

**Nov. 2022**

# **The challenges in testing small and highly integrated devices in a massive parallel test system**

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# Overview

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- ❑ Trends and objectives for high parallel testing
- ❑ The challenges of testing IC's in a massive parallel test system
- ❑ Concepts and solution for high parallel test contactor and results
- ❑ Thermal aspects
- ❑ Conclusion & follow-on work?



# Trends and Objective of IC Handling

# Backend Test Evolution

PST (post singulation test)

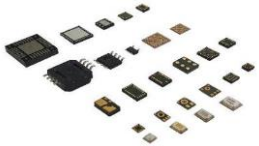
Strip/Wafer level probing

Gravity  
(till 2000)

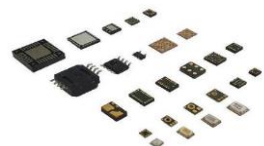
PnP  
2000 to 2020

TIS / Batch  
2020 →

Panel Test  
→ 2025



Gravity



Pick and Place



Test in Strip

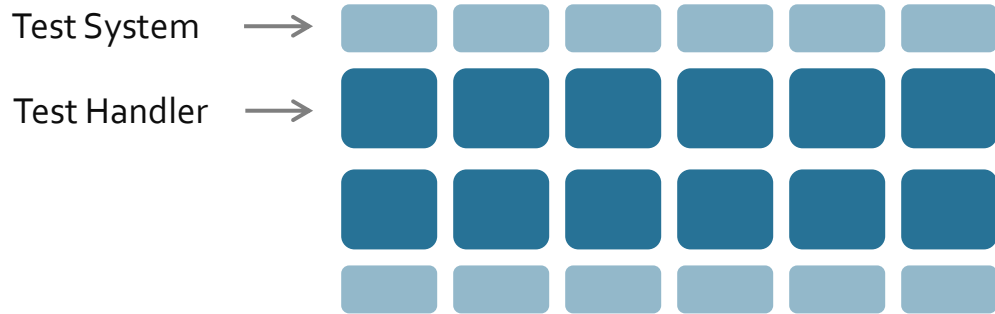


Sense+



# Singulated Handlers vs. Strip-Based Handlers

## ❑ Conventional Final Test Floor

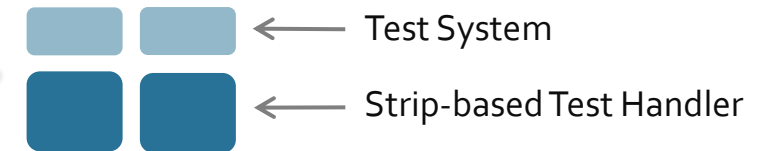


Objective: 2 Mio. devices / day

Ambient Quad = 7200 IC / h  
= 12 handler  
= 6000 FT<sup>2</sup>  
= \$9.6M

Assumptions: Test Cell \$0.8M, 0.75 uptime,  
index 500 ms TT=1 sec

## ❑ Strip-Based Test Floor



Replace 12 test  
cells with 2

Reduce m<sup>2</sup> x4

Reduce \$ x5

Objective: 2 M devices / day

Ambient x32 = 64500 IC / h  
= 1.5 handler  
= 1500 FT<sup>2</sup>  
= \$1.65M

Assumptions: Test Cell \$1.1M, 0.9 uptime, index 180 ms / strip  
index 2 sec TT=1 sec



# The challenges of testing IC's in a massive parallel test system

# Requirement and Challenges

*“Contactor / and Probe card architecture should evolve to simplify the interface, however just the opposite is happening — more complexity is built into the contactor and probe card interfaces”*

## ❑ Miniaturization

- Very precise contacting technology in X, Y and Z
- Pad and bumps may get damaged during the contacting process
- Very thin and fragile package require accurate pick and place as well as force-controlled contacting

## ❑ Diversification in Geometry of Device and Pads

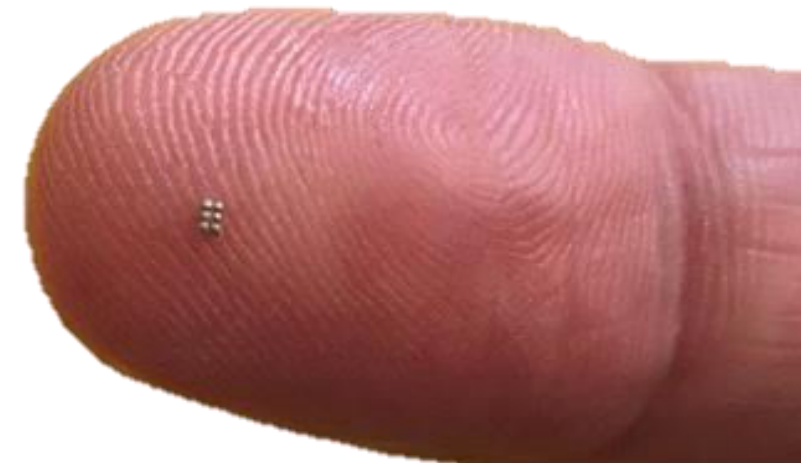
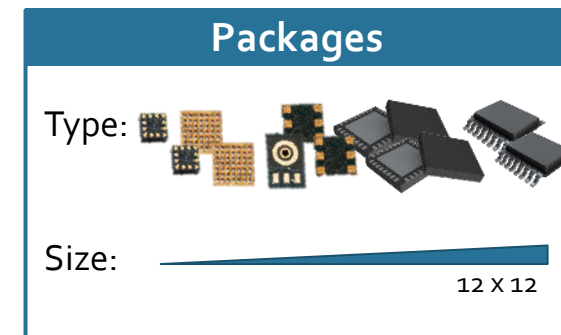
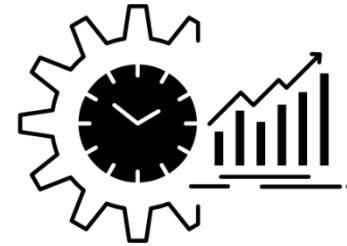
- Standardization is difficult
- Technical clarification becomes challenging

## ❑ Reducing cost is a constant goal

- Reliability
- Throughput – Tester capability, Handler thruput & Parallelism need to get balanced

## ❑ Time to market

- Shorter life cycle



# Requirement and Challenges

## ❑ Temperature management

- Homogeneous temperature over the entire contactor array
- Power applications need to dissipate Temperature to sustain the set-temperature
- Temperature ranges are expanding – Automotive, military, Aerospace...
- Immediate heat control

## ❑ Sensor & Stimuli

- MEMS application require a variety of testing environments such as pressure, magnetic, acceleration....

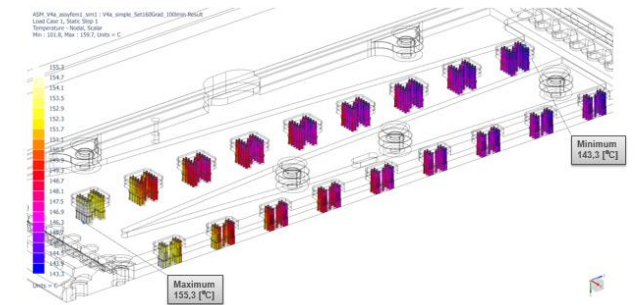
## ❑ Reliability Electrically and mechanically

- Manufacturing capabilities progressed which is raising the electrical and mechanical requirements of a test socket
- High power / voltage /current tighter pitch smaller formfactors (multi physics problems)

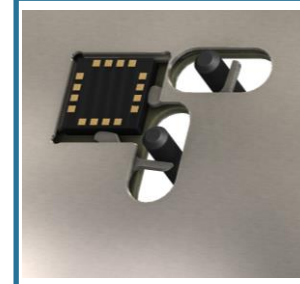
## ❑ Track and trace functionality

- Collecting data's
- Data analytics
- Maintenance

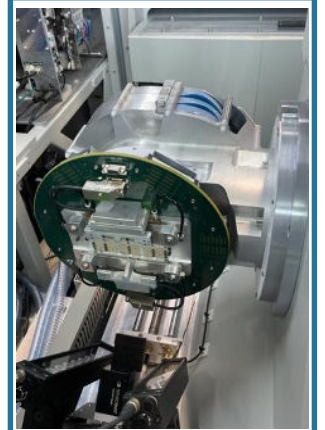
## Thermal simulation



## LGA 2 x 2 at InCarrier



## Gyro sensor test





# Concept / Solution for high parallel test contactor

# Integration on an Example of a MEMS Test



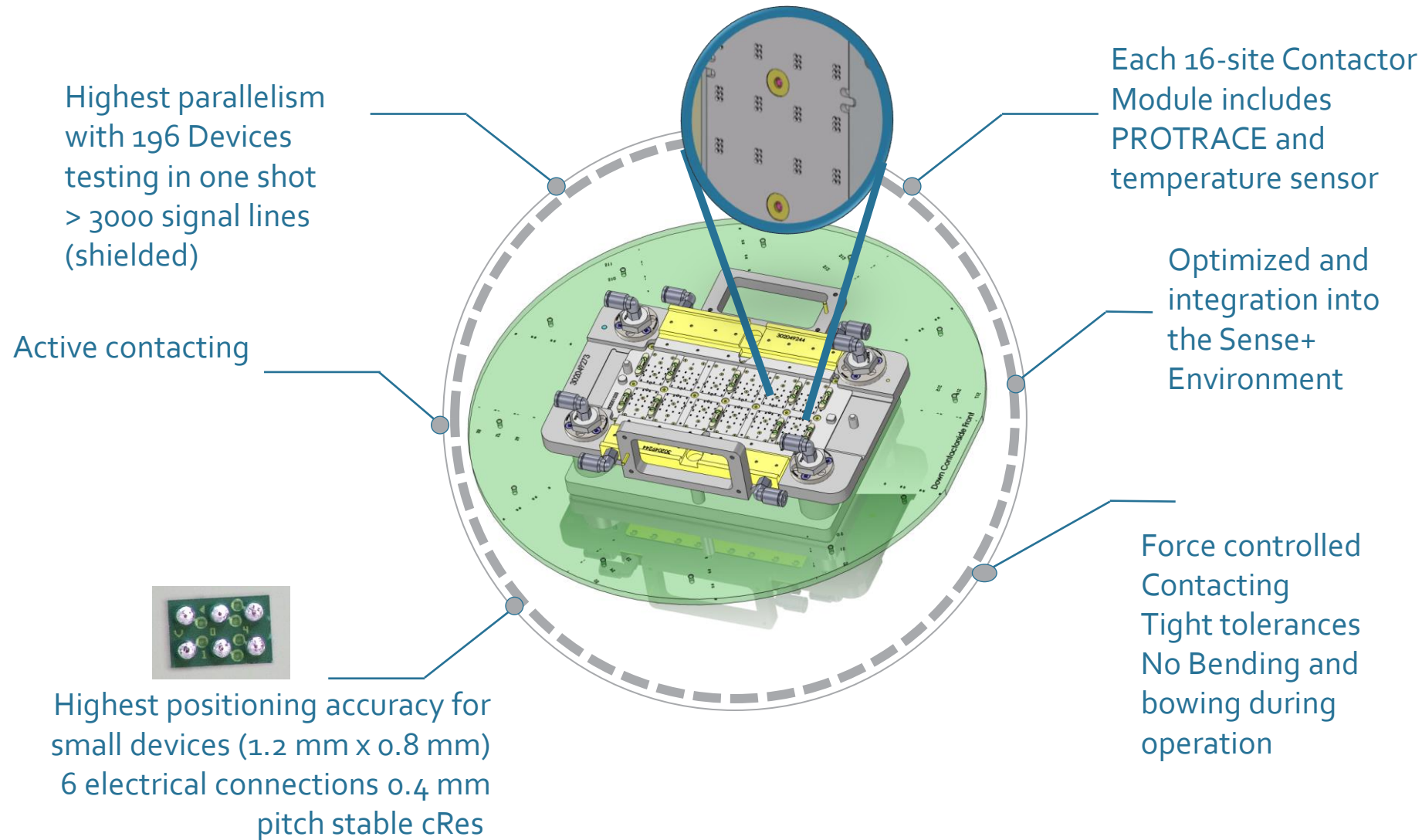
## ❑ Example describes a project:

- Implementation of generic methods and technology
- Applicable for further multi site testing projects

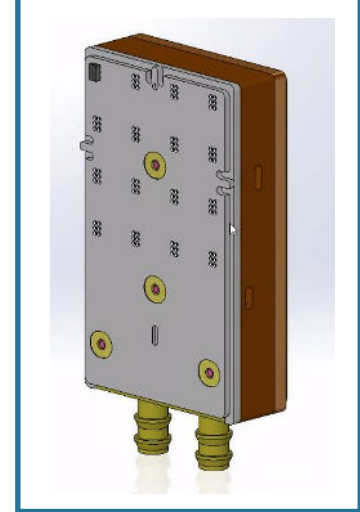
Batch Carrier Vacuum



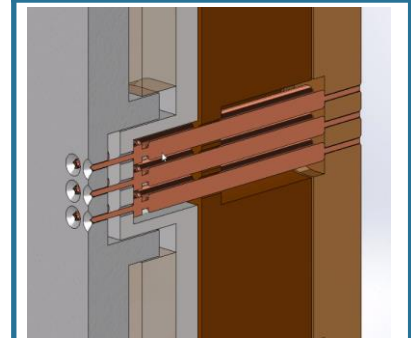
# Concept for a high parallelism contactor - Facts



## Single module



## Active retracting

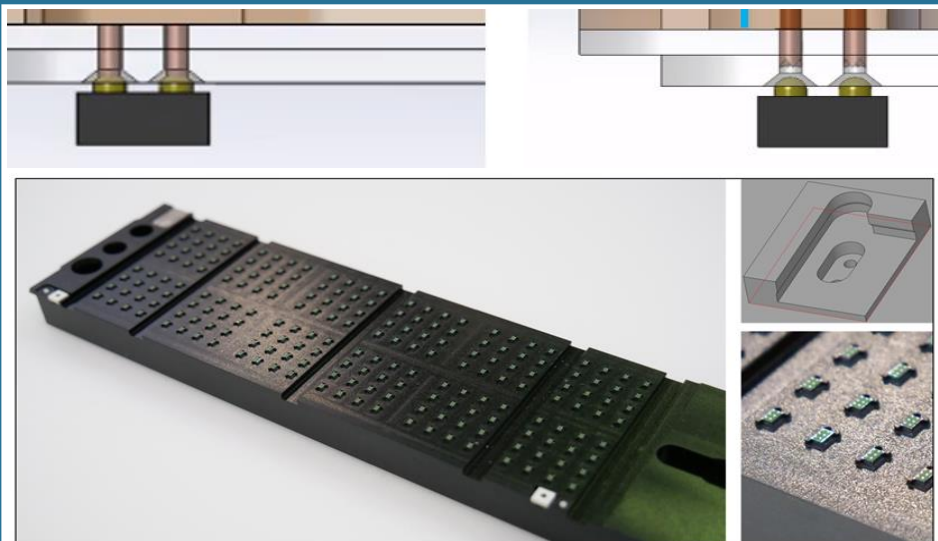


# Miniaturization - Reliability

## ❑ Simulation and Test

- Simulation of holding force on the “Accuchuck” - Batchcarrier
- Measurement of holding force
- Development of an „Active Retracting” concept - **Patented**
- Close corporation with all involved stake holders
  - Best solution /optimized solution

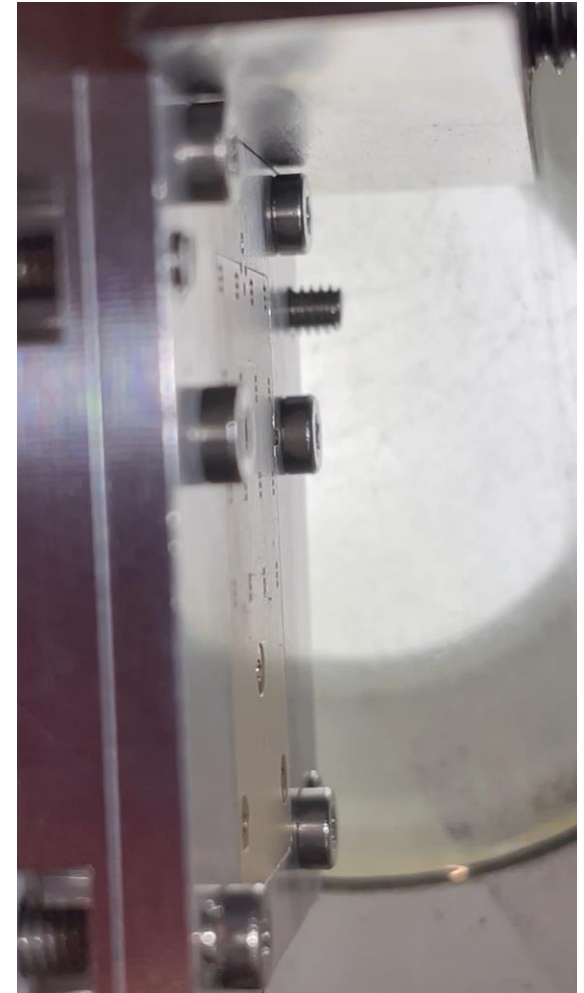
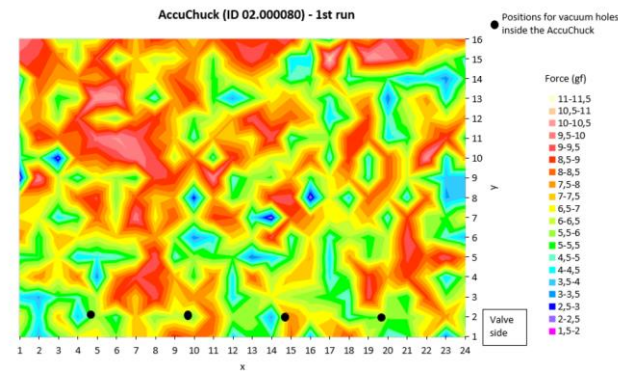
### Accu chuck – contactor



### Force measurement plot

#### Force measurements

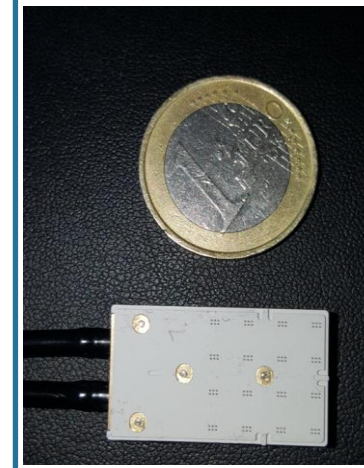
Note: The first run of ID 02.000080 is the fully populated AccuChuck of the report 20210531-1.



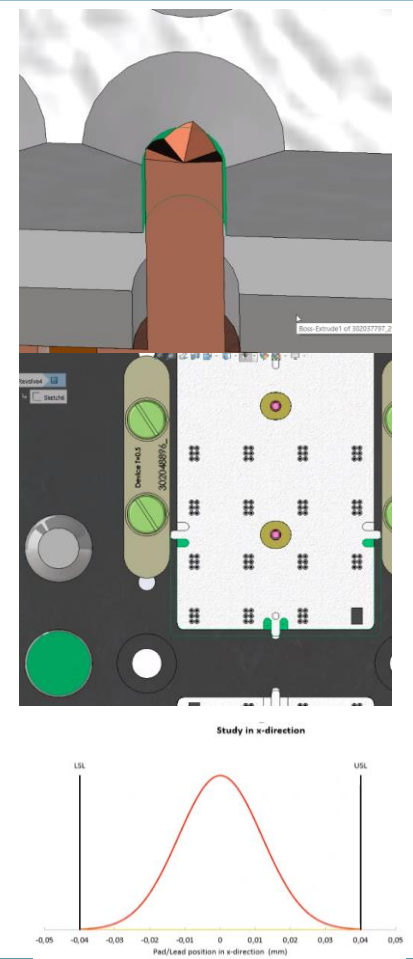
# Tolerance analysis and optimization

- ❑ Target : +/-40  $\mu\text{m}$  positioning accuracy over all 1176 I/O's)
  - Reduced tolerance chain  $\rightarrow$  only 4 dimensions from the contact tip to the positioning feature from the contactor
  - Appropriate material selection (Manufacturability/ Thermal expansion/ cost...)
  - Spring pin selection with an optimized tolerance of +/-0,0035mm in diameter (Kita Cohu Pin)
  - Hand in hand collaboration between handler team and Contactor team
  - Closed Loop tolerance analysis und mechanical simulation  $\rightarrow$  99.925% within +/-40  $\mu\text{m}$  cpk 1.12 (3.3Sigma)

## Miniaturization



## Tolerance chain



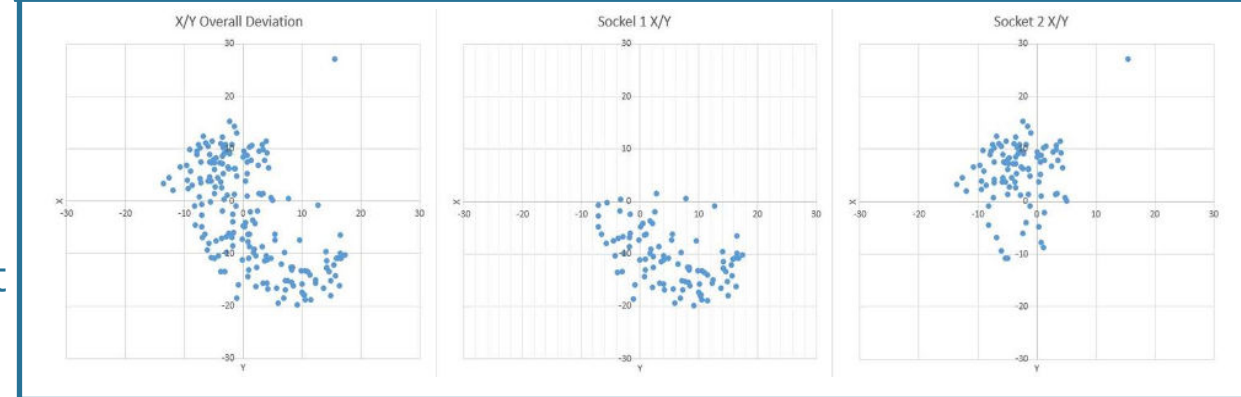
| Component | Distribution function | Tolerance type | Description                              | Material of this component | Algebraic sign | Nominal dimension (mm) | $\pm$ Tolerance | Angle dependence | Linear expansion coefficient (1/ $^{\circ}\text{C}$ ) | Statistical $\sigma_i$ (mm) | Contribution to deviation of $M_0$ |
|-----------|-----------------------|----------------|------------------------------------------|----------------------------|----------------|------------------------|-----------------|------------------|-------------------------------------------------------|-----------------------------|------------------------------------|
| M1        | Parabolic             |                |                                          |                            |                |                        |                 |                  | 0                                                     | 0,003812671                 | 10,314%                            |
|           | Trapezoidal (1/2:1)   | Female         | Pogo bohrloch                            |                            | +              | 0,14                   | 0,007           | yes              | 0                                                     | 0,003195048                 |                                    |
|           | Normal                | Male           | Pogo Diameter                            |                            | -              | 0,1265                 | 0,0035          |                  | 0                                                     | 0,001166667                 |                                    |
| M2        | Trapezoidal (1/2:1)   |                | Distance Pogohole to Base B X            |                            | +              | 6,2                    | 0,01            |                  | 0                                                     | 0,004564355                 | 14,781%                            |
|           |                       | not relevant   |                                          |                            |                |                        |                 | no               | 0                                                     |                             |                                    |
|           |                       | not relevant   |                                          |                            |                |                        |                 |                  | 0                                                     |                             |                                    |
| M3        | Trapezoidal (1/2:1)   |                | Distance Base B (x) to Nose              |                            | +              | 0                      | 0,01            |                  | 0                                                     | 0,004564355                 | 14,781%                            |
|           |                       | not relevant   |                                          |                            |                |                        |                 | no               | 0                                                     |                             |                                    |
|           |                       | not relevant   |                                          |                            |                |                        |                 |                  | 0                                                     |                             |                                    |
| M4        | Parabolic             |                |                                          |                            |                |                        |                 |                  | 0                                                     | 0,007994138                 | 45,342%                            |
|           | Trapezoidal (1/2:1)   | Female         | Nose Longhole                            |                            | +              | 0,61                   | 0,005           | no               | 0                                                     | 0,002282177                 |                                    |
|           | Trapezoidal (1/2:1)   | Male           | Nose with                                |                            | -              | 0,59                   | 0,01            |                  | 0                                                     | 0,004564355                 |                                    |
| M5        | Trapezoidal (1/2:1)   |                | Distance Precision Bolt to Nose Longhole |                            |                | 16                     | 0,01            |                  | 0                                                     | 0,004564355                 | 14,781%                            |
|           |                       | not relevant   |                                          |                            |                |                        |                 | no               | 0                                                     |                             |                                    |
|           |                       | not relevant   |                                          |                            |                |                        |                 |                  | 0                                                     |                             |                                    |
| M6        | Normal                |                |                                          |                            | +              | 9,8                    | 0               |                  | 0                                                     | 0                           | 0,000%                             |
|           |                       | not relevant   |                                          |                            |                |                        |                 | no               | 0                                                     |                             |                                    |
|           |                       | not relevant   |                                          |                            |                |                        |                 |                  | 0                                                     |                             |                                    |

# Results - Measurement

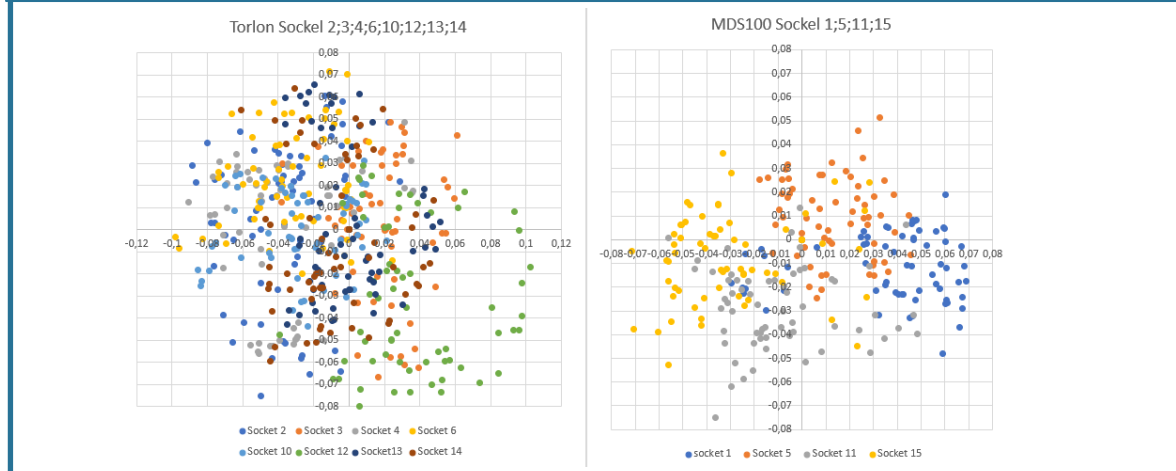
## ❑ What was achieved?

- Positioning accuracy:  $\pm 20 \mu\text{m}$
- active contacting – contacting feature
  - Force controlled contacting
  - Active release of device from contact element
- Lifetime test  $\gg 1.5\text{M}$  of active retracting feature

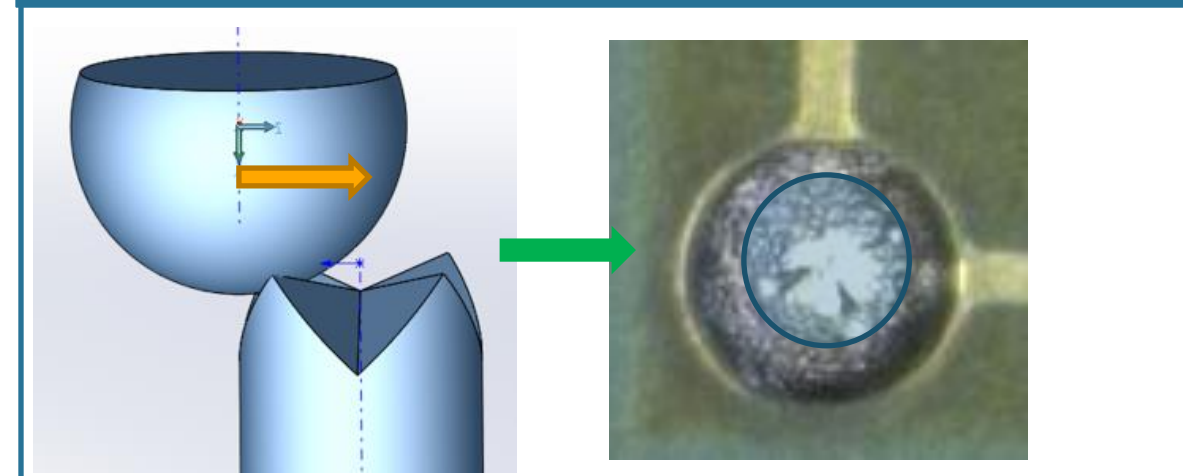
## Imprint measurement



## Imprint measurement



## Imprint check

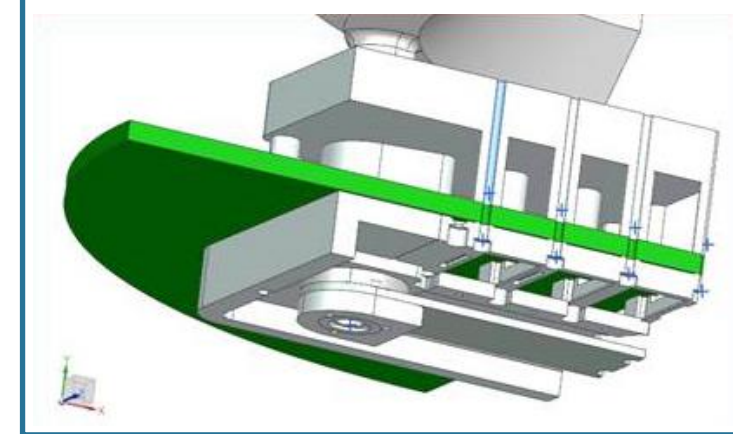


# Mechanical Integration – Simulation

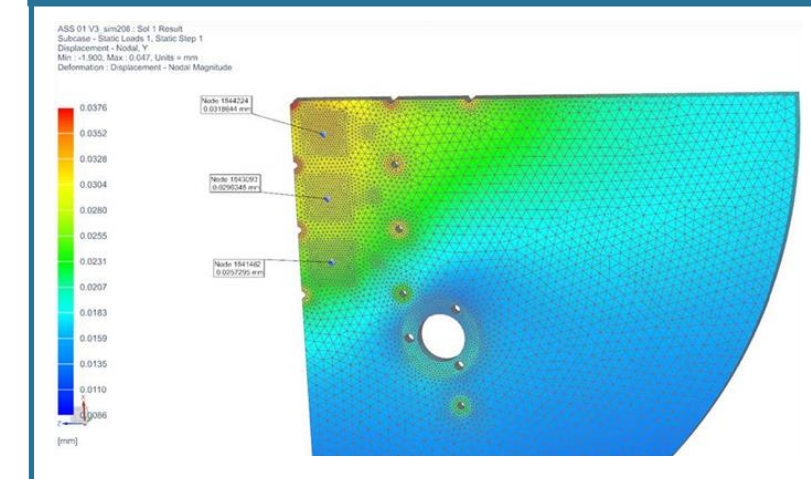
## Highly integrated

- One stop shop
  - Board, stiffener, contactor, reference sensors “Track & Trace” functionality and alignment concept with “AccuChuck”
  - Simulation (mechanical, tolerances, temperature)
  - Overall positioning accuracy over the entire contactor +/-60  $\mu\text{m}$  (including “AccuChuck”)
  - Maximum z-deflection on board <40  $\mu\text{m}$  over the entire test array

## Mechanical robustness



## Mech. Stress on board



# Service Terminal Overview

Supports stand-alone operation:

- Embedded temperature sensor
- Retrieve insertion count
- Retrieve socket ID
- Program user data
- Enables predictive maintenance
- Service terminal for

Home

**PROTRACE Terminal - Device Interface**

Device Address

1

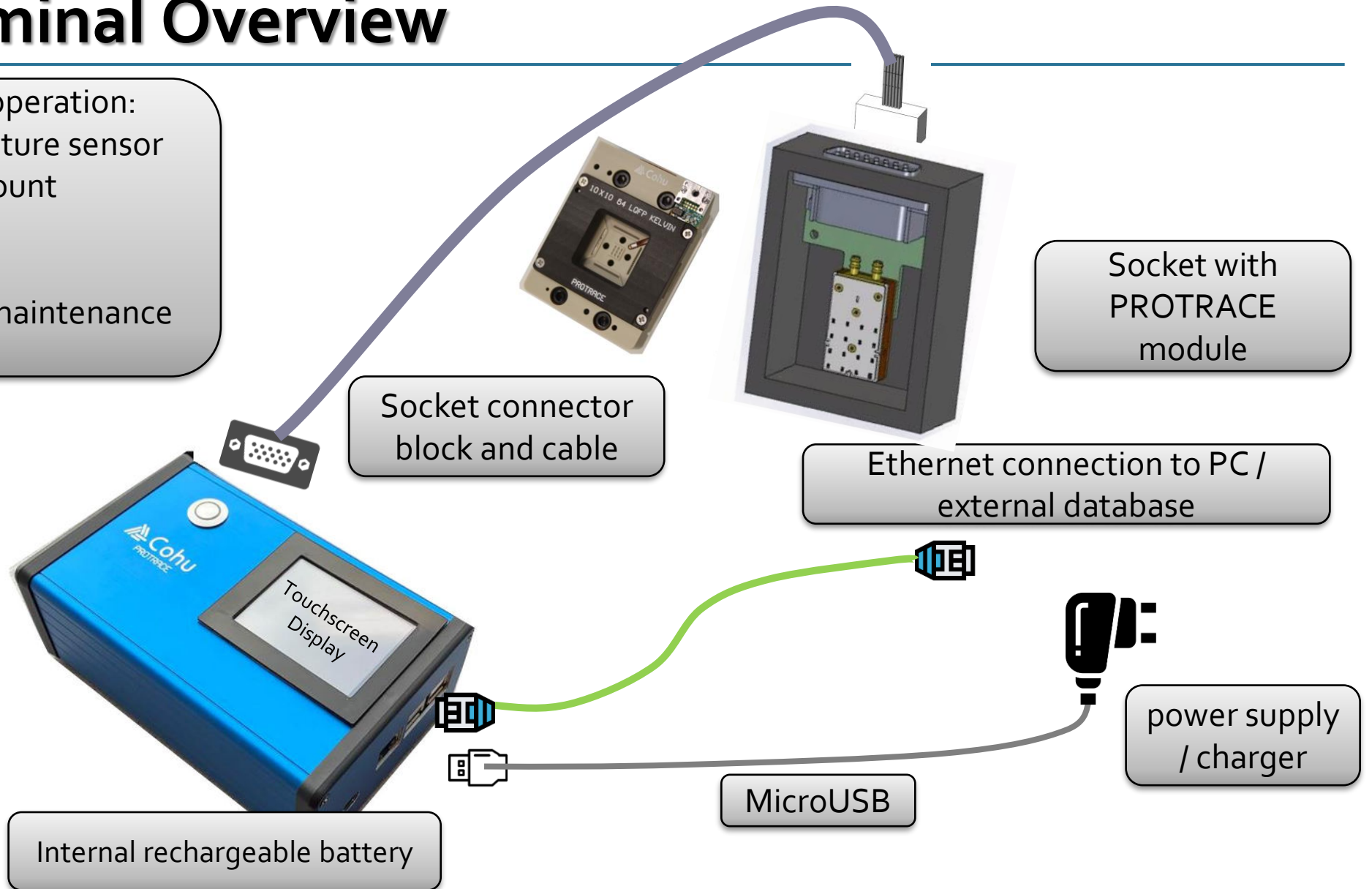
| Field                                 | Value        |
|---------------------------------------|--------------|
| Unique ID                             | Device 1     |
| Custom ID                             | The Blue One |
| Total Insertions                      | 123456       |
| Insertions After Last Pin Replacement | 32980        |
| Insertions After Last Cleaning        | 1245         |

Pins Replaced    Cleaning Performed

| Field          | Value                 |
|----------------|-----------------------|
| Service Tag 01 | 54804 Probes Cleaned  |
| Service Tag 02 | 90476 Probes Replaced |
| Service Tag 03 | 105124 Probes Cleaned |
| Service Tag 04 | 120112 Probes Cleaned |

New Custom ID

Write Custom ID





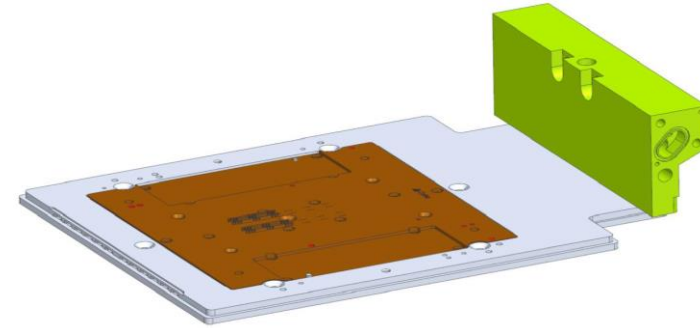
# Thermal aspects

# Thermal aspects at high parallelism

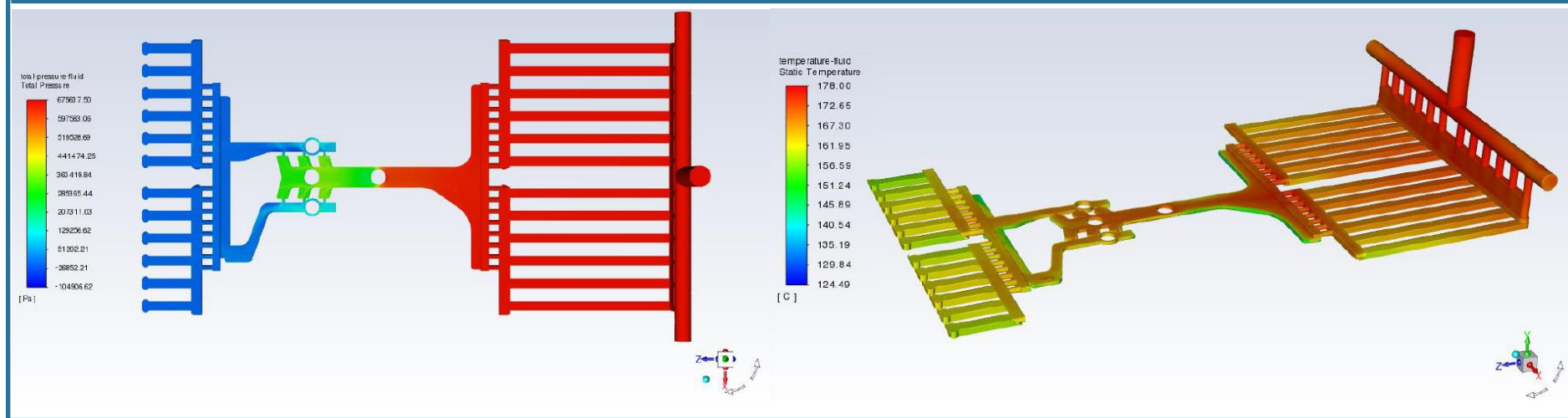
## □ Temperature management

- Homogeneous temperature over the entire contactor array
- Temperature ranges are expanding – Automotive, military, Aerospace...  $-60^{\circ}\text{C}$  –  $175^{\circ}\text{C}$
- Power applications need to dissipate Temperature to sustain the set-temperature
- Immediate heat control

## Thermal model



## Flow Simulation



# Conclusion and follow-on work

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## ❏ Conclusion

- Miniaturization, cost reduction, time to market, reliability, MEMS integration were successfully addressed by this project:
  - Higher Test Yield by tuned plunger and contactor **System** FEM Simulation assure mechanical robustness by appropriate material selection
  - Best handler touchdown efficiency by matched contact site parallelism
  - Cohu project management of all key deliverables
  - Coordination of activities with key supplier which simplifies customer experience and reduces risk
- Follow-on work - Can the effort be justified by only one application?
  - Recipe creation and active thermal control – Thermal aspects
  - Faster technical clarification by using standardized mechanical /electrical interfaces

Grazzi OBRIGADO KIITOS SPASIBO SHUKRIYA Go raibh maith agaibh CẢM ƠN  
SALAMAT XIEXIE DEKUJI ASANTE EFHARISTO  
TODA

NA GODE  
DO JEH  
GRATIAS TIBI

THANK YOU

Blagodarya

DANKE JE  
Gamsahabnida  
Dhanyavaad  
Khob-kun  
NGIYABONGA

MERCI  
GRACIAS  
Tusen takk  
Köszönöm  
DANK U  
FALEMINDERIT

HVALA MAHALO  
TERIMA KASIH  
GRAZIE  
DZIEKUJE  
Doumo Arigatou