropriate technological standards, regulatory requirements and OTA RF performance standards. A PTCRB accredited lab should be capable of managing a full scope of services needed for PTCRB approval, including:

- Conformance testing for 2G/2.5G technologies: GSM, GPRS, EDGE (850/900/1800/1900 MHz)
- Conformance testing for 3G technologies: W-CDMA, UMTS, HSPA (FDD I/FDD II/FDD V)
- Conformance testing for 4G/4G LTE
- Conformance testing for HSPA+/LTE
- TTY and SIM/USIM testing
- Application Enabler (AE) testing: MMS, PoC, VT and others
- TRP and TIS measurements (OTA performance testing)
- Radiated spurious emissions testing
- Specific Absorption Rate (SAR) testing
- FCC and IC testing and approval

Even if your device uses AT&T Certified modules previously certified by a PTCRB lab, the device itself will still need to receive its own PTCRB certification. Integrations utilizing PTCRB approved modules will be allowed to re-use test results from the module provided the certified software and hardware version of the module is used. This results in a sub-set of test requirements for the integration, based on the same NAPRD.03 release as the one used for the module's PTCRB approval. These test cases typically apply to the interfaces (i.e., RF, SIM, Power, etc.) This will also result in reduced lab costs, reduced certification fees and time of certification. Be sure to ask prospective test labs about this reduced rate.

It is recommended to use one of AT&Ts MBA labs for the PTCRB and FCC certification, since they are able to ensure that all AT&T requirements are met prior to completing PTCRB certification. These MBA labs are also set up to be able to assist manufacturers in completing the certification paperwork and submittal process for AT&T certification. A list of the current MBA Labs is available on the EDO website.

Consult with your module supplier if you require additional assistance in selecting a PTCRB accredited laboratory. It can beneficial to have your device tested where its module was tested, since that lab will already be familiar with the module capabilities and performance.

Note: The test labs have cyclical business cycles and may have times of the year when they are busier than others. Also, because PTCRB test labs are businesses, they may be willing to negotiate their rates with you — don't hesitate to ask.

8.2.3 Radiated RF (TRP/TIS) Testing Requirements

Internal Antennas

If your device incorporates an internal antenna, its radiated performance data (TRP and TIS) must meet minimum performance requirements for AT&T Network Ready certification. Also required is an Intermediate Channel relative sensitivity measurement. If any Intermediate Channel fails, you'll have to resolve the disparity.

Total Radiated Power (TRP) and Total Isotropic Sensitivity (TIS) must meet or exceed the specified values as measured using the CTIA radiated performance measurement method. For more information, refer to AT&T document 13340 "Device Requirements", chapter 66, which is available under NDA

For devices that are not intended to be placed next to a user's head or body during normal use, such as "smart" vending machines and electric meters, the Free Space measurement method can be used. If the device application is not used against the head or in free space, you need to contact AT&T to determine the best method for characterization.

The CTIA radiated test technique has been incorporated by the PTCRB as part of its certification process. Please contact your PTCRB test lab for further details.

External Antennas

If your device will use an external antenna, it must be vertically polarized, with a reasonable omnidirectional pattern. If the antenna is located within 20cm's from the device then you also have to provide radiated performance data (TRP and TIS) for all applicable AT&T bands supported by the device. In addition, most devices that do not include an antenna are installed by professionals. Professional installers can optimize the antenna location for most conditions.

8.2.4 Relevant Requirements for Data-with-Voice Devices

As mentioned before, devices that will support voice services must use both full-rate and half-rate AMR codecs. They also must comply with all applicable regulatory and safety requirements such as E911 emergency dialing, TTY support (including for emergency calls), and hearing aid compatibility. Devices that are able to dial 911 will also be required to support A-GPS Control plane in order to meet the FCCs E911 phase 2 requirements on location accuracy.

8.3 AT&T's Certification Highlights

AT&T's device certification is a detailed process and your device must be certified by the following agencies:

- **FCC certification** — http://www.fcc.gov
- **PTCRB certification** — http://www.ptcrb.org
- **CTIA radiated testing** — http://ctia.org

The process by which we conduct our AT&T network certification breaks down into the following steps:

1. Register for a free login on AT&T's Developer Program portal. After you've registered to the Developer Program, you'll need to submit your device for Network Ready testing; you can find out more information about this testing on the Get Connected page on the EDO website.
2. AT&T will evaluate your device to determine whether it is eligible for certification. Upon receipt of your signed NDA**,** AT&T will deliver proprietary AT&T certification requirements and process documentation for review.
3. Upon receipt and review of all completed documentation (13289 Tab H), proof of FCC and PTCRB certifications and if applicable AGPS reports, we will assign an AT&T lab entry date for your device.
4. Upon receipt of the hardware and all required components**,** your device will enter into the AT&T testing lab on the assigned lab entry date.
5. Once your device completes all testing and paperwork requirements**,** AT&T will send you a Notice of Technical Acceptance. Upon receipt of your Notice of Technical Acceptance, your device can be used on the AT&T wireless network.
6. We'll then request your approval to list your certified device(s) on the AT&T website, where AT&T sales teams, developers, customers, and prospects can locate it as they search for solutions. This step is critical and must have your approval before we can post your device to our portal.
7. AT&T encourages you to seek out partners who can assist with preparation, scheduling, deliverables, and issue resolution during the certification process. Consulting partners are available who can guide you through the entire process. Bob Witter at Device Solutions points out that "Being fully prepared for AT&T Lab Entry is the key to a successful certification cycle. All efforts leading up to the AT&T Lab Entry date should be aligned to make sure that the device will pass through AT&T's lab with few, if any, issues. Major issues found in AT&T's lab testing will result in costly redesign, retesting, re-certification testing at the 3rd party labs, restart of the Lab Entry process, and delays in product launch.

8.3.1 Estimated Certification Time Frames, Costs, and (Inter) Dependencies

We think a broad look at the time frames and estimated costs of the various certifications as well as the various dependencies could help the development of your device plus its business case and go-to-market plan.

Our caveat: Please keep in mind that these estimates are highly dependent on a number of factors, highlights of which will follow, and can change at any time. In no way does AT&T warrant these estimates of time frames and costs.

First, you should note that while third-party test labs charge for their services, AT&T does not charge for its network certification testing as long as an AT&T approved module is integrated.

Certification	Time Frame (5-day workweeks)	Cost
FCC (with pre-approved module)	2–3 weeks	$3–5K
PTCRB (multi-band, pre-approved module)	2 weeks	$12–18K
RF Performance / OTA (Over The Air) Antenna Performance, for devices with internal antennas or external antennas under 20cm in length	1 week	$5–15K
AT&T Network Ready Lab (integrated devices with approved modules)	2weeks	No charge
AT&T Network Ready Lab without approved modules	Request estimate based on integrated technology	$175K

Table 1. Estimated Certification Time Frames, Costs, and their Dependencies

(Inter) Dependencies. Two of the most obvious and interdependent factors that can affect these time frames and costs are the complexity of your device and the quality of its engineering — especially its RF engineering. Simply put, the more complex your device is, the greater the number of engineering challenges you will face.

A barcode reader is an example of a complex ruggedized hand-held device with many dependencies. A device like this might have multiple radios, an internal multiband antenna, a backlit display, computational capabilities and other unique electronic features. In this case, the ruggedization

engineering will be subject to your own standards and tests, but the RF engineering will be subject to standards and tests set by the FCC, PTCRB, and AT&T.

The next section of this document will go into a bit more detail on those RF engineering dependencies and their effects on certification. Clearly you will want to work out all of your tradeoffs, optimizations, and validations before you enter your selected third-party test lab. Keep in mind however, that this doesn't mean you have to have them all worked out before you engage your test lab or the AT&T lab.

In fact, the sooner you select your test lab and contact AT&T, the better. Good test labs can be huge sources of information and advice, including experienced guidance on fundamental architecture and design. Also, test labs can conduct pretests to validate various solutions to sources of RF interference, which are generated in multiple dimensions by just about every electronic component, PCB trace, and line connection. Module vendors can pretest devices to avoid PTCRB lab time costs and multiple iterations testing. They are equipped for finding issues and testing their resolutions before entering the PTCRB lab.

Costs can vary depending on your device's complexities and your lab's seasonal business cycle. Test labs may have times of the year when they are busier than others. Generally speaking, it will be easier to get your device tested in June rather than in December. If you do have to repeat test cases after discovering and resolving an engineering issue, your test lab might be willing to reduce its rates on subsequent testing. Be sure to ask if rates are negotiable when you're selecting a third-party test lab.

8.3.2 Certification Guidelines: Keys to Success

CETECOM's Maan Ghanma says FCC approval can be expedited for simple device solutions without additional radios, because they can leverage the FCC certificate from the third-party module they use. If that's the case, your module supplier should be able to provide its certificate from which you can determine its grant limits and whether your device falls inside or outside those limits. Ghanma says his lab can help you determine this, then set up a test plan accordingly.

If your device is more complex, it will require a full FCC certification by the lab. But assuming your device was designed and engineered according to general RF guiding principles, the FCC certification can be achieved in the time frame of 10–12 weeks. **Note**: Both FCC and PTCRB testing can be done in parallel. Consult with your test lab on how to best do this.

PTCRB certification is your next stage of testing. "Ninety percent of PTCRB certification can be ensured," Ghanma says, "if three pitfalls are avoided." These pitfalls are:

Spurious, out-of-band emissions. Ghanma says that the extreme RF sensitivity of GSM radio receivers can surprise new device integrators and derail their designs. That is, GSM receivers can pick up

interference from just about any part of the host device especially in the 30 MHz to 1 GHz frequency range. Antennas, power supplies, PCB circuit traces (even depending on length and direction), and line connections can all play RF havoc on your device.

Antenna matching. Another challenge is matching your device's antenna to the GSM network. A mismatch can cause interference when the radio signal creates harmonics in the front end of the receiver. External antennas are easier to match. If you're using an internal antenna, it is critical to get your antenna design and OTA characteristics pretested in the earliest stages of your device development. AT&T relies on its OTA performance to meet specific standards based on calculations established by existing cell site locations and distances. If your antenna fails to meet OTA requirements, it can affect your entire device design and set you back weeks if not months, not to mention all the costs of its reengineering.

Required software and network access for testing. Your device will need software aboard that is capable of answering a call and establishing network connections. Ghanma says many new devices entering his lab lack this software and creating it takes time. Consult your module vendor who can help you design the appropriate software tool so that the PTCRB lab can conduct their testing easily. Ideally, a mode where you can directly send AT commands to the module is the most efficient solution and will minimize lab time, as it offers access to the entire feature set of the module

Again, if you engage a well-qualified lab early enough that is willing to provide upfront counsel on these issues, you can minimize them, if not avoid them altogether. For example, if pretests show that your device emits spurious emissions, Ghanma can advise you on a variety of ways to block those using filter, capacitor or ferrite solutions. Your other technology partners can also be helpful on these issues, especially the module, antenna, and battery suppliers.

As for AT&T's Network Ready certification, success is dependent on contacting us as early as possible in your project — even before development begins — so you have a complete understanding of what we require to give your device access to our network. Contacting AT&T early will enable you to gain access to our technical guidelines. As business book author Stephen Covey says, "Begin with the end in mind." Although AT&T's certification is certainly not your ultimate end, network access is an important part of your future success.

Following are two key pitfalls that you can avoid by knowing what compliance issues you must resolve before you start engineering your device:

- **Lack of communication:** AT&T is keen on getting early information and updates on the device certification and availability. Create awareness around your device.

- **Antenna not meeting TRP/TIS requirements:** TRP/TIS indicate the efficiency of the antenna system. A good antenna mated with an AT&T approved radio module goes a very long way

toward the approval of your device. This can be detected and or pretested early so that when the CTIA approved lab runs the test, you will be confident that you meet the AT&T requirements.

8.4 Beyond Certification: Go-to-Market Success

Determining the best way for you to connect to our backend network is key step in bringing a device to market. Connection requirements will vary based on your product offering and anticipated sales volumes of which you may engage up to four AT&T Mobility Data Centers (DC). Once your device is certified, you can take advantage of our industry leadership to help boost your success in your target market(s). Depending on what business model you pursue, various channels may be available to you. AT&T's retail channels include AT&T owned retail stores, partner retail locations, and those at online att.com. More information about connecting to our network is available on the EDO website by clicking the link: Connect to Our Network.

AT&T has the flexibility to support the entire spectrum of business and functional support models, ensuring you are correctly positioned for the needs of your product, customers, and business. Device certification and wireless transport are two core competencies that AT&T offers. If it works for both parties, you can then add available services related to end-user support, end-user billing, or branding that will shape the partnership into an AT&T retail model. When defining your desired model, first consider the customer experience you want to deliver, and then consider how leveraging AT&T's expertise and resources can maximize your opportunities in the emerging devices arena.

A business model's position on the spectrum is defined by the level of ownership and control of both service elements and the customer. For example, companies with a mature infrastructure may be best served by a traditional wholesale model. Business model information is available on the EDO website.

For business solutions, AT&T's channels include the VAR and Alliance Dealer channels, and the AT&T direct sales force. Among the privileges available are:

- Potential exposure to the AT&T customer base through our sales teams
- Listing of your AT&T network compatible device in the Developer Program’s devices section
- Qualification for Dealer status in the Business Alliance Partner Program

The Business Alliance Partner Program comprises two segments:

Dealer Program: Dealers are established, independent businesses with experience selling and supporting communication products and services to business customers. Through their direct relationship with AT&T, dealers will make volume commitments to sell AT&T stocked and non-stocked

devices and services in addition to their own value-added solutions.

Value Added Resellers (VARs) Program: VARs offer integrated solutions with data-centric applications which target vertical markets where AT&T does not offer a branded solution. They also provide direct billing and customer support for their integrated solutions. VARs maintain a direct relationship with AT&T, and make a minimum service revenue commitment, but do not sell AT&T stocked devices.

Benefits of joining AT&T's Industry & Mobility Alliance Programs include:

- Increased revenue opportunities
- Exposure to new markets through AT&T's industry leadership
- Training and educational support
- Next-generation network technology for your products
- Access to a vast portfolio of wireless business solutions
- Use of the nation's fastest mobile broadband network

Additional program details are available by clicking the link:
Industry & Mobility Alliance Programs.

Finally, we offer best-in-class support once your device is live in the market. We will assist you with provisioning and tracking, provide call center support, and help with billing support. More information about the steps you need to take in order to bring your device to market can be found at by visiting: www.att.com/edo.

9. Engaging AT&T

Once you've considered your high-level business plan and your device specifications, you are ready to engage with AT&T's Emerging Devices Organization. We have a dedicated team, focused exclusively on working with the best and most innovative companies. Visit the EDO website to complete our Partner Engagement Form. The information will go to our business development team who will follow up with you within three business days. Existing customers should reach out to their Business Development or Account Manager.

In conjunction to your hardware development efforts, you may also need software application development support. The AT&T Developer Program is your official resource for wireless development that is packed with information, online training content, monitored Web boards, developer tools, and much more.

10. Conclusion

We hope you have found this white paper informative. As a new wireless device developer, you will face many challenges. Some of these challenges are not just those in gaining the various technical certification needed for y our device, but they are also the many business and marketing challenges that occur before, during, and after your device's development.

It's part of AT&T's philosophy to help you gain certification to our network, and then help you to succeed commercially. After all, the richer the number and diversity of available devices and applications AT&T can host on its network, the more valuable the network will be to all of our customers. And ultimately, the more valuable it will be to you and your business, too.

11. Feedback — Sending Questions or Comments

Please send an e-mail message with any comments or questions regarding this white paper to DL-EDOWebmaster@awsmail.att.com. Be sure to reference the title of this document (Hardware Development —Best Practices to Ensure Successful Outcomes) in subject field of your e-mail message.

Appendix A — AT&T Approved Module Sources

For a list of AT&T approved modules and module manufacturers, please refer to this spreadsheet: www.att.com/modules

Appendix B — Resources

- **AT&T Emerging Devices Organization:** http://www.att.com/edo
- **Enterprise Reference Library:** http://developer.att.com
  (Registration is free, but a user name and password are required to access the site.)
- **E911:** http://www.fcc.gov/pshs/services/911-services/
- **FCC Office of Engineering and Technology:** http://www.fcc.gov/oet/ea/
- **Moisture and particulate ingress IP Code standard IEC 60529:**
  http://www.nema.org/Standards/ComplimentaryDocuments/ANSI-IEC-60529.pdf
- **PTCRB:** http://www.ptcrb.org/
  (Registration is free, but a user name and password are required to access the site. NAPRD03 and PPMD documents are available for download.)
- **IEEE 1725 Battery Certification:**
  http://www.ctia.org/business_resources/certification/index.cfm/AID/10624

Appendix C — Terms and Acronyms

2G	Second Generation Communication System (e.g. GSM, GPRS, EDGE)
3G	Third Generation Communication System (e.g. UMTS, HSPA)
3GPP	Third Generation Partnership Project
4G	Fourth Generation Communication System
AC	Alternating Current
AE	Application Enabler
AMR	Adaptive Multi-Rate (also, Automated Meter Reading)
API	Application Programming Interface
CRM	Customer Relationship Management
DC	Direct Current
E911	Enhanced 911, the emergency calling feature of the North American telephone network

EDGE	Enhanced Data rates for GSM Evolution
EIRP	Equivalent Isotropically Radiated Power
EMI	Electro-Magnetic Interference
EMR	Electro-Magnetic Radiation
ENS	Enhanced Network Selection
FCC	Federal Communications Commission (part of the U.S. government executive branch)
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile communications (originally, *Groupe Spécial Mobile)*
HSDPA	High Speed Downlink Packet Access
HSPA	High Speed Packet Access *(referencing both HSDPA and HSUPA)*
HSUPA	High Speed Uplink Packet Access
IC	Intermediate Channel
IEC	International Electrotechnical Commission
IOT	Inter-Operability Testing
IP Code	Ingress Protection Code
Kbps	Kilobits per second
LAN	Local Area Network
LTE	Long Term Evolution
M2M	Machine-to-Machine
MBA	Mobile Broadband Accelerator
MDM	Mobile Device Management
MMS	Multimedia Messaging Service
NDA	Non-Disclosure Agreement
NRL	Network Ready Labs
Network Ready Device	Devices that AT&T does not stock or sell itself but which are certified by AT&T to access its network
PSAP	Public Safety Answering Point

PCB	Printed Circuit Board
PoC	Push-to-talk Over Cellular
PTCRB	A certification body originally established in North America that is now used globally to ensure compliance to a set of requirements, including 3GPP standards.
OMA	Open Mobile Alliance
OS	Operating System
OTA	Over-the-Air
RF	Radio Frequency
SIM	Subscriber Identity Module
SVD	Specialty Vertical Device (see Non-Stocked)
TIS	Total Isotropic Sensitivity
TRP	Total Radiated Power
VSWR	Voltage Standing Wave Ratio
UMTS	Universal Mobile Telephone System
VAR	Value Added Reseller
VT	Video Telephony
WAN	Wide Area Network
WAP	Wireless Application Protocol
WLAN	Wireless Local Area Network
WWAN	Wireless Wide Area Network

Appendix D — Acknowledgements

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