IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

An Integrated Registration System for High Technology Multilayer PCBs

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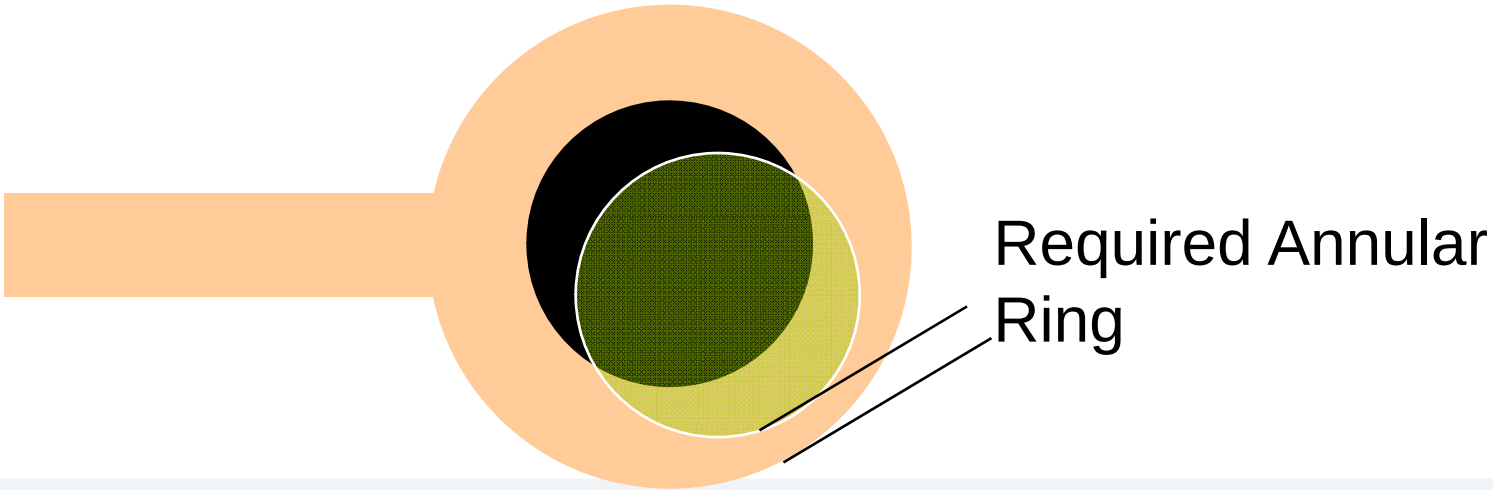
XACT PCB & Excellon Automation

Embracing New Technologies to Survive…

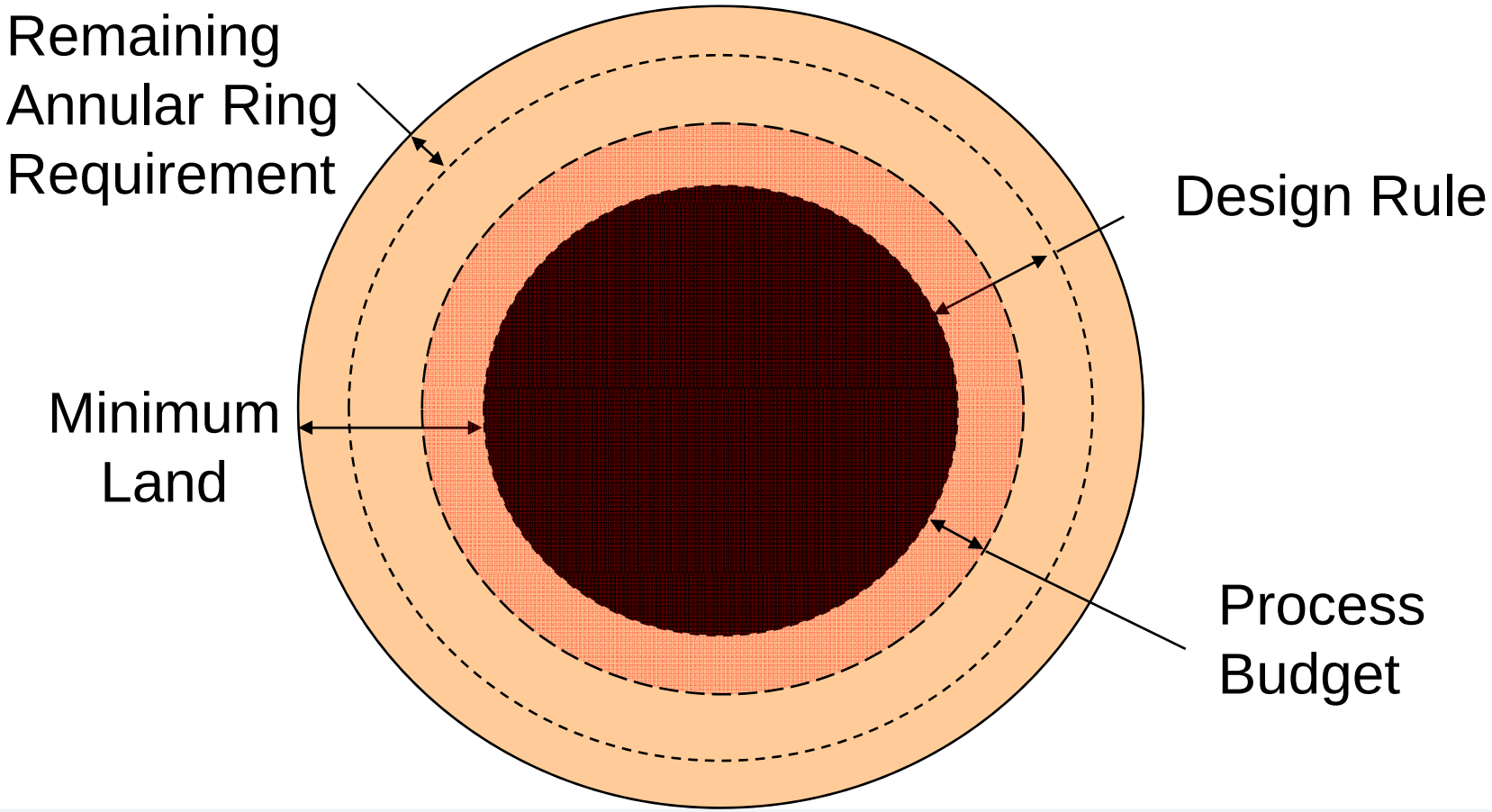
A definition

The *Registration Budget*

The **allowance** in a PCB design to cope with distortion of the materials, variance of process and manufacturing methods”



Definitions:



PCB Registration is like economics:

"It all works best when you have a BUDGET that you can understand, stay within and balance".

Registration Budget

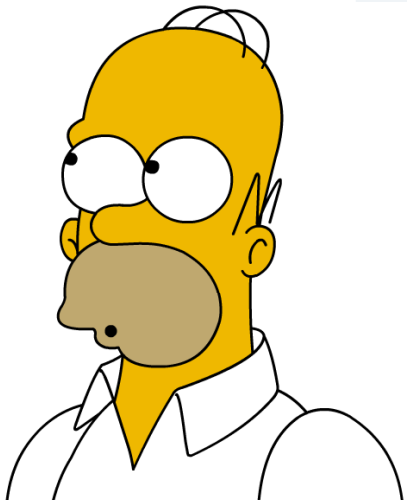
- Every design has a determinable **Registration Budget** – an allowance for the sum of process/material variations
- Every time a compensation is applied at a process step, part of this budget is used up
- Standard “best fit” compensations can use more of the budget than intelligent, process aware compensation systems.

Registration Budget

- If all the registration budget is used up at bonding, then drilling in specification will be impossible

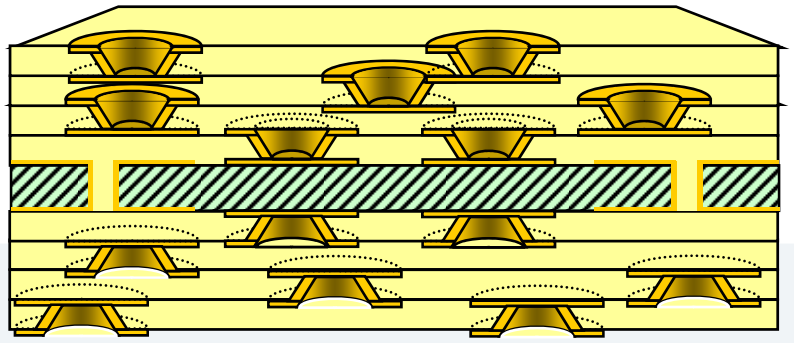
…. or

- If all the beer money is gone by Tuesday then Friday night is much less fun!



The Registration Challenge: Customer Driven

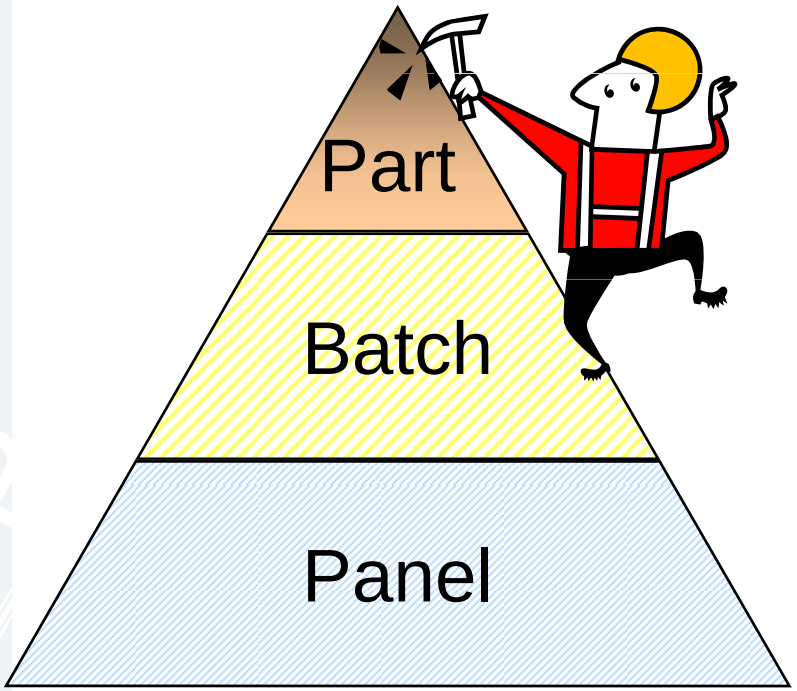
- Density demands increasing
- *Registration Budget* decreasing:
  - Increasing layer count for complex through hole PCBs
  - Tighter design rules: smaller annular ring
    - e.g. CSP, Cell phones etc: increasing level of SBU (up to 4+2+4 and 3+4+3)



The Registration Challenge: Customer Driven

- Customers require the collation of data from the ENTIRE process to drive process improvement
- Finished PCB dimensional tolerances getting tougher
  - For some designs is not allowed to compensate
  - Prediction of correct scale factor is critical
- Awareness of non linear distortion is increasing rapidly (PCB and OEM)

The PCB Tooling Challenge



- Currently, PCB shops tool for the part number
- Yet, variation takes place at the batch level
- ..and almost always at the panel level

Panel Level Compensation

- Latest generation equipment provides individual panel compensations based upon measurement of targets (e.g. Intelli-Drill®, Laser drill, X-ray/camera aligned drill machines and LDI)
- Registration system can link process data to make INTELLIGENT decisions about subsequent processes.

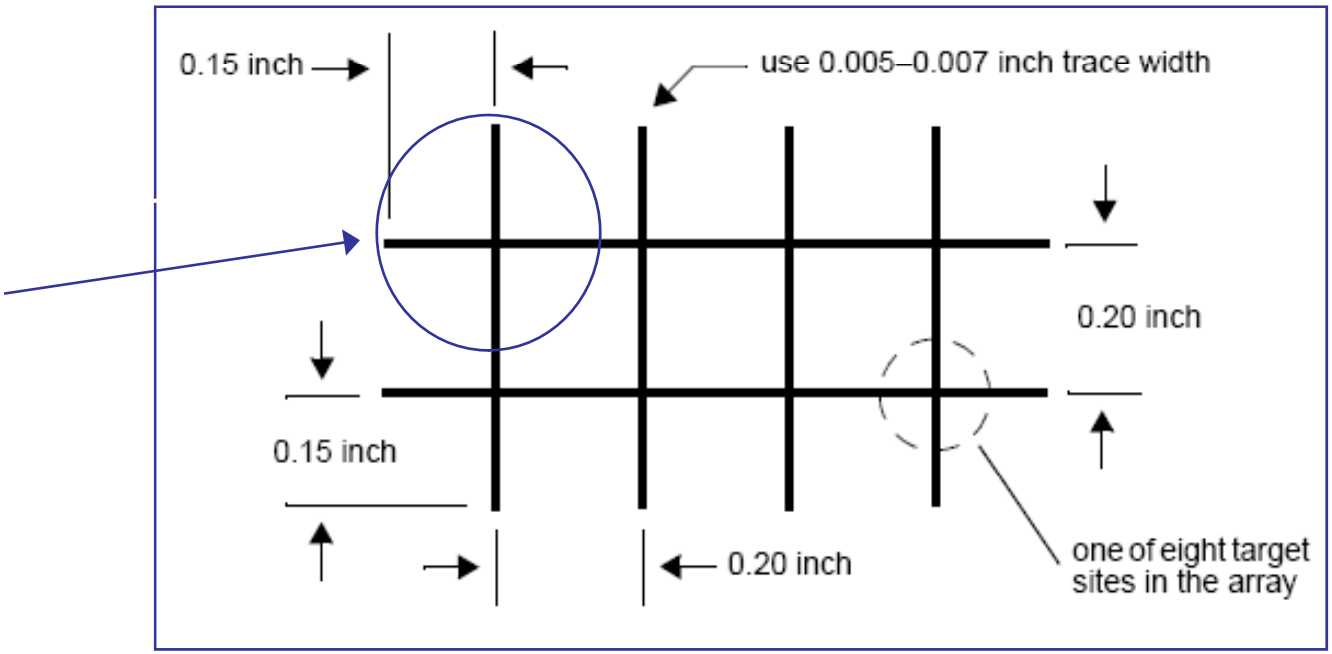
Registration system Interface with Optimiser

- Uses standard targets for each layer
  - Linear
    - 4 corner positions
  - NonLinear
    - Multiple peripheral positions
- Registration system reads optimiser's database

Collecting Data:

- Target Acquisition
- Internal Layer Inspection
- Vision Algorithms-X,Y Offset, Rotation, Scaling and Best Fit
- Vision Corrected (Best Fit) Drilling of Circuit Pattern or New Tooling Holes
- Average Best Fit of Tooling for a Batch / Lot of Panels

Internal Targets



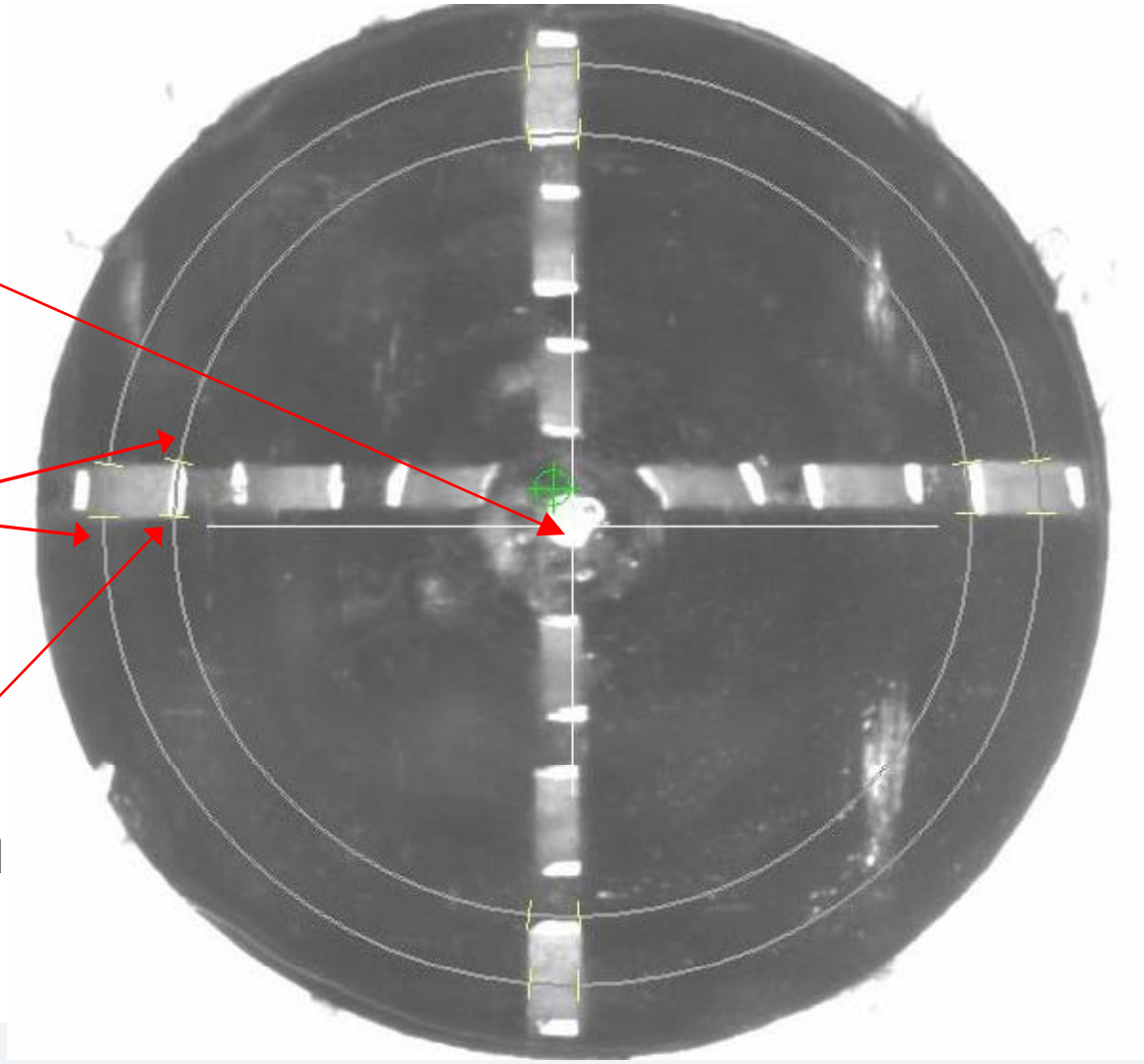
X-Ray would use round images on each layer

Target Inspection

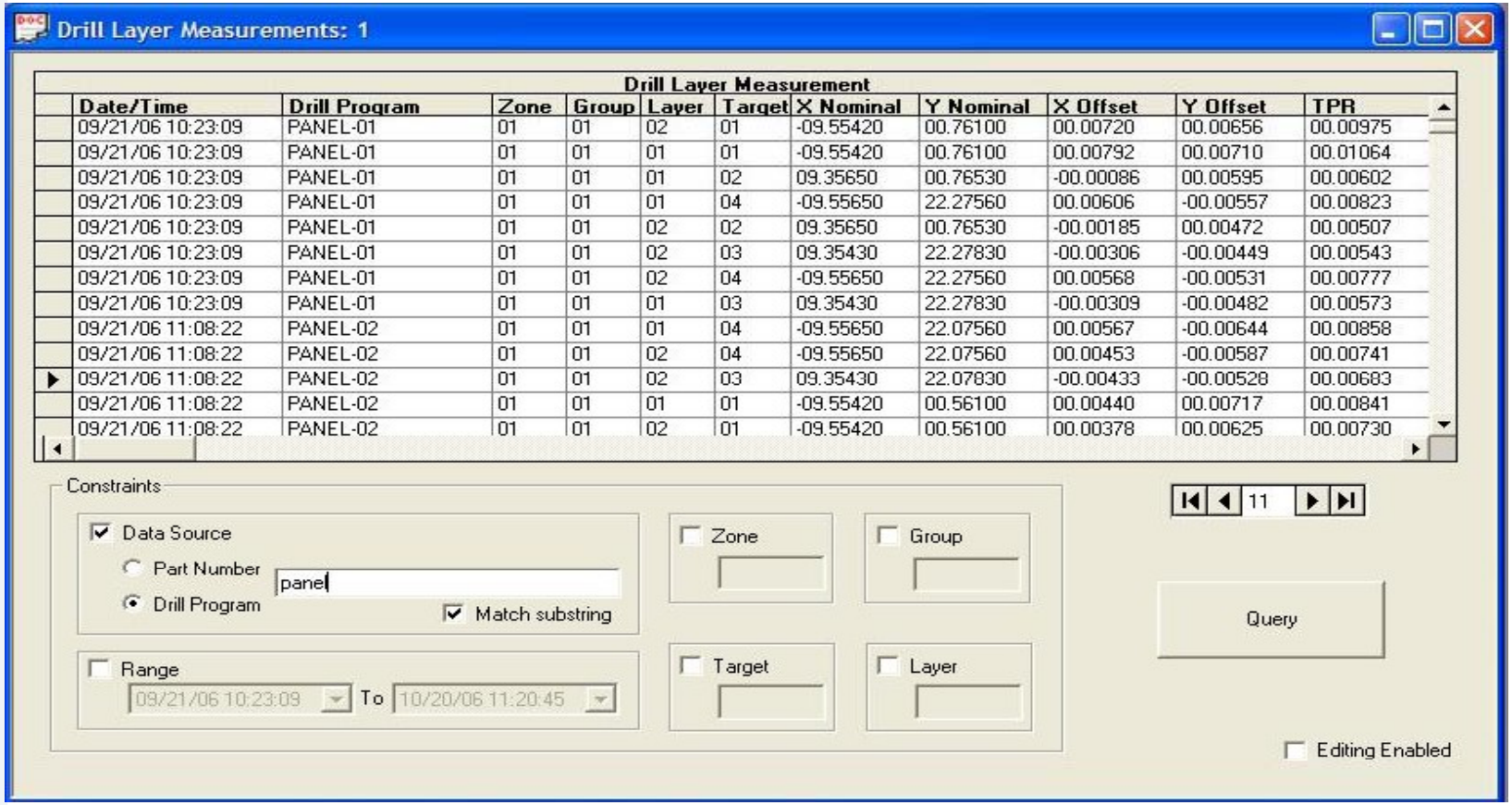
Vision system finding the "Best Fit" coordinates in both axes.

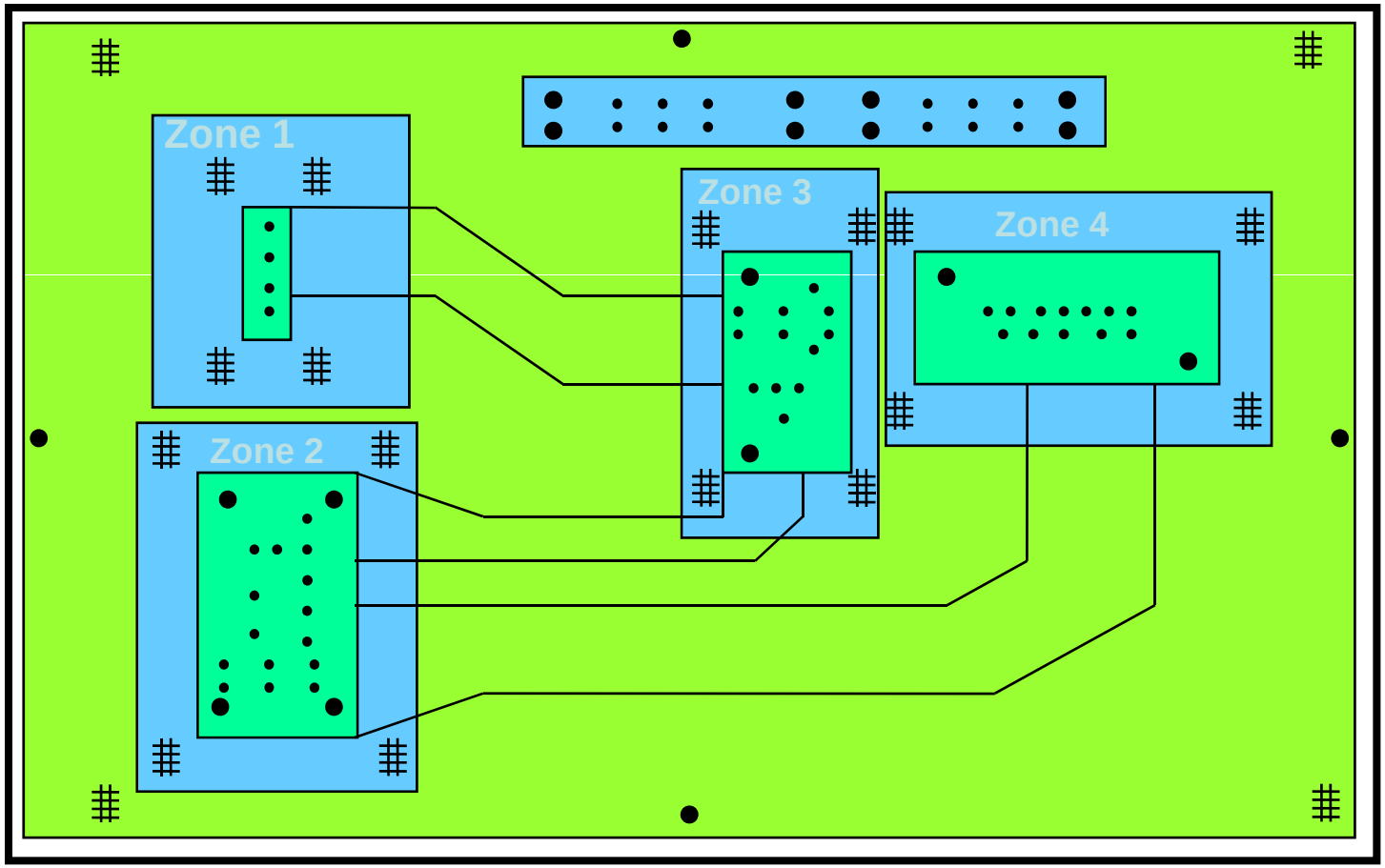
Depth rings indicate layers to analyze

Trace Edge Markers of found layer



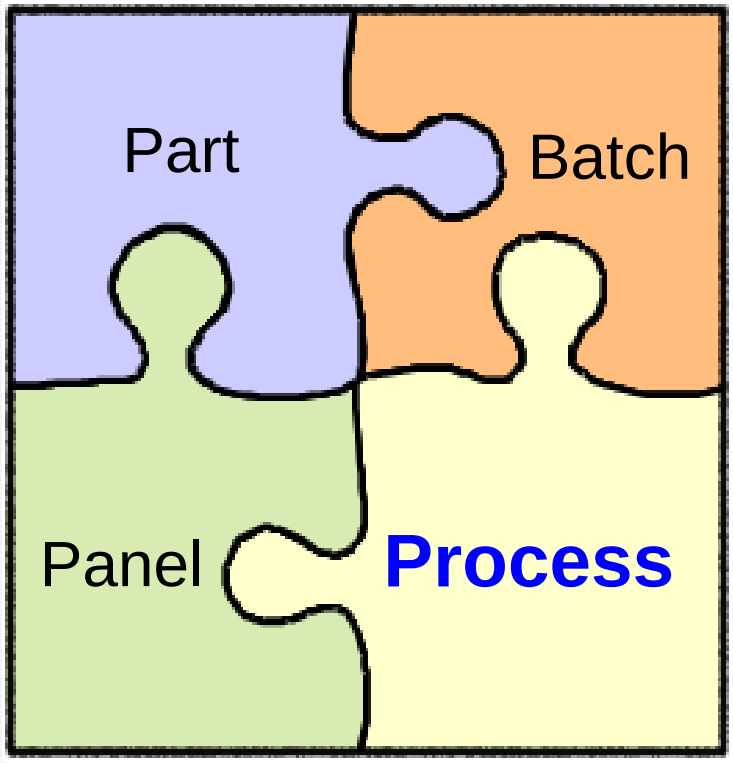
Drill Layer Measurement Data





Vision Corrected Zone Drilling

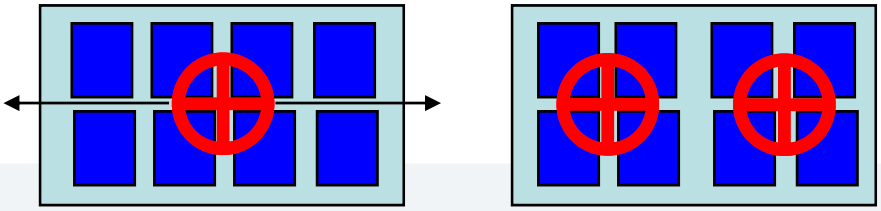
Expert Registration System Methodology



- Data drives Intelligent decisions for Tooling and Process
  - Panel,
  - Batch(es),
  - Part number
- Learn about the Process and Part number requirements by understanding the Batch and Panel level distortions

System's Intelligent Decisions

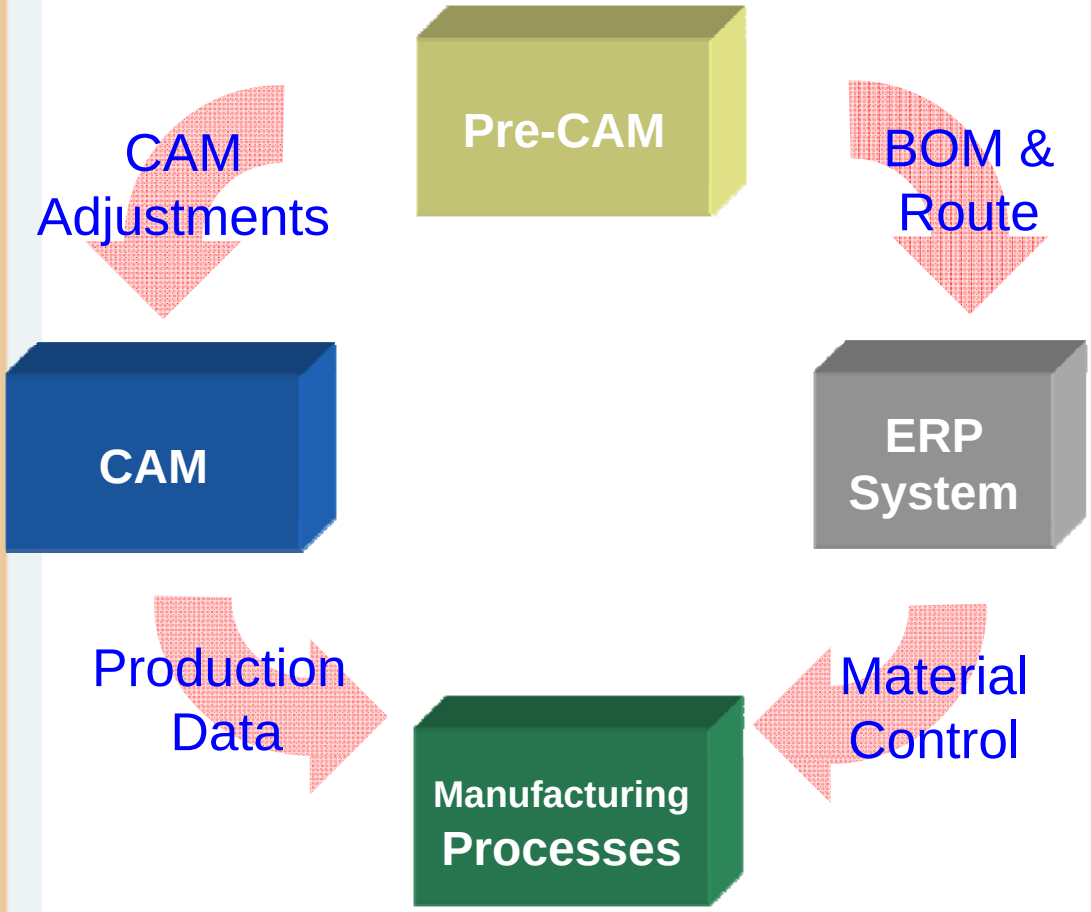
- Determine the Registration Budget for the product
- **Rules-based decisions**: Always target nominal at end of process.
  - Apply Linear or Non Linear Scale compensation ?
  - Apply Step only
  - Apply Scale AND Step
  - Do nothing.
- Establish Product Confidence at each step in the process
- Create modified tooling for downstream processes
- Establish Panel-level / Batch-level traceability



Scale about centre

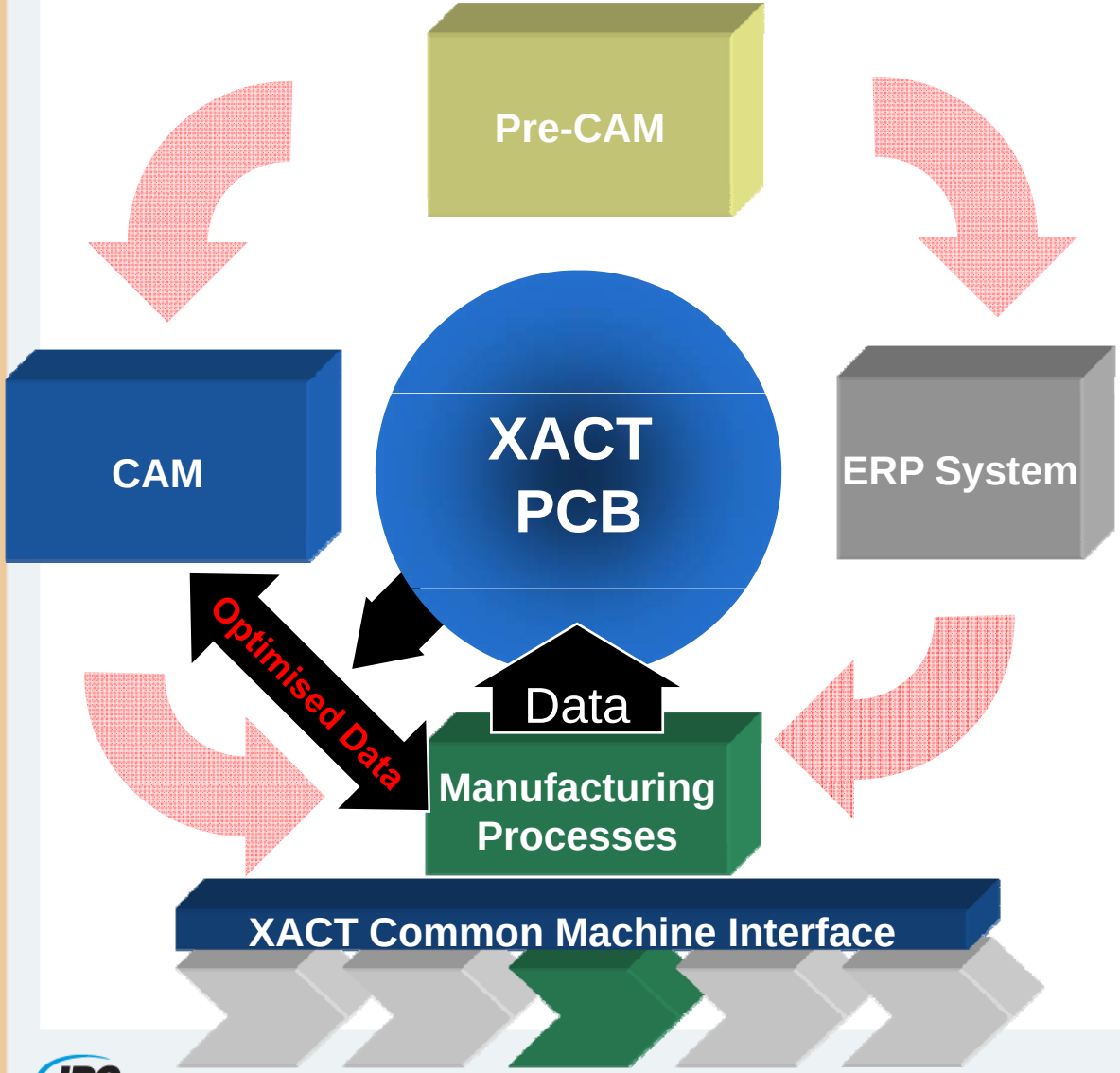
Change circuit **STEP**
Means splitting the error

Generic Engineering Work Flow



- Machines and CAM are not directly linked
- There is little or no data flow from the process back to CAM & Engineering
- Data is often not centralised

XACT Linear and Non Linear Control

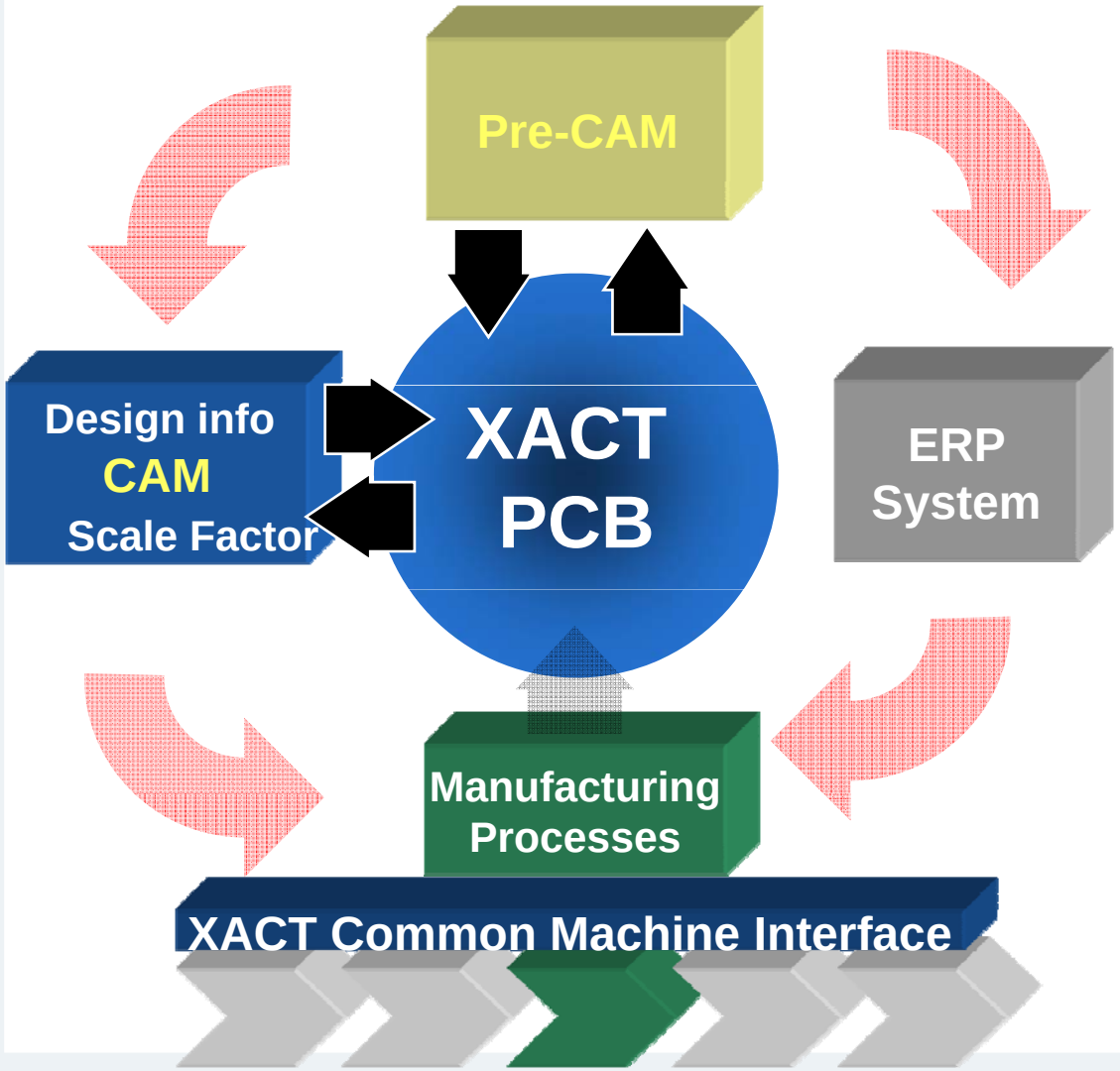


- Uses a Common Machine Interface to process data from the post bond optimisers
  - Intelli-Drill®
  - X Ray Drill
  - X Ray CMM
  - Etc
- System Returns
  - Intelligent and optimised drill data and scale factors

Batch and Panel Analysis

- System interfaces to production machines via a common graphical interface
- Batch and Panel data can be analysed and compared to previous production
- Closed loop to CAD for batch and (if required) panel compensation

Linear and Non Linear Prediction



- Pre-CAM & CAM Provide
  - Cu distribution
  - Stackup
- XACT Returns
  - **Accurate, Predicted Layer Scale Data**
  - **Scale Factor Confidence levels** and data from previous builds

Registration system configurations

Linear

Optimises batch-to-batch variability, measure and compensate dynamically. **Improves yield immediately**

Linear+

All the features of Linear combined with **advanced prediction capability**

NonLinear

Linear+ combined with **Non-Linear measurement and compensation** capability

NonLinear +

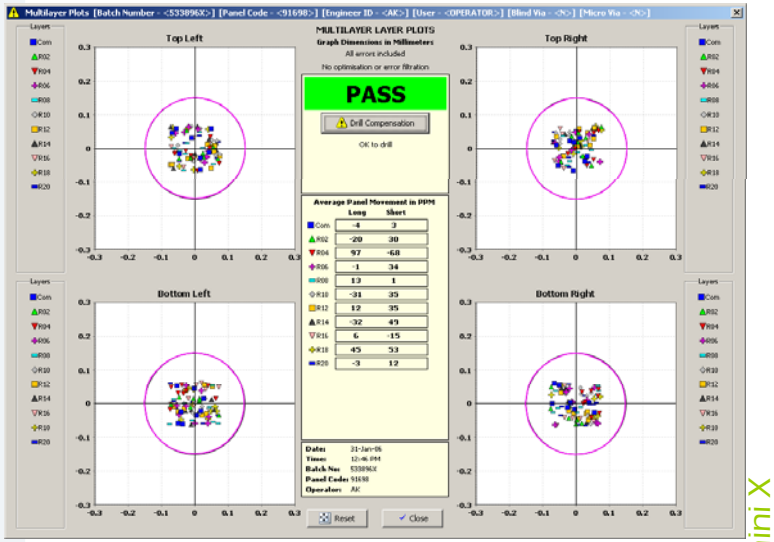
Non-linear prediction & compensation capability

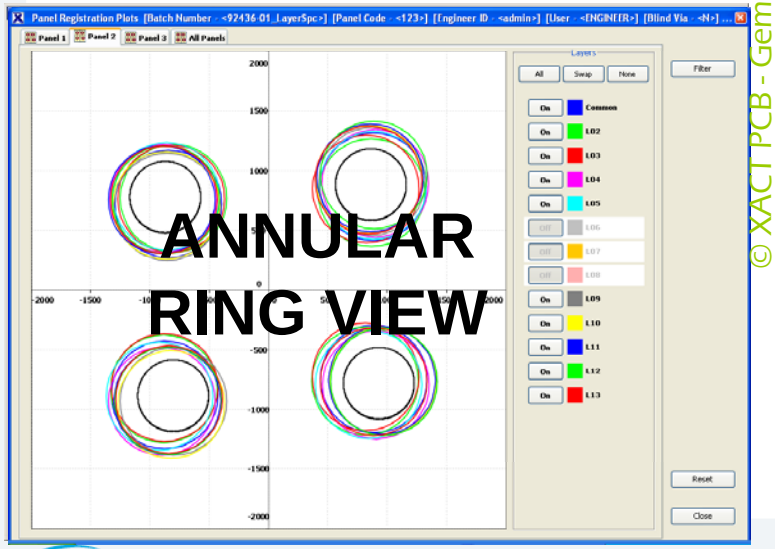
Designed for HDI production at the best possible yield

MODULAR STRUCTURE

- *Machine Analysis Interfaces*
- *CAM/ERP Interfaces*
- *Database Interfaces*
- *Drill Optimiser Interfaces*

Measurement and Analysis Common Machine Interface





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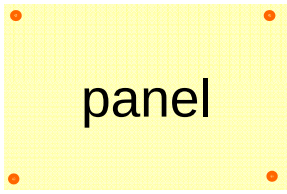
Linear and Linear+

Four corner measurement



Direct link to process machines Improve yields immediately

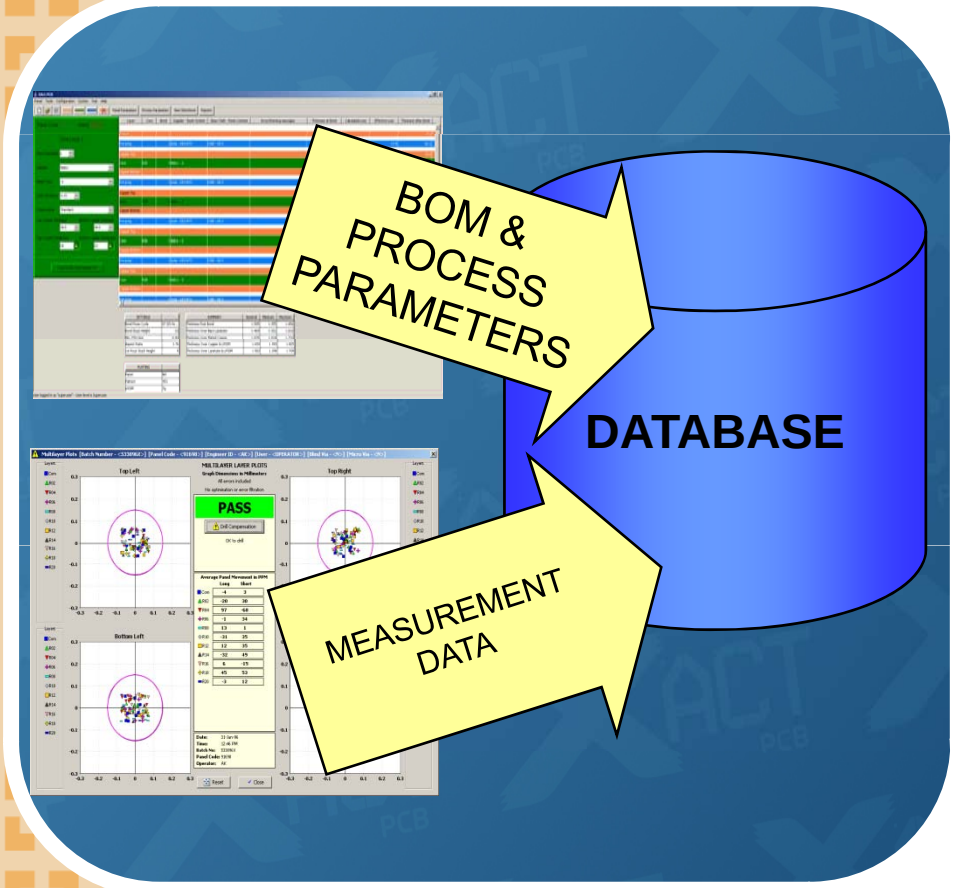
Feed forward and feed back compensation derived in real time

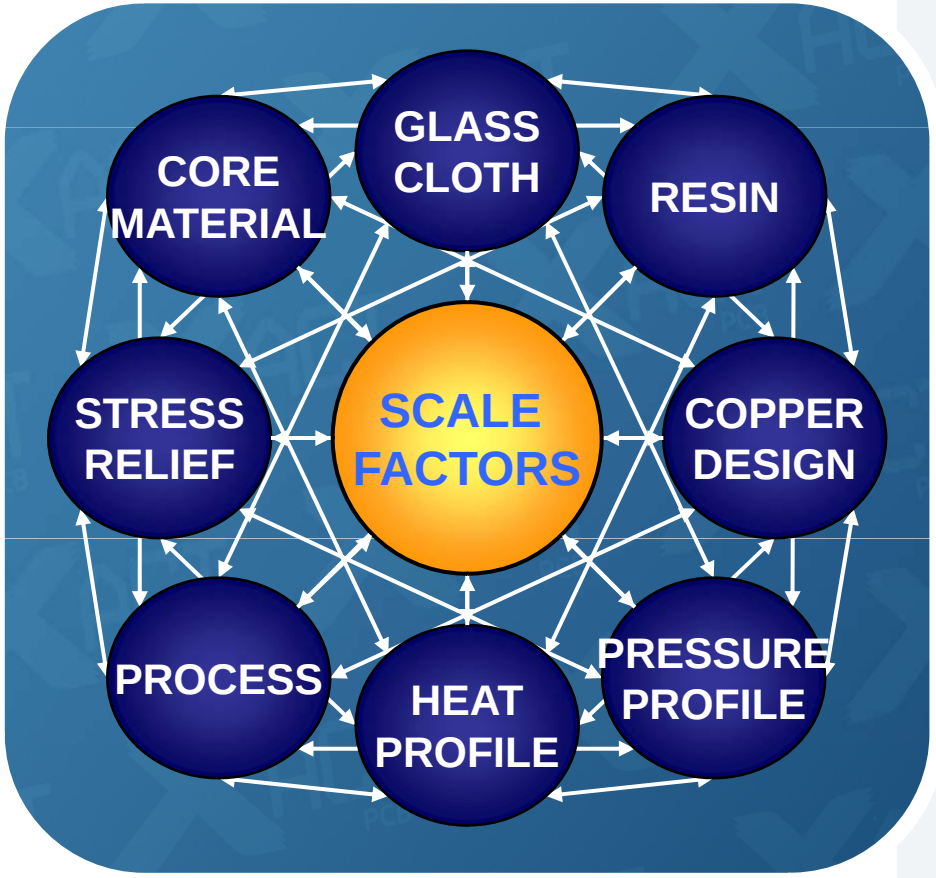
Reporting for every panel of a batch if required

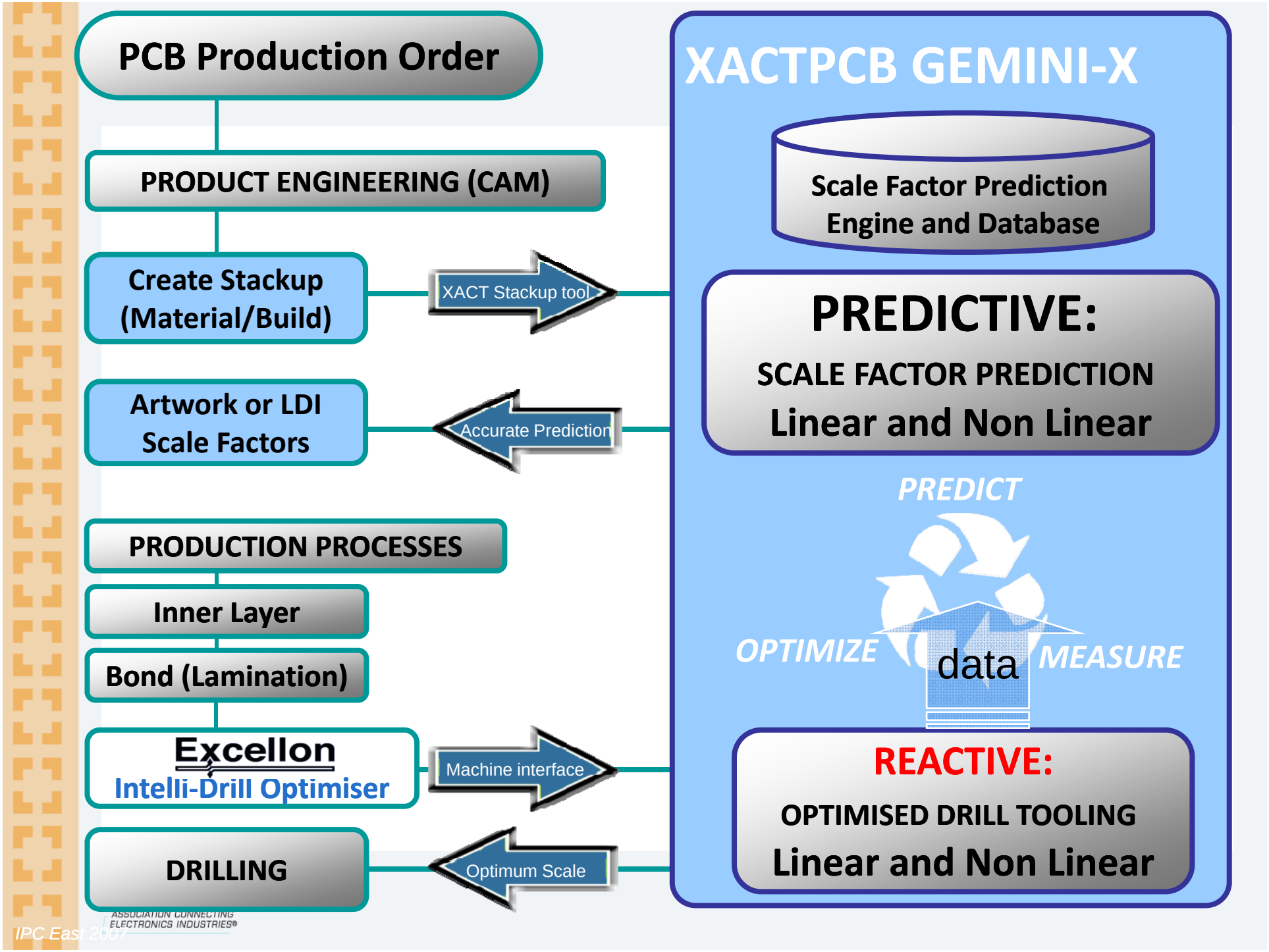
Registration System Predictive Model

- Self learning model
- Powerful and Fast algorithm
- The model is easy to train
- Implement with CAM
- Unmatched accuracy

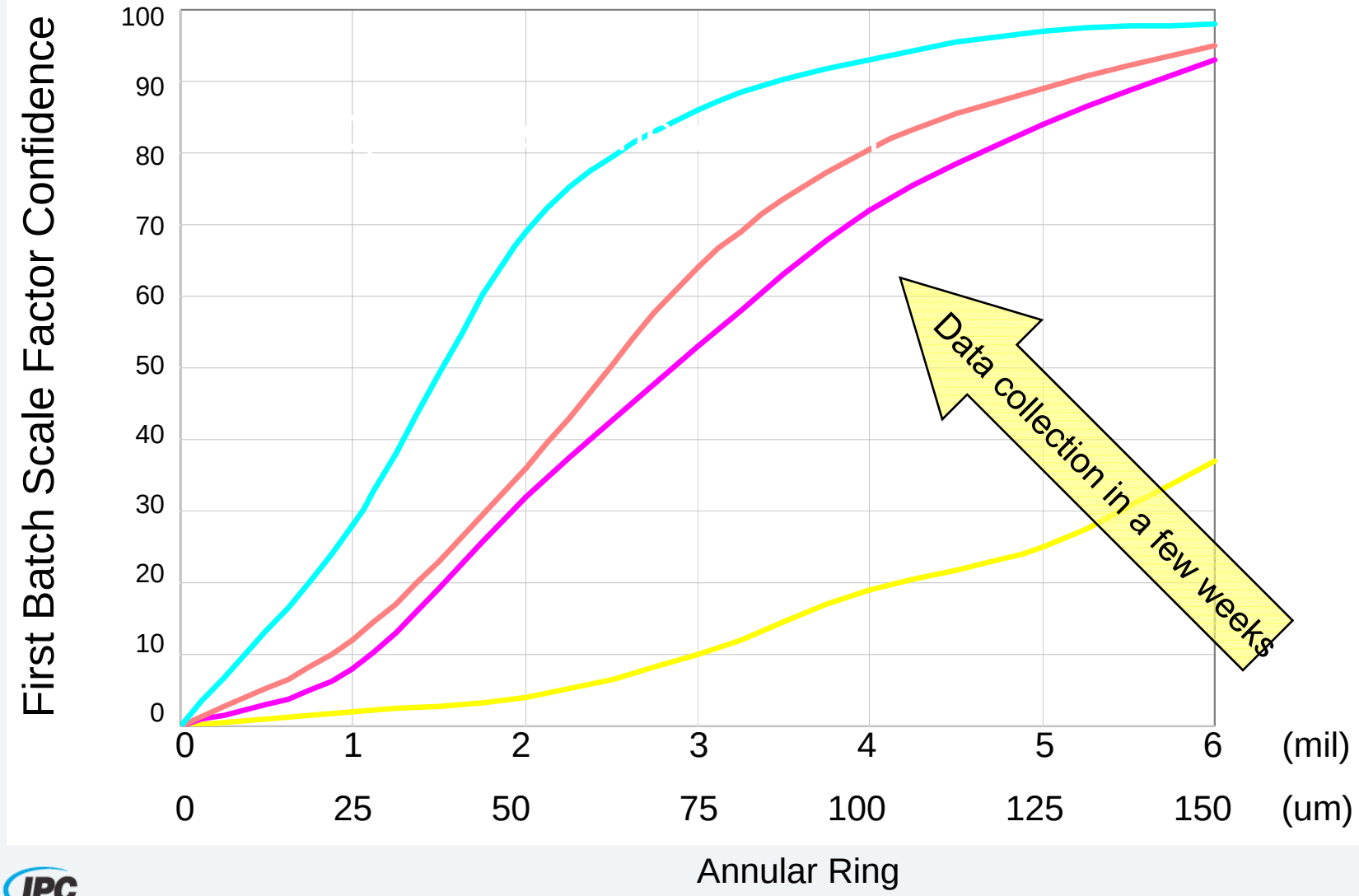
Fast Self-Learning Model






PCB Production Order
PRODUCT ENGINEERING (CAM)
Create Stackup (Material/Build)
XACT Stackup tool
Artwork or LDI Scale Factors
Accurate Prediction
PRODUCTION PROCESSES
Inner Layer
Bond (Lamination)
Excellon
Intelli-Drill Optimiser
Machine interface
DRILLING
Optimum Scale
XACTPCB GEMINI-X
Scale Factor Prediction Engine and Database
PREDICTIVE:
SCALE FACTOR PREDICTION
Linear and Non Linear
PREDICT
OPTIMIZE
data
MEASURE
REACTIVE:
OPTIMISED DRILL TOOLING
Linear and Non Linear

Improvement in first pass yield



Linear+ summary

- ✓ Interface with existing equipment and data
- ✓ Close the loop between CAD and process
- ✓ **Predict** scale factors with unrivalled accuracy
- ✓ **No large coupons** – no loss of expensive real estate
- ✓ Improve yields
- ✓ Reduce leadtime
- ✓ Improved throughput
- ✓ Improve profit

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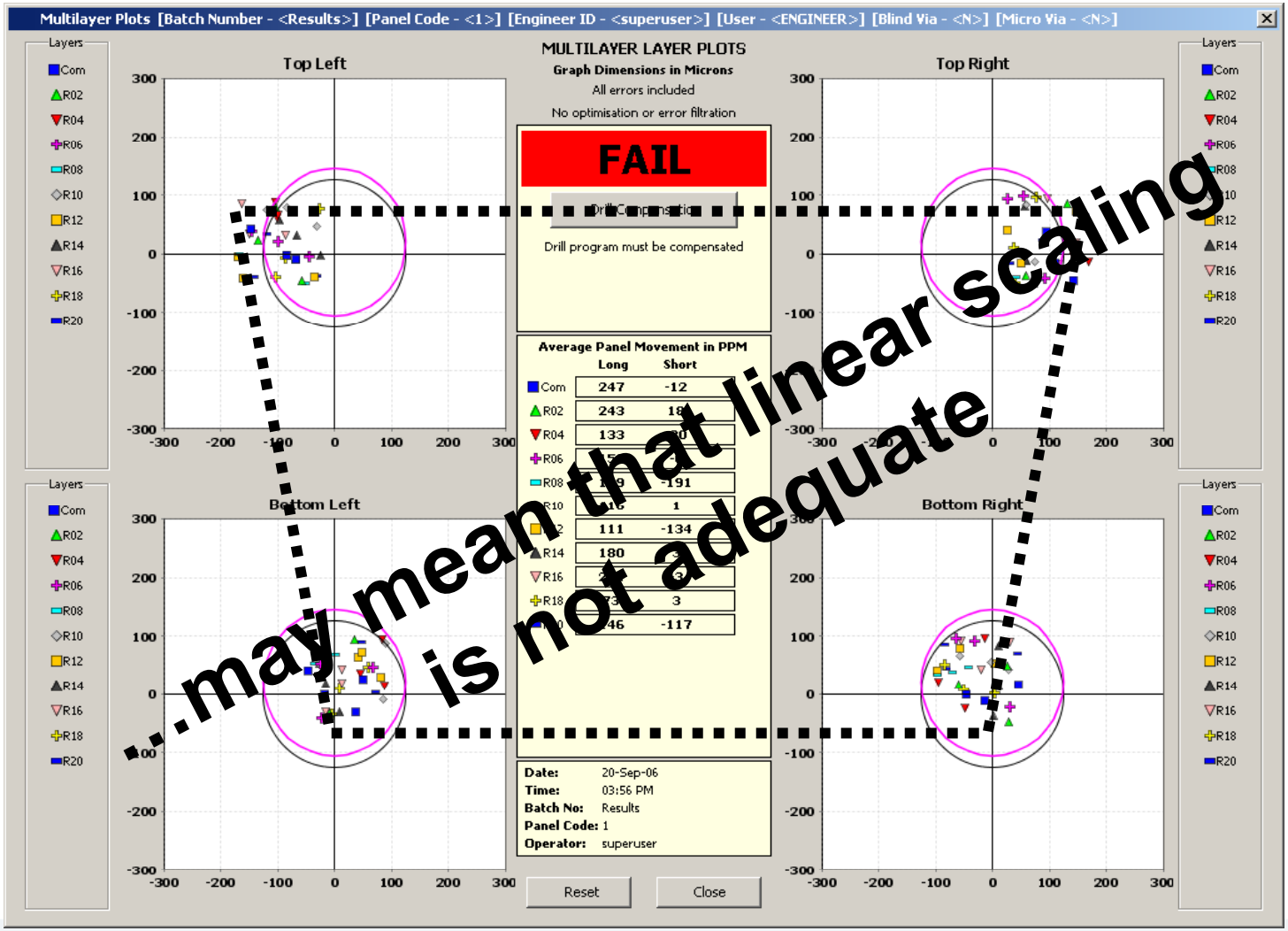
AND NOW

“The Rest of the Story”

IPC ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES®

Non Linear distortion

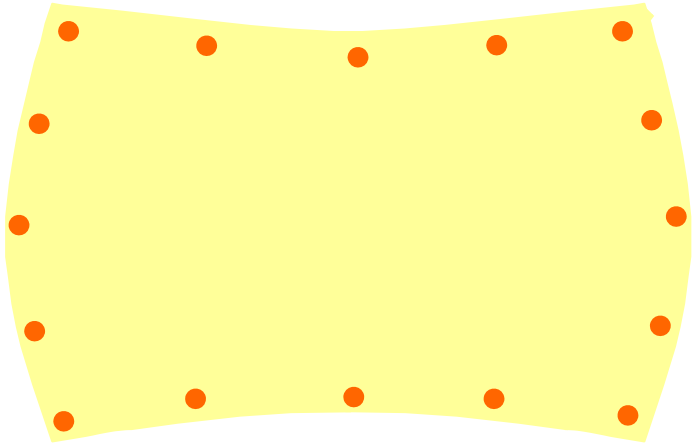


NON-LINEAR

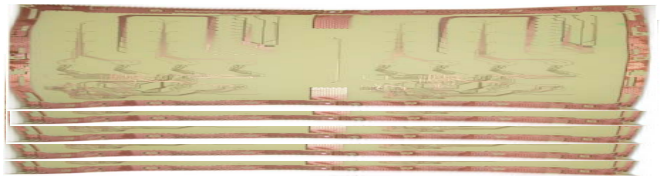
Non-Linear Measurement

(an inner layer core after bonding)

Inner layer Core

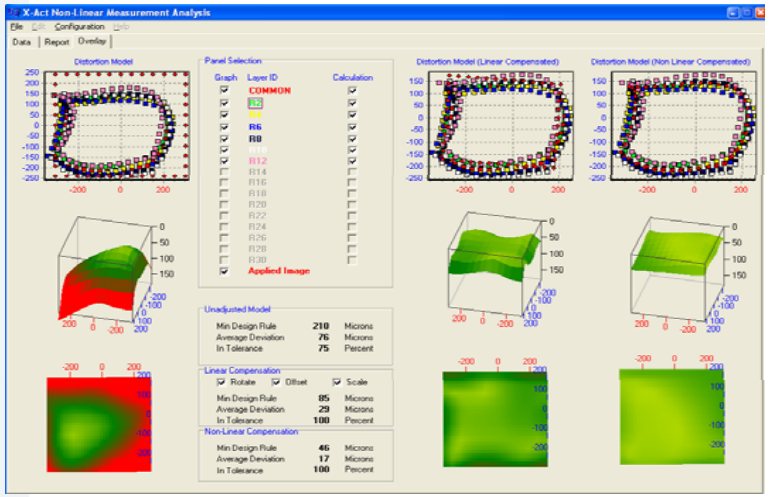


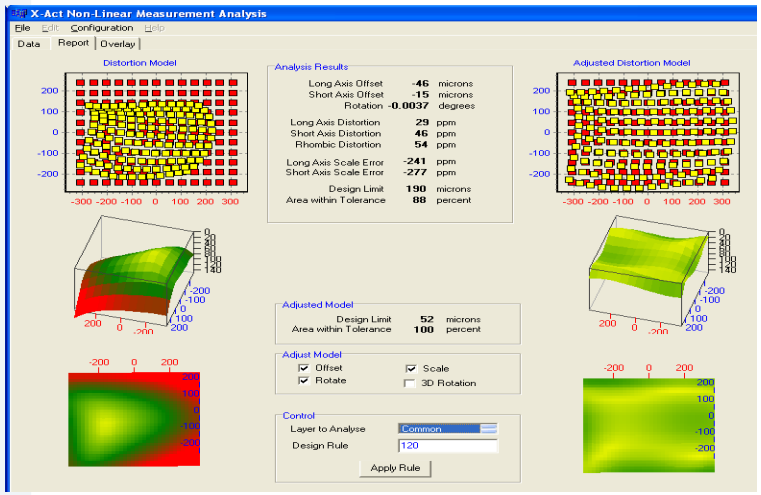
Stackup



Each core and the full stackup is characterised by its Non Linear distortion

Measurement and Analysis Common Machine Interface





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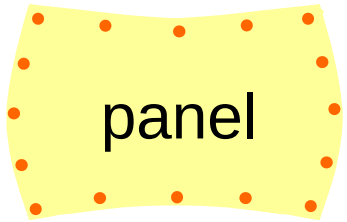
NonLinear and NonLinear

Peripheral measurements



Unique analysis capability

Compensate non linear distortion (Linear and NonLinear reactive capability)

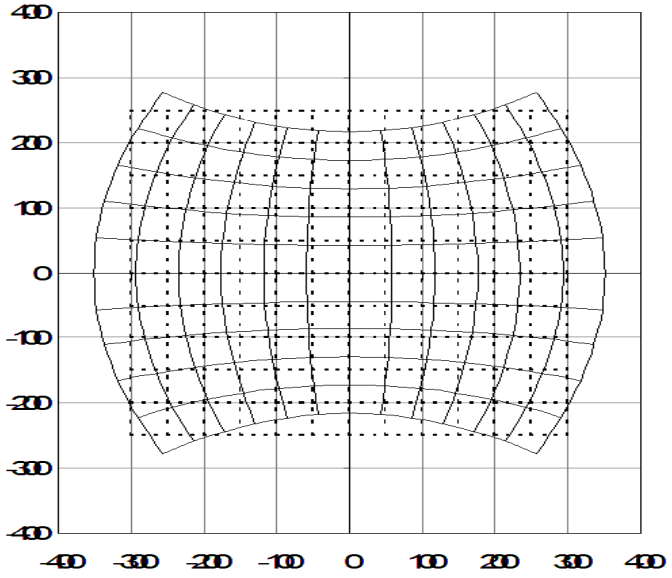
Feedback non linear distortions

NON-LINEAR

Non-Linear Prediction

Standard process

Artwork Scaling At CAM

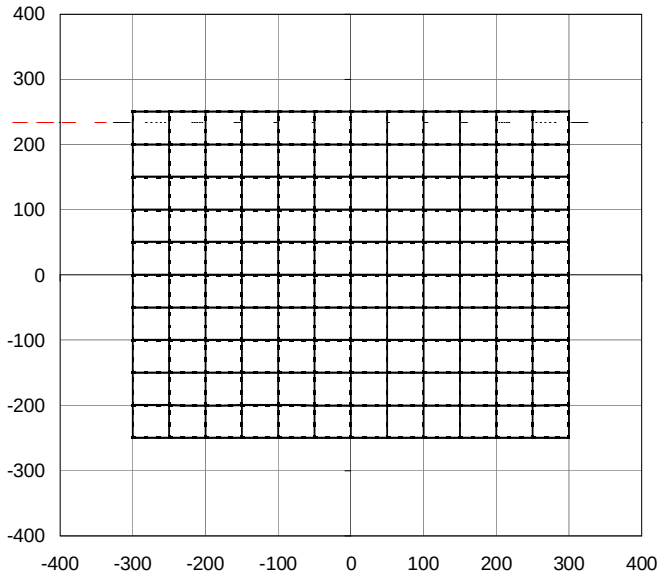


Non-linear distortion

Non-Linear Prediction

"Inverse Distortion applied at CAM"

Non-Linear Compensation At CAM



No distortion

NON-LINEAR

Non Linear+ Summary

- Prediction of non linear distortion:
  - inversely scale artworks or LDI data.

✓ Improve HDI capability

✓ Design for manufacture verification

✓ No coupons – no loss of expensive real estate

✓ Improve yields

✓ Reduce leadtime

✓ Improve profit

Summary of System's Solutions

- Instantly improve yields and product quality
- Maximise return from installed capital base
- ROI within weeks
- Reduce lead-time
- Maximise profit
- Link CAM with key shop-floor process controls

Conclusions

- Understanding your *registration budget* is critical
- The *registration budget* is going to get tougher and we have to be ready
- The paradigm of tooling only for the part number is changing
- Understanding the process means understanding the batch and panel level variation

- Tools from XACT PCB and Excellon can ensure that you are ready for the next challenges of registration.

- THANK YOU,

Excellon®

Precision Drilling • Routing • Micromachining

XACT PCB