Reliability Challenges for Automated Vehicles

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Contents

• Short introduction to Swerea IVF AB
• The TRACE Project
  • Background
  • Project model
  • Partners
• Examples of reliability problems
  • Solder joint fatigue
• The lack of relevant standards
About Swerea IVF

Swerea IVF is a research institute
We offer advanced research and consulting services.
We put new technology and new methods into practice.
We care about the world’s limited resources.

Number of employees 156, of which the majority are qualified researchers

CEO Mats Lundin

Turnover MSEK 243 (2015)

Locations Mölndal, Stockholm, Eskilstuna, Jönköping, Linköping och Trollhättan
The Big Picture

- Innovative automotive functions, for example autonomous driving for a safe and sustainable society, require sophisticated electronics.
- Availability of qualified complex automotive devices decreases
  - High development costs
  - Low volume automotive market
- Required functions available through the deployment of consumer electronics – high performance computing, sensors, communication
- Consumer electronics devices are not qualified for life-critical systems & harsh environments

Action from the automotive industry is required
The TRACE Project

- Constant pressure towards new innovations in the automotive* applications
- Commercial pressure in the automotive* semiconductor segment

Paradigm shift in the automotive* component and system development process necessary!

What to do?

- Develop and demonstrate methods, processes and tools to facilitate usage of CE components to be deployable more rapidly in automotive* domain
- Achieve general acceptance of methods through participation within the entire automotive value chain, including semiconductor manufacturers, system integrators and OEMs

* Also true for other domains such as industrial/automation electronics
Demonstrator 1: Detection and Ranging

Demonstrator 2: Navigation

Demonstrator 3: Autonomous Infrastructure Interaction
Project Information

- European OEMs and Tier 1, Tier 2, semiconductor companies and large number of research institutes and universities are represented.
- Funded by:  
  ![CATRENE logo]

<table>
<thead>
<tr>
<th>Products &amp; Systems chapter</th>
<th>Large Enterprise (LE)</th>
<th>Small and Medium Enterprise (SME)</th>
<th>Research &amp; University</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEM automotive</td>
<td>VW, Daimler, BMW, Volvo</td>
<td>iMAR, Open Wide, StatXpert, VEDECOM</td>
<td></td>
</tr>
<tr>
<td>System level (Tier1)</td>
<td>BOSCH, Continental, Siemens, VEDECOM</td>
<td>TRONICS, IMSYS</td>
<td></td>
</tr>
<tr>
<td>Semiconductor Component level</td>
<td>BOSCH, NXP, AMS, STM</td>
<td>CEA</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge &amp; Technology-based chapter</th>
<th>Design</th>
<th>Technology</th>
<th>Test &amp; Validation</th>
<th>Simulation</th>
</tr>
</thead>
<tbody>
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<td>Large Enterprise (LE)</td>
<td>Silkan RT</td>
<td>QRTECH, HELIOX</td>
<td>Berliner Nanotest, Fries, TWT</td>
<td>Catena, Coventor</td>
</tr>
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<td>Small and Medium Enterprise (SME)</td>
<td>KTH</td>
<td>CEA, Uni Siegen, Uni Bordeaux</td>
<td>Swerea, Fraunhofer, Uni Bremen</td>
<td>Fraunhofer, TU Delft, FH Johanneum</td>
</tr>
</tbody>
</table>
Solder joint fatigue - Critical failure mechanism not covered by AEC Q100

- As there is a continuous decrease of component dimensions to improve functionality, the fatigue lives of solder joints have decreased.

Typical characteristic fatigue lives (63% failures) for various component types:
- US car manufacturers require no failures after 3000 cycles between -40°C and 125°C (according to Carpenter et al. in 2014)
High stress in lead-free solder joints due to unisotropic single-grained solder joints

SEM image of solder joints after thermal cycling (top image) and EBSD images of the solder joints (bottom images)
Impact of new moulding compounds and conformal coatings

- New low CTE moulding compounds used in components may reduce the fatigue lives of the solder joints with up to 85%.
- Also conformal coating of BGA and QFN components may reduce the fatigue life of the solder joints with up to 85%.

Cracks formed in solder joints to a conformally coated BGA after one year in the field (indoor)
Gap analysis regarding solder joint fatigue between CE and AE

- There is a standard* for CE for how to evaluate solder joint fatigue life but with no acceptance criteria - "At this point in time, the reliability requirements need to be established by agreement between customer and supplier”
- For AE, there is not even a standard for how to evaluate solder joint fatigue life and, consequently, no acceptance criteria.
- Standards such as ISO 16750** for reliability verification at product and system level does not assure reliability at part, material or assembly level.

* IPC-9701A: Performance Test Methods and Qualification Requirements for Surface Mount Solder Attachments (2006)
** ISO 16750: Road vehicles - Environmental conditions and electrical testing for electrical and electronic equipment
1. Determining application specific test requirements
   - Identification of environmental, lifetime and manufacturing conditions
2. Identification of potential failure modes
3. Selection of failure modes for known failure mechanisms
4. Selection of test hardware
5. Selection of stress/reliability tests
6. Selection of test conditions and durations
7. Establish product performance
Summary

- There is a significant risk that the life time of solder joints of electronic components in vehicles will not be sufficient.
- The tests used to qualify electronics for vehicles are not relevant to detect these kinds of failures.
- A new methodology based on ´physics-of-failure´ approaches is required to ensure the reliability of electronics hardware.
- The recently started project TRACE have a focus on self-driving cars and smart cities.
- The focus of TRACE is how the reliability of the electronics can be ensured when car manufacturers and the industrial/automation market are forced to use electronics developed for the consumer market.