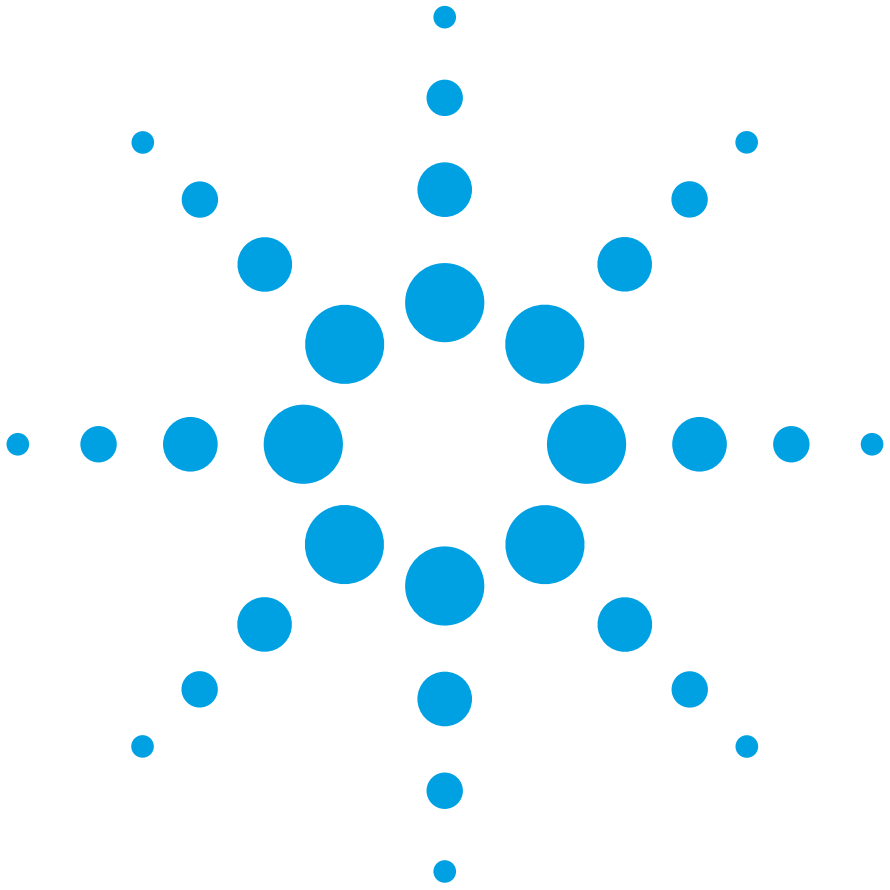

The Value of Handset RF Testing

Application Note 1375

Agilent Technologies

Is RF testing based on cost or value?

If there is one subject handset manufacturers around the world talk about daily, that subject is "RF testing," and the probable theme to these conversations is the high cost. This paper changes that conversation to one centered on the value of handset RF testing, not the cost.

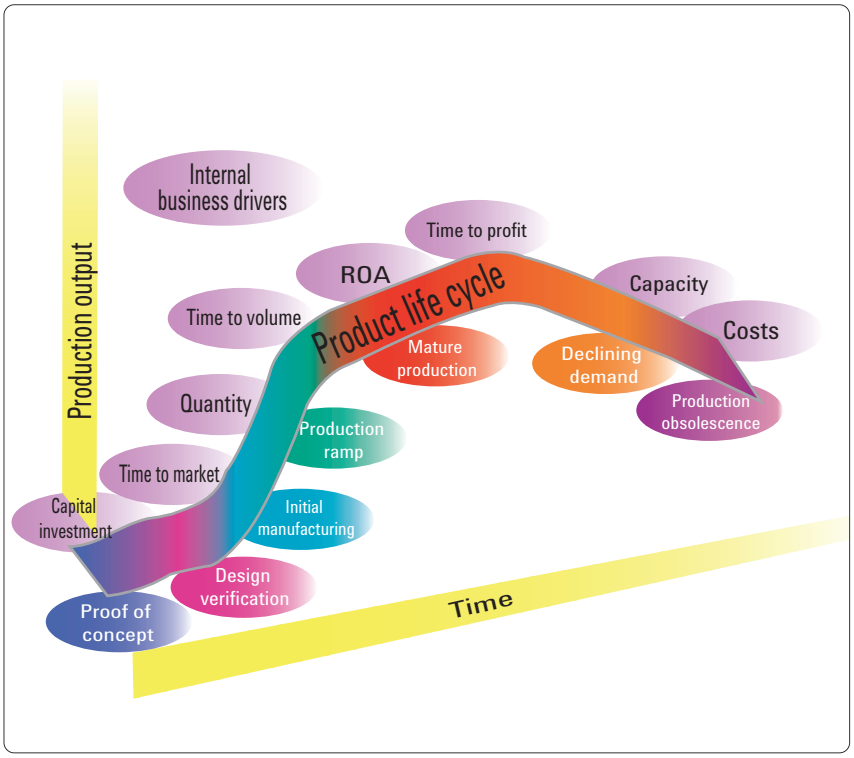

Figure 1. The handset product life cycle with associated business drivers

Is RF testing based on cost or is it based on value? It is both. First, RF testing systems are second only to surface mount equipment in cost. High cost constraints can drive decisions to design and build less expensive test systems. While this may reduce up front expenditures, the performance of that system and ultimately the quality of the handset being produced relies heavily on how well the RF test system and software is created, tuned, and maintained. This creation, continuous tuning, and maintenance all provide the value in RF testing.

RF testing is unique in that it impacts every stage of handset device's product life cycle from conception through obsolescence. RF testing is the driver in many capital investment and improvement decisions. Location on the product life cycle along with the current business environment determines where and how investments are made. Understanding of the RF testing process determines if that investment is cost based or value based.

R&D

At the R&D level (proof of concept, design verification), RF technology drives the design and operation of the handset. The handset must meet a wide and ever changing array of industry specifications. New technologies or variations on existing technologies emerge almost daily. Regardless of the technology, three functional requirements will continue to require accurate and repeatable RF testing into the foreseeable future.

What is the impact of RF testing on each stage of the product life cycle?

Those three functional requirements are:

- voice and data quality
- battery life
- optimum performance within the service provider network

While voice quality is important, data recovery systems and the human ear allow for some level of error. Data quality on the other hand is fast becoming more and more of an issue as handsets are used increasingly for data transfer uses where data accuracy is a must. Battery life also plays an important role in operational protocol. If power control settings are off, the battery life will not meet promised levels and the handset will add additional noise into the service provider's system. To top it off, more and more users must be accommodated into existing systems driving demand for continual system optimization.

To put this in perspective, let's look at one inadequately tested handset. Any one, or all of the following can happen.

- Calls made or received near the edges of coverage are dropped or not received at all.
- Data integrity falls off when it should not.
- The handset transmits at a higher power level than is necessary reducing battery life, affecting overall system use and adding to environmental concerns.
- Dropped calls means a re-dial adding to an already over crowded network.

If RF testing at the R&D level is not as accurate as possible, missed design errors may turn that one handset into one million. The costs can become enormous and far-reaching.

Initial manufacturing

At the initial manufacturing phase, several steps in moving the product from R&D to manufacturing require extensive RF testing. The design of the handset must be able to be tested at "competitive" test times and test margins. If the handset requires relatively lengthy test times or has a high failure rate, it may be very difficult to recover in time to meet time-to-market demands.

RF testing plays a key role in simulating test margins, setting test variables, identifying and resolving early performance issues to name a few. Without RF testing at its best, subtle problems will remain unknown, waiting to be uncovered during volume production.

With early performance information, a first pass test plan and subsequent test code is developed. The RF test equipment can either complement the test plan or hinder it. Some questions will have to be answered in order to get the most value out of the RF testing process.

- How will each measurement be made?
- In what order should the tests be made?
- What specifications have to be met and to what tolerances?
- Are there test drivers available, and if so, how robust are they?
- What is the test system's and handset's total measurement uncertainty and its effect on test results?

These are just some of the questions that will have to be answered for value-based RF testing. Not answering them leads to cost-based RF testing.

With a first production test plan and test code, it is time to marry the test software with the process, the enabled test hardware, and the product itself. The interdependency of these four factors is enormous and will play a major role in the ability of the four to work together in a successful manner. Assuming R&D has provided, at a minimum, a reasonable design, RF testing remains a key ingredient in getting the handset ready for volume production.

Production ramp

The challenge of getting to volume production is getting the production line ramped from a few handsets for initial manufacturing to thousands of handsets being produced every day. Every conceivable problem will arise as the dial is turned to higher and higher output. Problems areas include:

- handset design
- the order and concurrency of RF tests
- incorrect or sub-optimal RF test parameters
- RF process flow
- people
- equipment

All of these and more make themselves known during this production ramp period. RF testing is a very important factor in making it to volume production.

With value-based RF testing philosophy, RF testing will provide a steady stream of invaluable information about the handset, the process, and the equipment. As the RF test database grows, statistical analysis becomes another tool with which the RF test process can be further refined.

Volume production

Major problems have been resolved and product is being shipped. It may seem to be the time to produce handsets. Regrettably this is not the case. Volume production is throughput, yields, and cost-per-test. With production ramp problems mostly resolved, attention can now be paid to what has been the goal all along: profitably produce a quality handset product at high volumes.

Because RF testing is often the primary constraint in volume handset production, throughput, yield, and cost-per-device are key components to the overall production line's final production output. Test times directly impact throughput. RF measurement accuracy, repeatability, and uncertainty directly impacts yield via NTFs (No Trouble Found) failures. And equipment costs and daily operating costs versus production output directly impact the final cost-per-device (and profit-per-device).

Declining demand

Even towards the end of the life of the handset, RF testing affects costs and value. If the test equipment is being poorly utilized, some attention to the RF testing process at this point can easily free up entire test systems for use on new production lines. This value is two-fold. Number one, money does not have to be spent on new equipment, and second, the return on the existing equipment is increased dramatically.

How about after the product has shipped? There is a consumer somewhere down the value chain. What about that one inadequately tested handset talked about at the beginning of this paper? Should the handset perform badly enough to cause the customer to return it, the costs associated with that handset skyrocket and any profits it has generated evaporate instantaneously.

It would appear that handset RF technology and manufacturing demand optimized RF performance at every step along the way. While optimized RF performance is a very important part of RF testing, there is one last factor not yet talked about.

That last factor is cost-per-device. Cost-per-device provides the balance. Ongoing market pressures are continually driving the cost of the handset to the consumer downward with estimates up to as much as 20 percent per year. This continuous market pressure travels back up the value chain to the service provider to the manufacturer to the designer. Each in turn having to somehow strike a balance between costs (handset components and equipment) and the quality of the handset while always striving to meet aggressive deadlines. This is not an easy task, but by understanding the value available at each stage of the handset's product life cycle, decisions can be made to reach and maintain this elusive and ever changing balance point.

Quantifying the value

Looking at the volume manufacturing stage in more detail will help further describe the value in RF testing. Primarily, the value is maximized because of the large volume of product being produced. Small changes equate to large gains. Consider the following:

- RF testing is typically the primary constraint to overall production output. As such, improvements to this step directly translate to increased production output for increased profits and decreased cost-per-device.
- The accuracy and repeatability of the RF test system has a direct effect on measurement uncertainty, which translates to a certain percentage of NTF failures. Decreasing the NTF rate directly increases production output with increased profits and decreased cost-per-device.
- Software or system configuration can be directly leveraged into the other systems both locally and glob ally if so desired.
- Unique testing requirements and downward cost pressures provide a steady stream of failed handsets. This data is invaluable in the never-ending quest of RF test process improvement.
- The relatively high price of handsets contributes to the value model. Opportunity costs become more important as the price of the device in production increases.
- Improvements are relatively easy to measure. With a complete benchmarking of the process, the effect and extent of an improvement can be known within a day or two of implementation.

The following graph demonstrates the value potential in just one portion of RF testing, that being the test time. A production line is at maximum production output. Using 12 systems, a test time of 190 seconds, 90 percent yield, and a profit of $20.00 per handset, the following graph visually displays the potential value range in just the reduction of test time.

As a point of reference, Agilent Technologies RF Test Optimization Consultants routinely reduce test times by 10 percent or more. A 10 percent improvement with this example would equal approximately a potential 3.5 million dollars in additional profit per year per line. This is, of course, assuming the other process steps could handle the increase in throughput.

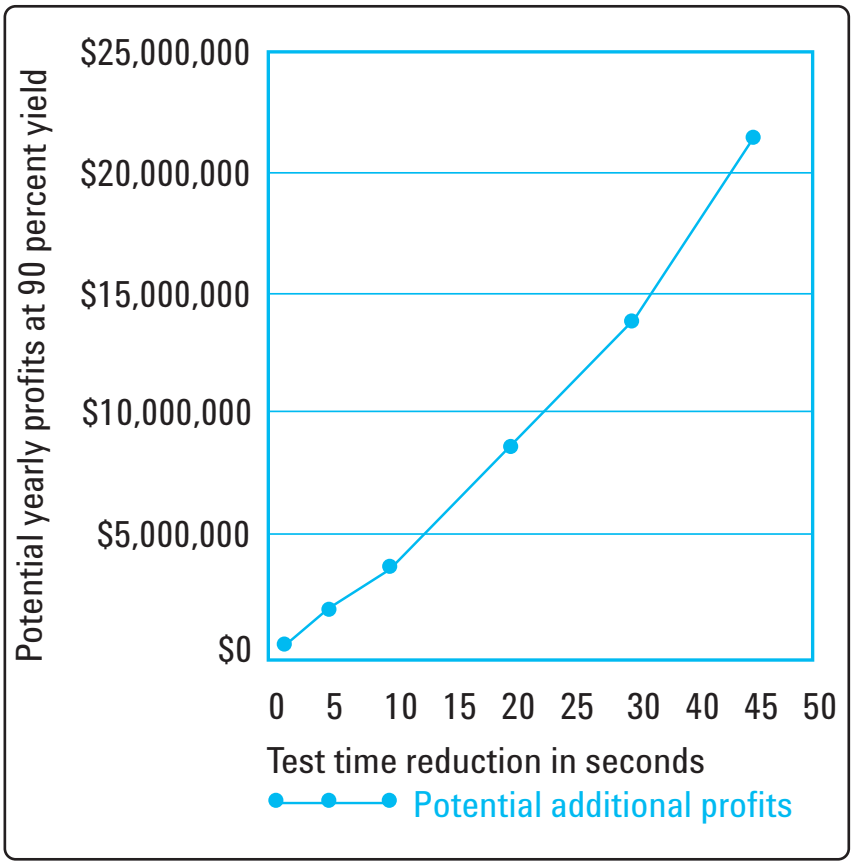

Figure 2. The value of time

Quantifying the value (continued)

Yield improvements are another specific area within manufacturing that offer high value in regard to RF testing. Consider the following:

- It reduces rework costs since yield improvements are a one-for-one reduction in failure percentages.
- It reduces scrap costs.
- If you are using your production test systems to test reworked handsets, an increase in yield provides the opportunity to test more pristine handsets per day. In most cases pristine handsets have a higher pass rate than that of reworked handsets. Thus increasing daily production output.
- A yield increase will reduce the number handsets requiring rework allowing more flexibility with rework equipment and labor.

There is one additional point to keep in mind with regard to yield. Yield improvements get more difficult and usually more expensive as one approaches 100 percent yield. At some point, yield improvements prove no longer value effective in that they cost too much or they drive processing times so high that throughput is reduced such that the production line is no longer profitable.

How do the two improvements outlined affect cost-per-device? The calculations are tricky due to accounting practices, but with some fairly gross assumptions as to variable costs, a 10 percent reduction in test time reduces the cost-per-device roughly 10 percent. If you wish to maintain your present throughput, a 10 percent reduction in test time with the above example will allow you to eliminate an entire test system to use on another line.

Is RF testing based on cost or is it based on value? Your own personal approach to RF testing will tell. Are your decisions based on only the high cost constraints inherent in RF testing which then leads to the design and building of less expensive test systems? Or are you also looking into what is available from a value perspective and continually assessing that elusive balance point between value and cost? The choice is yours.

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