Reducing Cost of Testing Prototypes with the Agilent *Medalist* i1000D In-Circuit Test System

White Paper

The prototype run is a critical part of the project path, and any time spent by R&D resources diagnosing manufacturing faults is generally considered time wasted. The expectation is that boards coming into the R&D department from the manufacturing centre will power up smoothly and start functioning, allowing the engineers to continue performance validation and software testing.

In general, prototypes are built on the same or similar lines to those used for volume production and components that are used on existing production boards will be used to assemble prototypes. However, there are some distinct differences between the demands for prototype testing and volume manufacturing test.

For volume manufacturing, the processes would usually have already been optimized, so generally the defects are more random in nature. In addition, the cost and time to develop a test is not as critical and there is usually good statistical data on the defect spectrum.

For prototype testing, the time to develop a test is critical; the costs should be kept to a minimum and the defect coverage should be optimized to ensure all critical manufacturing defects are detected during the new product introduction (NPI) phase. During prototype manufacturing, the processes are still being developed so the defect levels are typically higher than in volume production.

Flying probe has often been seen as the de-facto electrical test solution for new product introductions (NPI) until board volumes increase above 1000 units, at which point, low-cost in-circuit testers (ICT) become cost effective.

In this article, we are going to challenge this argument and show that the break even point for using low-cost in-circuit testers such as the *Medalist* i1000D ICT is often much lower, in addition to other distinct advantages, making the i1000D a viable option for NPI testing.

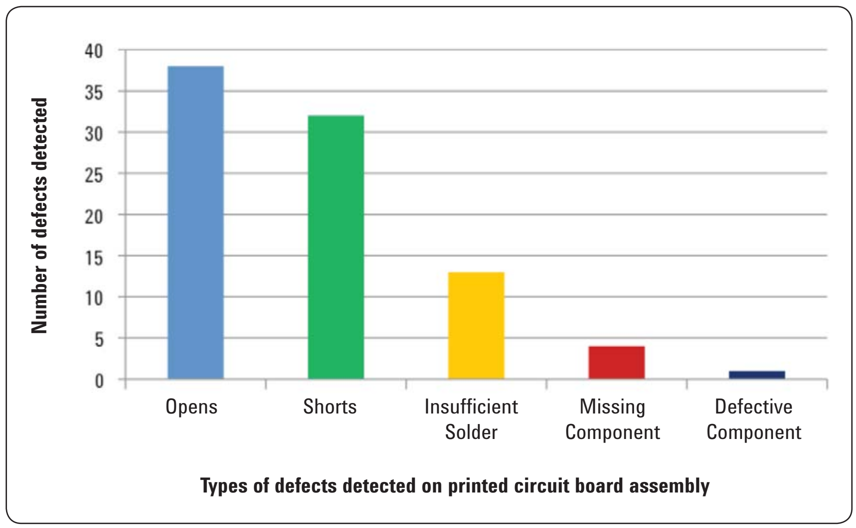

Figure 1. Breakdown of manufacturing defects spectrum for a complex NPI product.

Defect Spectrum

Many studies have been carried out by Agilent which look at the defect spectrum of manufacturing lines, and data in Figure 1 shows that structural defects are a dominant component.

From Figure 1, you can see that for prototype testing, the focus must be on ensuring the opens, shorts and missing components are detected early so that these defects are fixed upstream. While insufficient solder defects are not important in relation to getting boards to power up, process improvement information is required to ensure these do not magnify into opens when the product ramps to volume production.

Flying Probe

Flying probe systems use movable probes to connect to test points or component leads as a way of testing discrete components and identifying shorts between nodes. A flying prober is useful in situations where there is a high level of analog components. Some flying probes now include limited tests for opens on digital devices using capacitive probe techniques.

These systems are often viewed as the primary NPI test method mainly because they are often portrayed as 'ICT-like' systems with shorter development times and without carrying the cost of fixtures. Upon closer look, however, we find this is a highly over-simplified statement, without addressing these shortcomings:

Coverage

The coverage offered by flying probers is well below that offered by ICT systems; flying probers offer limited coverage for many digital device packages like BGAs, CSPs and QFNs. Coverage on SMT connectors is very limited and their shorts and opens coverage is limited on complex boards.

Test Times

Test times for flying probers are much longer than low-cost ICT systems and are often in the range of 20-30 minutes. At first glance, this may not appear to be an issue for a batch of 10 boards; but if you also consider that during NPI the yields are often in the 50% -70% range, it means that you may actually need to run the test over 15 times and suddenly, you may well end up with a whole day of testing. By the time you wait for the boards to be repaired and re-tested, this will soon turn into two days, which will mean split shipments and increased costs, adding delays to the critical path of the project schedule.

The test time achieved by flying probers is also dependant on the skill of the programmer, and this can vary by as much as 50% -- a significant difference when you are talking about test times of around 30 minutes.

Costs

In today's credit crunch world, justifying any capital expenditure is difficult. Flying probers are generally in the range of $250K-$400K, depending on the manufacturer and the options selected. In addition, you will need to spend another $25-$40K per year on the support contract.

In-Circuit Test

Bed of nails in-circuit test systems have traditionally been viewed as being not suitable for prototype testing for a number of reasons: system costs, fixture costs, fixture and program development time. These reasons are in addition to costs incurred for scrapping of fixtures if boards are changed and lack of test point access related to board density or signal integrity issues.

Some of these reasons ma seem valid when they relate to an in-circuit test solution for full volume manufacturing test needs. However, recent industry developments on the ICT front have evolved to overcome many of the concerns listed above. Let's take a closer look at one relatively new low-cost ICT option like the Agilent *Medalist* i1000D.

Better defects coverage

A powered low-cost in-circuit tester like the Agilent *Medalist* i1000D system costs approximately $50K for a 1,000-node system. Fixtures and programs are very easy to develop and can be up and running in three to four days with much of the work being carried out whilst the boards are still going through production, and fixture costs are typically less than $2,000. Any higher cost fixture parts, for example, vector less test plates, can be re-used if the fixture needs to be scrapped.

Some board access issues can be overcome by using Agilent's Bead Probe Technology; this is a technique which allows test points to be added to boards without taking up any board space or impacting signal integrity. Agilent has also developed a technology called Cover-Extend Technology, which combines boundary scan with vector less test, thereby giving high levels of coverage on non-boundary scan devices, including connectors, without the need for access. This means that the fixture costs can be reduced even further and because this technique is set up automatically without any boundary scan library test development, the test development time is kept to a minimum.

It's all about lowering the cost of test

Bed of nails ICT has a higher level of defect coverage than flying probers, due to the fact that all probes are available at all times and also because the board can be powered up. The test speeds are much faster – a 1,000- node board on a flying prober will take approximately 15 minutes but the test time on a typical i1000D will be approximately only 15 seconds. Using this example, and assigning costs of $250K for a flying prober and $50K for a 1000-node i1000D system, you will see that the break even point is approximately 500 boards (as per the graph in Figure 2 above right). When you consider this and also compare the purchase cost of a flying prober against the cost of a low-cost ICT system, you will need to do many different low volume prototypes to get a return on the investment from the flying prober.

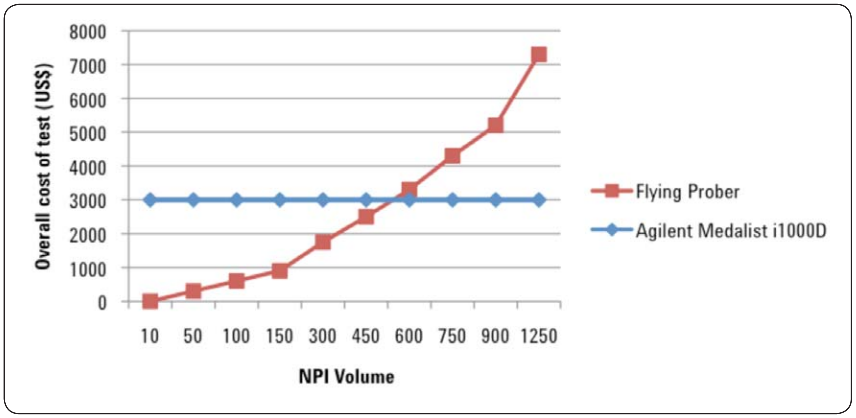

Figure 2. Overall cost of test comparisons for Agilent Medalist i1000D versus flying prober

Let us do another cost comparison analysis. In Figure 3, we compare the test cost on a per board basis for a ICT system versus that for a flying prober, with the following parameters: system cost, fixture cost and labor cost.

In a typical NPI shop, the test engineer usually needs to consider the number of NPI projects they handle in a year and the number of boards involved in each of these projects.

Using an assumption of 10 boards per NPI project, the cost analysis in Figure 3 shows that ICT offers a cost advantage until the number of projects exceeds 58. This suggests that manufacturers should consider using the i1000D if their NPI shop has fewer than 58 projects to run in a year. If the number of projects a year should exceed 58, perhaps then they should consider a flying prober.

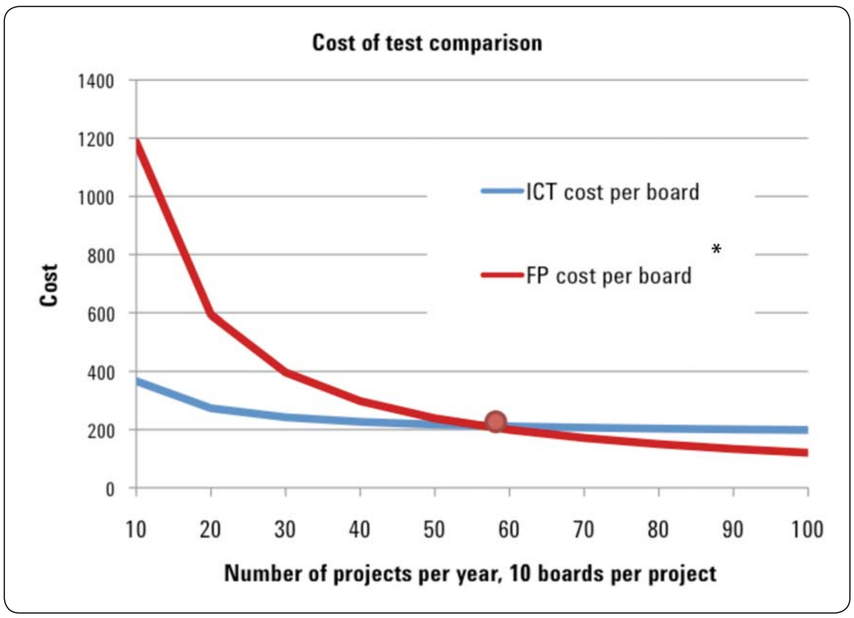

Figure 3. Comparing the cost of test between Medalist i1000D and flying prober

**Do note that the above chart compares the two options based on running the projects on one tester. When there are over 90 projects a year, you will need to invest in another flying prober for the extra capacity needed.*

NPI shops should seriously analyze the number of NPI projects they carry out each year and the average number of boards per project they build, before making the decision of whether to buy an ICT or a Flying Prober.

These days, with optimal resource loading, it is unlikely that NPI shops will only be handling 10 boards per project. A typical NPI shop may receive orders for 100 or more boards to be built and tested. In this case, we will need to compare the break-even point for the number of projects versus the number of boards in each project, as illustrated in Figure 4.

At the start of your NPI shop business, the number of projects might be lower and the flying prober is likely to be one of the heavier investment items. Figure 4 illustrates that if you are running fewer than 60 NPI projects per year, it is probably a better idea to invest in the *Medalist* i1000D if your customer is ordering more than 70 boards per project. When your business grows bigger, it might be a good idea to invest in a flying prober. Having said that however, the i1000D will offer an advantage if there are normally 150 boards to be built in each of the NPI projects.

Normally, NPI projects are separated into multiple phases, and the overall number of boards to be built typically exceeds 100. In fact, the overall cost of test of the i1000D is actually not more expensive than the flying prober for all cases exceeding 200 boards per NPI project. The overall test cost between the i1000D and flying prober are very similar if we consider project sizes of between 150~200 boards per project.

Some people may overweigh the investment in the ICT fixture at the starting phase of the NPI due to initial layout changes. However, with the availability of new limited access tools like Agilent Bead Probe Technology, Cover-Extend Technology, etc. in the in-circuit tester, the reuse of the fixture at the later NPI phases is made easier compared to before.

Conclusions

There are unique requirements for a test strategy at the prototype production stage – the critical factors are speed of development, speed to complete the testing, and high test coverage for critical defects, which if undetected, will prevent the board from powering up and add the product development cost.

Flying probe has often been seen as the de-facto standard for the testing of NPI boards but as this article demonstrates, low-cost in-circuit testers such as the *Medalist* i1000D system offer a more cost effective alternative in many situations. If you are considering investing in a flying probe for prototype testing, maybe you should think again?

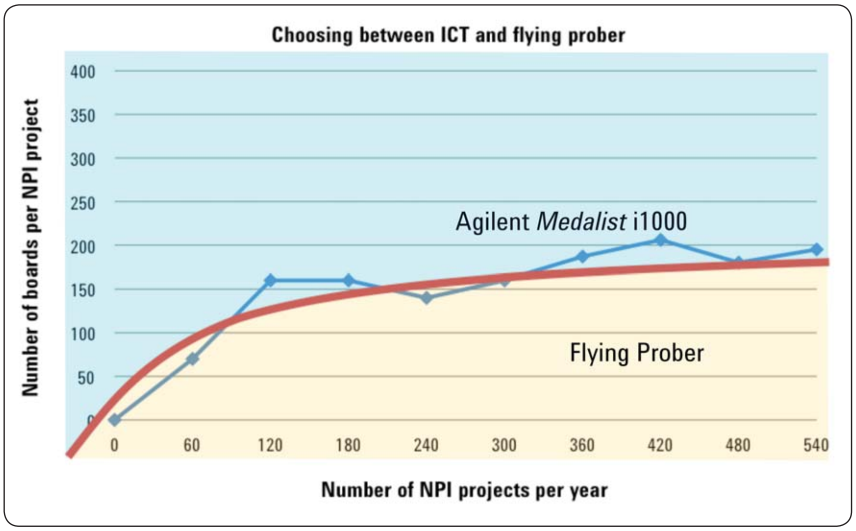

Figure 4. Flying prober or i1000D ICT? This chart provides a guide on when you should consider either options, based on the number of projects you carry out each year and the number of boards tested during each project.

www.agilent.com
www.agilent.com/find/i1000D

For more information on Agilent Technologies' products, applications or services, please contact your local Agilent office. The complete list is available at:

www.agilent.com/find/contactus

Americas	
Canada	(877) 894 4414
Brazil	(11) 4197 3500
Latin America	305 269 7500
Mexico	01800 5064 800
United States	(800) 829 4444

Asia Pacific	
Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 112 929
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Thailand	1 800 226 008

Europe & Middle East	
Austria	43 (0) 1 360 277 1571
Belgium	32 (0) 2 404 93 40
Denmark	45 70 13 15 15
Finland	358 (0) 10 855 2100
France	0825 010 700*
	*0.125 €/minute
Germany	49 (0) 7031 464 6333
Ireland	1890 924 204
Israel	972-3-9288-504/544
Italy	39 02 92 60 8484
Netherlands	31 (0) 20 547 2111
Spain	34 (91) 631 3300
Sweden	0200-88 22 55
Switzerland	0800 80 53 53
United Kingdom	44 (0) 118 9276201

Other European Countries:
www.agilent.com/find/contactus

Revised: July 8, 2010

Product specifications and descriptions in this document subject to change without notice.

Printed in USA, September 24, 2010
5990-6592EN

Agilent Technologies