Production Test for Modern Electronics Production

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Motivation

- **Why**
- **What**
- **How**

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Why.

In the 1980s and early 90s we worked to reduce the brick wall between development and production. Outsourcing gives formal interface and rebuilds the wall. The production companies therefore need to improve their routines.

Technology advances require more advanced production machines, and skilled personnel is required. To find the equipment suitable for the respective production lines is a complex, time consuming and expensive task. By co-operation between several companies the cost and labour is divided among the participants.

What.

In order to ease the burden on each company, we arranged a co-operation between nine partners, and got funding from the government to evaluate tools. Thereby, the only company expenses are the the time spent. The government covers the travel and course expenses, and the cost related to project management.

How.

We determined what are the main phases of production and divided the group into four sub projects.

We have still half a year to go and there are still tasks to perform, but so far the project has been a success. And we will finish the scheduled tasks this year.

Contents

- Project Description
  - CIM
  - Inspection Systems
  - B-Scan and Mixed-Signal Test Bus
  - Diagnosis and Repair
- Project Status
- Conclusion

I was asked to give a provocative presentation, and although I am a peaceful person I will try to do so.

To put you in a suitable mood I will give a project description and the present status interspersed with some provocative comments or questions.

We have divided the project into the following subprojects.

Finally I will conclude with some propositions for research work.

Project Description

- Partners
  - Electronic Production Companies
  - University of Trondheim (NTNU)
  - Technical College of Buskerud (HiBu)
  - SINTEF Electronics and Cybernetics
- What to do

Two of the partners has it all: Research, development, production and test. But they are both negotiating with larger production companies to sell out their production lines.

The six other companies are all pure production companies.

The university and college are hardly contributing to the work, they participate to learn about production and production test.

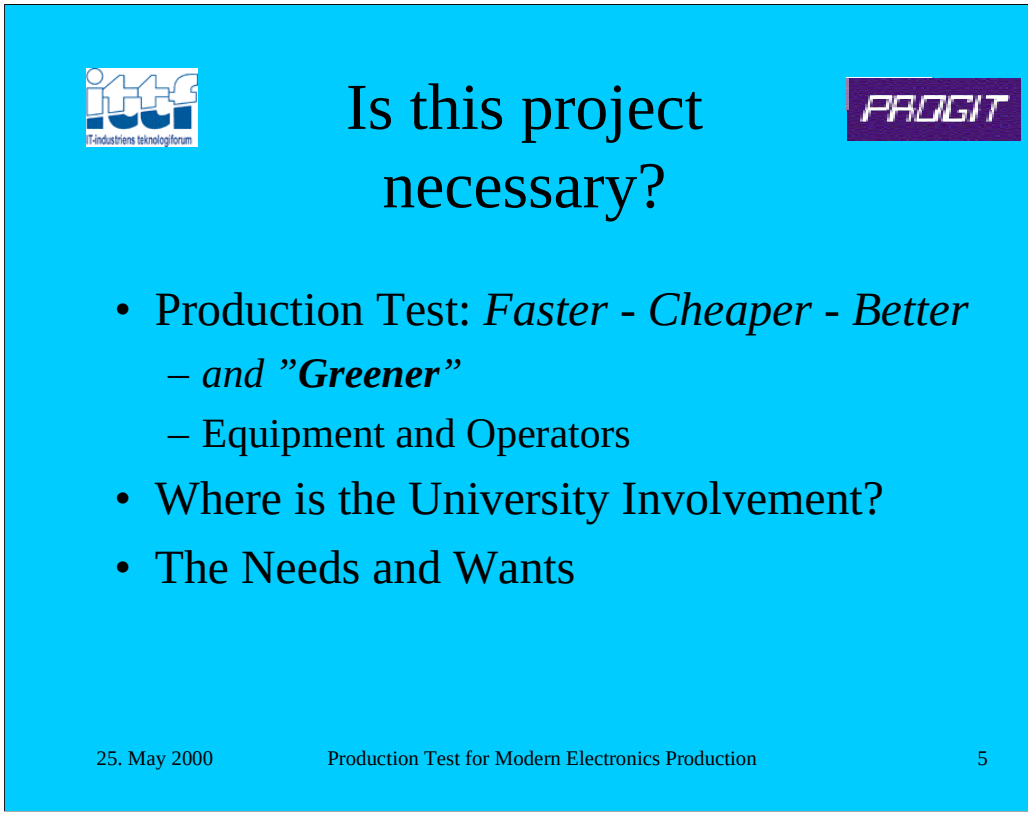
SINTEF has the project management.

To do.

We had to find out what functions were needed and what equipment was available to solve the functions. So we described a typical production line and what kind of challenges were common at what stage.

Based on that we divided the project into main tasks which became subprojects. Each company determined where they had the major problems, and joined the subprojects accordingly. One important asset of this is that it was a production management decision to participate. The participants therefore have backing in their own organisation.

For all the participants, tool evaluation was considered the most important because that is time consuming and costly. Based on the evaluations we are making a report describing the different tools and how they operate. We will not make any recommendations because that will be production line dependent.



To compete in this business you need a lean production, and to buy components at low prices which requires high production. There are no development company in Norway that has such a high production that they can compete with let's say Flextronic. Besides, when there is a shortage of components, those with the higher production are able to purchase component while the others are not.

Because of modern components which requires hundreds and thousands of interconnects with fine lines, the production equipment must be very advanced. This means you have to maintain an extreme good control with your production process, and you need skilled personnel to operate the machines.

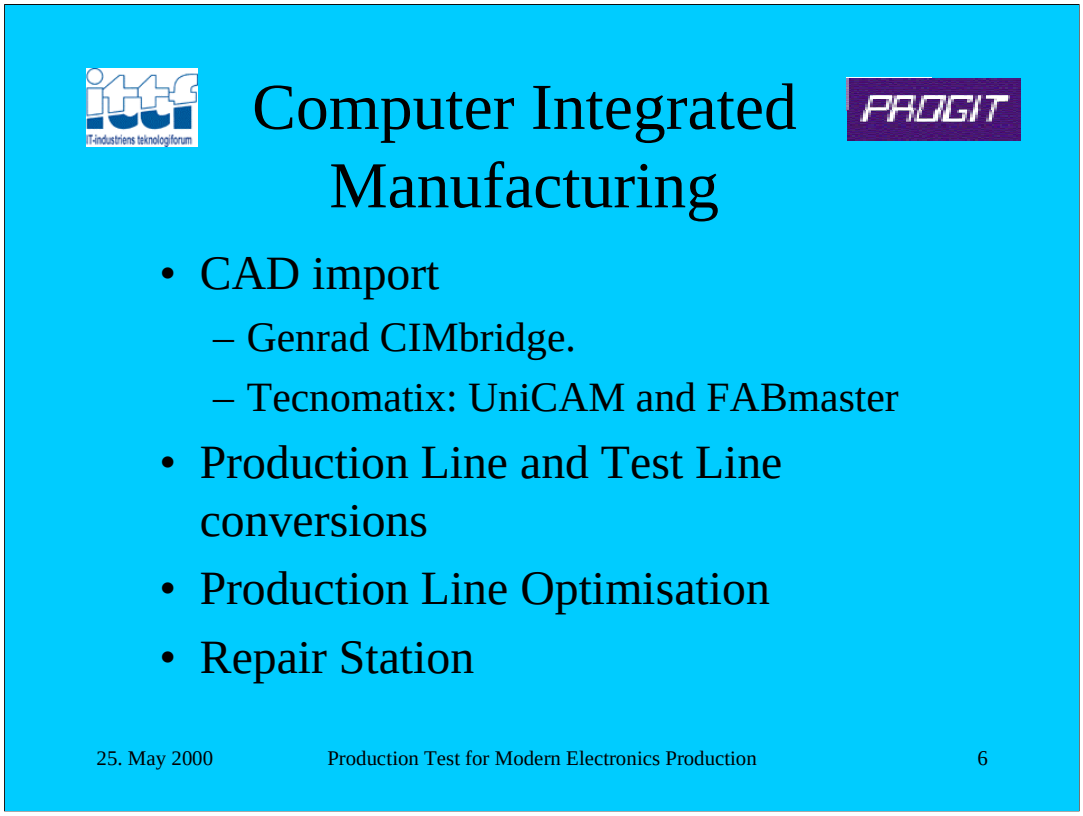
University

Almost every technical university in the world is involved in some activity related to ASIC development, verification or test. There are very few activities related to PCB.

Listen guys, there are lots of interesting topics related to PCB that ought to be researched. PCB technologies are approaching the level of what ASICs used in the late 70's. I will point out some areas for research during my presentation. And also in the "green" area there are lots of interesting problems.

Needs and Wants

What do the industry need to perform their operations and what do they want? The industry must be clear on what they want is what they need to be profitable. And what they need must be related to what they already have. New equipment must be compatible to their existing production lines.



I am now going into the subprojects. When the designer has finished his construction and completed the layout, he takes his CAD data and dumps it to production: “Produce this!”. So we need something that can convert the CAD data to production machine language.

Once upon a time there were three competing vendors of such tools. There was CIMbridge, UniCAM and FABmaster.

Last year came the big Tecnomatix and purchased UniCAM, and early this year they also acquired FABmaster. They are now merging the two tools into one under the name of UniCAM. But this will obviously take some time, so we had to evaluated all three.

UniCAM and CIMbridge handled assembly machines best while FABmaster was best on conversion to test machines. Otherwise they of course do a little of everything.

The Tecnomatix tool will be very good at everything, and they claim to have 70% of the market.

Production line optimisation. To set up a machine for a new product is time consuming. We therefor want so few changes as possible.

Another feature these tools have is a repair station. They have the graphics information from the CAD data which they merge with information from the test machine. I will come back to that on the last subproject.

Research?

- Well handled by the Vendors?
- We have a dream . . .
  - From CAD to Machines
- Other Topics?
  - Statistics
  - Graphics
  - . . .

Is this topic well handled by the vendors? The tools they have are good, they do in most cases what they are supposed to do, and they improve over the years. We found some minor problem areas during our evaluations, but they were all solvable or with workarounds.

But. We have a dream.

We would like to go directly from CAD to machines. That is, the CAD tools should have the necessary conversion tools included, and deliver whatever the production demands.

As the evaluations have proceeded I have to rephrase it: We had a dream. It would be like a push button silicon compiler. It could be nice to have, but you don’t really want it. All the CAD vendors had to maintain all conversion programs. No way.

Other topics for research: Statistics, graphics, . . .

Inspection Systems

- Purpose:
  - Detect Faults without Power-up
  - Production Line Quality
- In-line and Off-line
- Optical and X-Ray
- Repair Station

These tools replace humans. In stead of a person glaring at a board for 5 minutes, these machines achieves the same result in seconds. Typical faults detected are shorts, opens, misaligned or wrong components. You can go back and adjust the production line before you have produced to many faulty boards.

We grouped the tools in In-line and Off-line equipment. In-line equipment are in the production line and inspects every product automatic. These machines have to be fast, usually at the sacrifice of accuracy. Off-line machines are for random sampling to check the production line quality. They are manually operated, and you can turn and rotate the board to view it from different angles.

Another grouping is optical and X-ray machines. The main difference is obviously what you can inspect. Optical machines see the visible while x-ray machines see underneath components and inside boards.

Another way of grouping is 2D and 3D. Optical 3D is based on views from several cameras, while x-ray 3D is slicing (Agilent) or tomography(Nicolet). The main difference is in the software.

Some of the tools require a long time to program while others are easier. Long time means several days. This is a topic where clever students could achieve quite a lot.

Research?

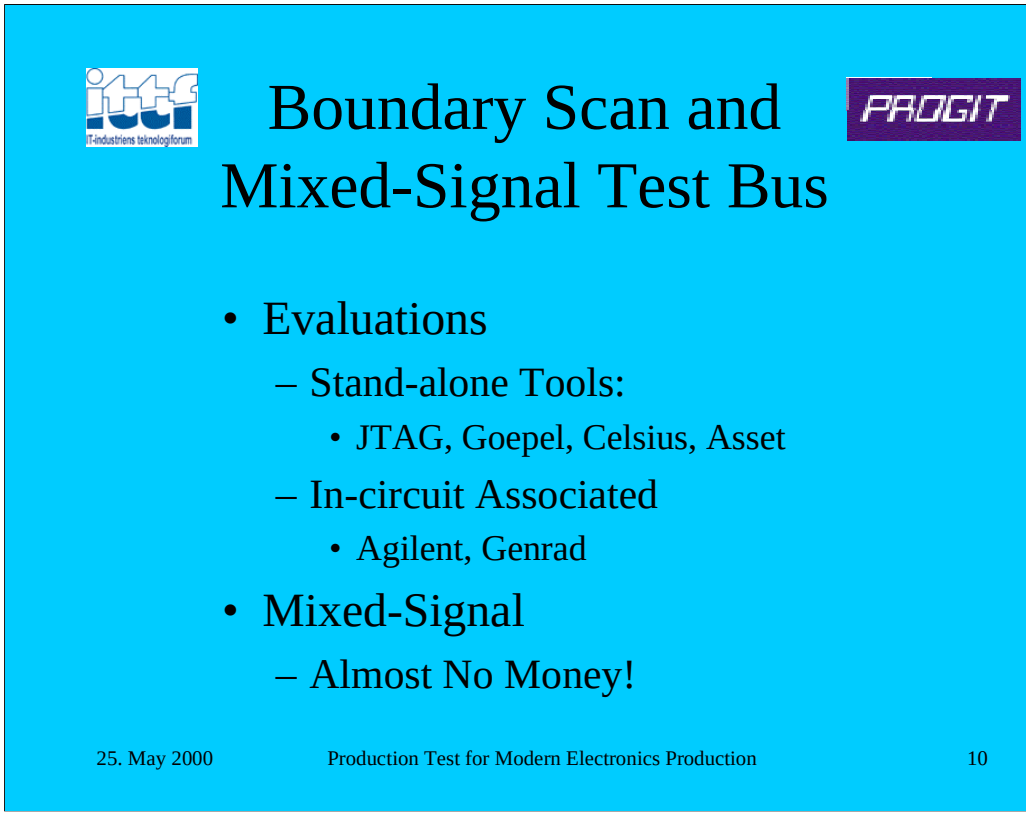
- Image Enhancements
- Image Analysis and Pattern Recognition
- Machine programming

Optical equipment use several cameras at different angels, and some use rings of diods, or light sources of different colours. And the picture quality is accordingly. Shadows from adjacent components is a problem. There are special arrangements for looking underneath BGA components.

X-ray equipment uses one camera, but different techniques for focusing, and to produce 3D views. We had a mini seminar with Agilent and Nicolet because they have different methods. Agilent focuses in slices and builds a 3D view by putting the slices on top of each other. Nicolet uses the DSP techique used in medicine, called tomography. By sending the x-ray beam in different angles through the board they can calculate the 3D picture.

There are still lots of work to do on image analysis and pattern recognition.

And by combining CAD data and an image from the board, there should be faster ways of programming those tools.



We have evaluated four stand-alone B-Scan tools, and they are all usable. You get what you pay for. A trend is now that they distinguish between programming and operating stations, the latter being somewhat lower priced.

At the DATE 2000 in Paris we also discovered a fifth tool, Intellitech which also was very interesting. However, there will be no evaluation of that tool.

We evaluate only two in-circuit tools: Agilent and Genrad. We will ask Teradyne and a few others to reply to a list of questions only.

Mixed-Signal

There is not enough money in the project to do a real job on mixed-signal, and this is a field that would be emphasised if we shall have a follow-up project.

However, we have allocated some money for Prof. Jose Ferreira while he is at the College of Buskerud.

Research?

- Ongoing University Work
  - Test Pattern Generation
  - Diagnosis
- Mixed-Signal
  - Use 1076.1 for 1149.4
  - Special Purposes

Boundary Scan is a hot topic at most universities, although most work is probably done at ASIC level. But there are still lots of work to be done on pattern generation and diagnosis, and several other topics.

Mixed-signal is also becomming very hot, and here there are even more work to do, both at ASIC level, but definitely also on PCB.

The use of 1076.1 on 1149.4 with respect to description at various levels, simulation, trying out different soultions, special purposes for DfT on analog parts, and so on.

There is work for several years in this area.

Diagnosis and Repair

- Spent Long Time to Determine What to do
  - Involve Development Teams?
  - Design for Testability. B-Scan?
- Decision: Use CIM Repair Station Tools
  - Agilent PRS
  - UniCAM
  - Genrad Tracs

The goal of this subproject is to shorten the debug and repair time for boards that have failed in the production test. But the resulting methods will also be useful for boards that has failed anywhere in its life time.

This subproject is the one most behind schedules. We spent a long time on arguing and discussing how to solve this goal. At first we tried to involve development teams, and even though we allocated money to cover their extra expenses, they didn't want to join us. May be they didn't like to be told what to do by production people? We looked at testable design methods, but there were not sufficient manpower and cash to solve such tasks.

Finally, late last year we decided to go for the tools already included in the CIM Tools. The main tools are the UniCAM and the Genrad Tracs.

We also included the Agilent Paperless Repair Station which works with the HP-3070 in-circuit tester, but Agilent advised us not to. They were going to make a new tool, and the present one would not be supported.

Research?

- Fault Localisation and Diagnosis
  - Inspection
  - In-circuit Test. With or without B-Scan
  - Functional Test
- Graphics
  - Fault Representation
- Design for Testability on PCB

The error information from the tester is dependent on what kind of tester.

From an inspection system you get the faulty component directly pinpointed. The in-circuit tester might be more inaccurate. It may point to an erronous component, but usually it points to a faulty net which may be connected to several components. And from a functional tester you are informed of the faulty function, but where is the error?

Research: How to localise the error, and also the graphic representation of the error could be improved.

Design for testability on PCB should be a must, but:

Real board designers do not simulate.

Major obstacle!

Real board designers do not simulate!

Project Status

- Not as Fast as Planned!
  - But Fast Enough
- Evaluations Contributed to Improved Level of Knowledge
- Informal network

If this had been an industry project, we could have done it in little over one year. But this is work the industry partners are doing on the side. The project was therefore planned with lots of slack, and we got funding for two years. And although all subprojects are from one month to almost half a year delayed, we should have no problem finishing the tasks before the end of November.

In all subprojects the participants have learned a lot about the different tools they evaluated. And in addition to the knowledge useful to their companies for selection of machines that matches their existing production lines, they have also learned the techniques behind the machines.

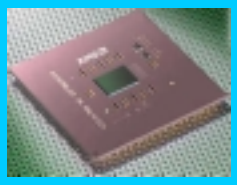
Second, we have established informal networks among the participants.

Research Topics Summary

- Imaging and Pattern Recognition
- IEEE 1076.1 and 1149.4 Description and Simulation
- Fault Analysis and Diagnosis
- PCB Technologies
- Follow-up Project on Selected Topics
  - Co-operation with EU Project?

Conclusion

- **ASIC!!!**



- Technology Advancements on PCB
- Need for Co-operation
- Interesting Research Topics
- Universities: ***Go for it!!***

ASIC is and will be an interesting topic at universities and technical colleges for a long time. But it is on time to open your eyes towards printed circuit board technologies. They are getting more advanced, and they get more complex every year. They are experiencing many of the same problems and challenges the ASICs experienced 15 years ago. There is definitely need for co-operation between development and production of PCBs, and I believe that if the ASIC and PCB communities would get together, they would both benefit.

There are more interesting research topics than what I have mentioned today.

Universities: Go for it!