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Cell-based Architecture for Adaptive Wiring Panels: A First Approach

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Outline

- What is a wiring harness?
- Why would we want to make it reconfigurable and adaptive?
- Basic concept of adaptive wiring harness
- Challenges
- Cellular architecture for adaptive wiring harness
- Current Status
- Future Work
- Conclusions

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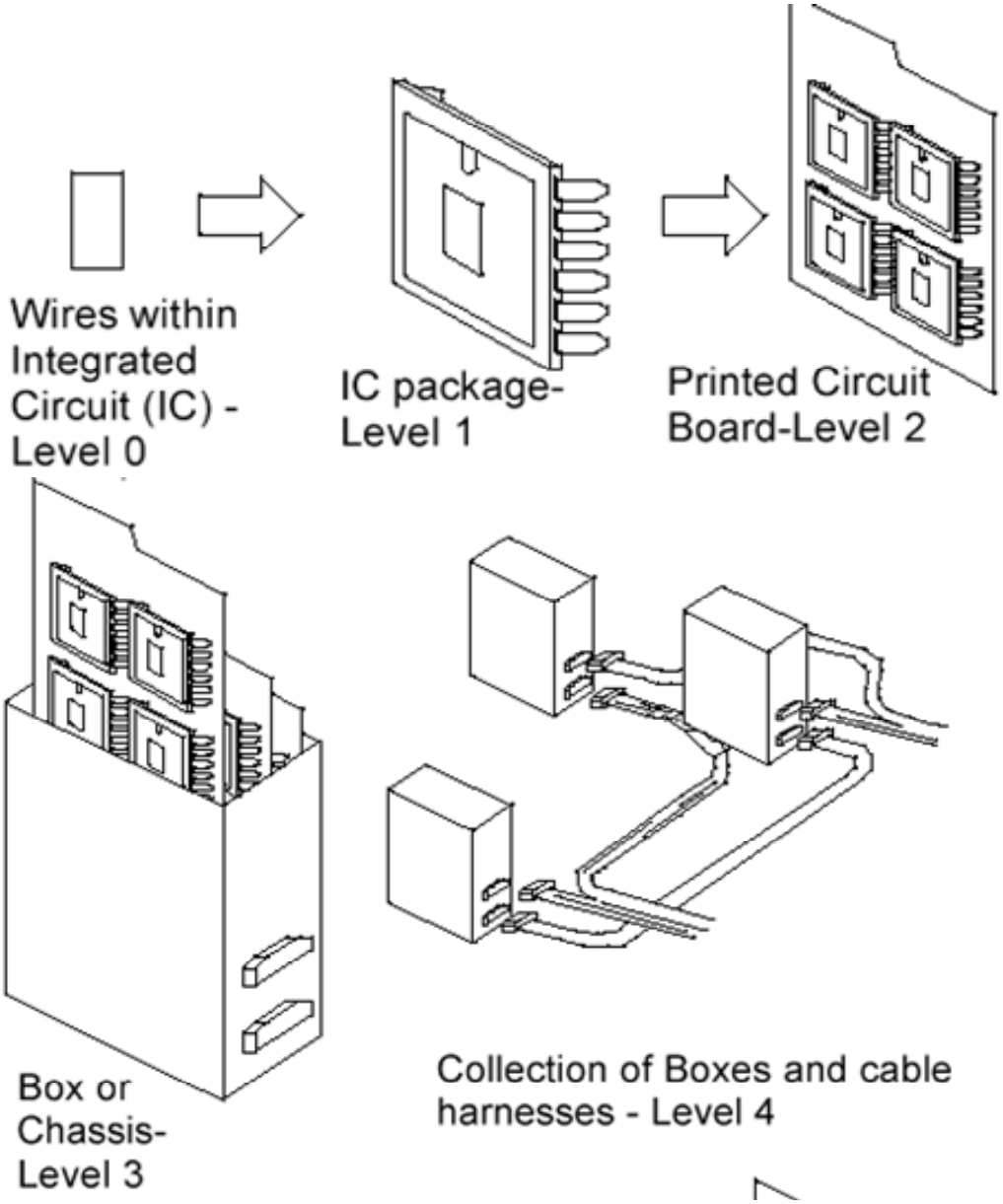
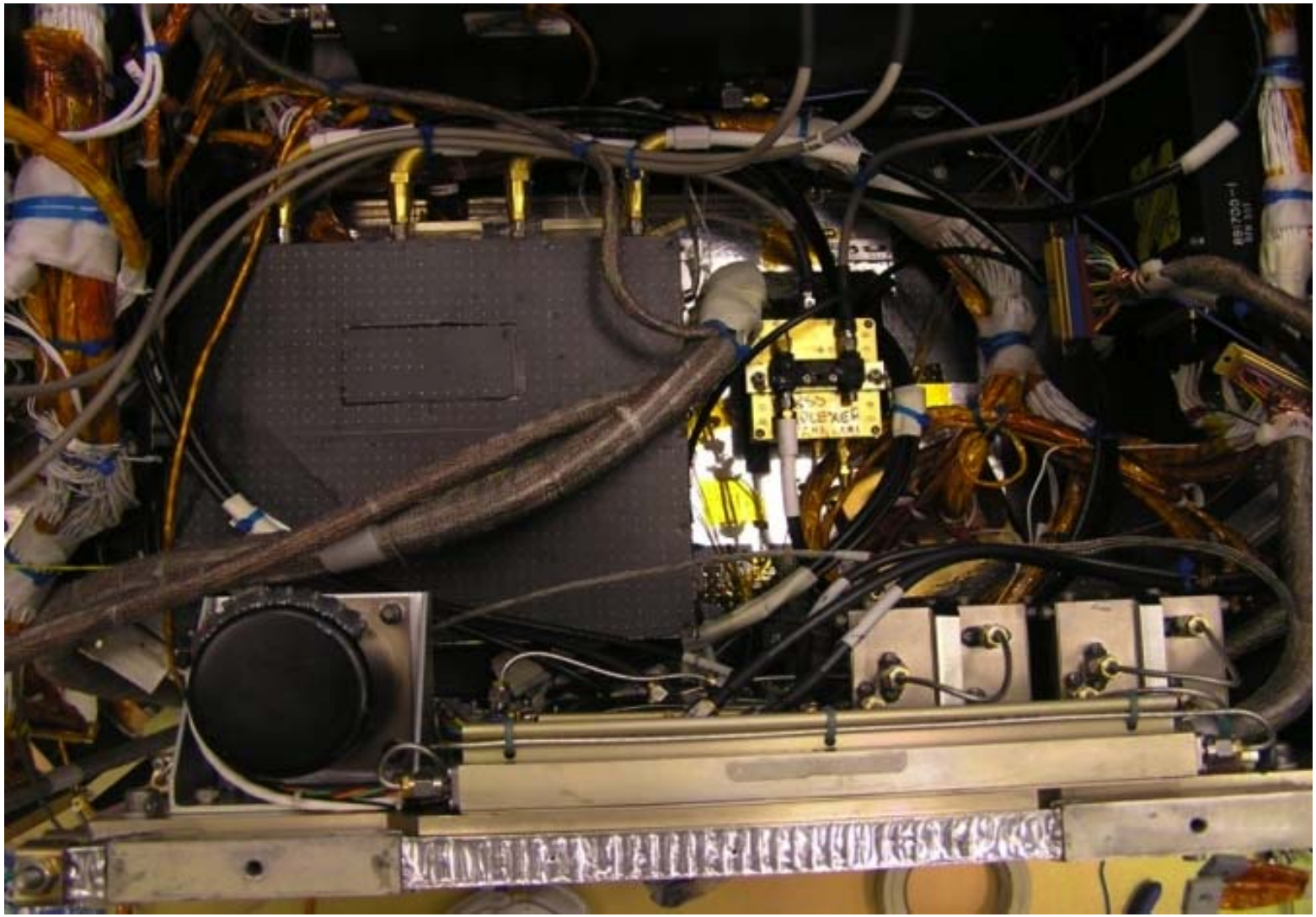
What is a wiring harness?



- **Packaging hierarchy from transistor to system**
- **Wires dominate the content of electronics in systems**
- **Harnesses are wires that form Level 4 connections**

Real World Example – Tacsat 2



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Advantages

- **Dramatic time reduction**
  - **Reduces weeks and months to minutes**
- **Flexibility**
  - **Accommodate last minute changes**
  - **Fixing errors after the fact**
- **Diagnostic enhancement**
  - **Form temporary probes without dismantling system**
- **Robustness**
  - **Ability to route around damage**
  - **Ability to make self-healing**

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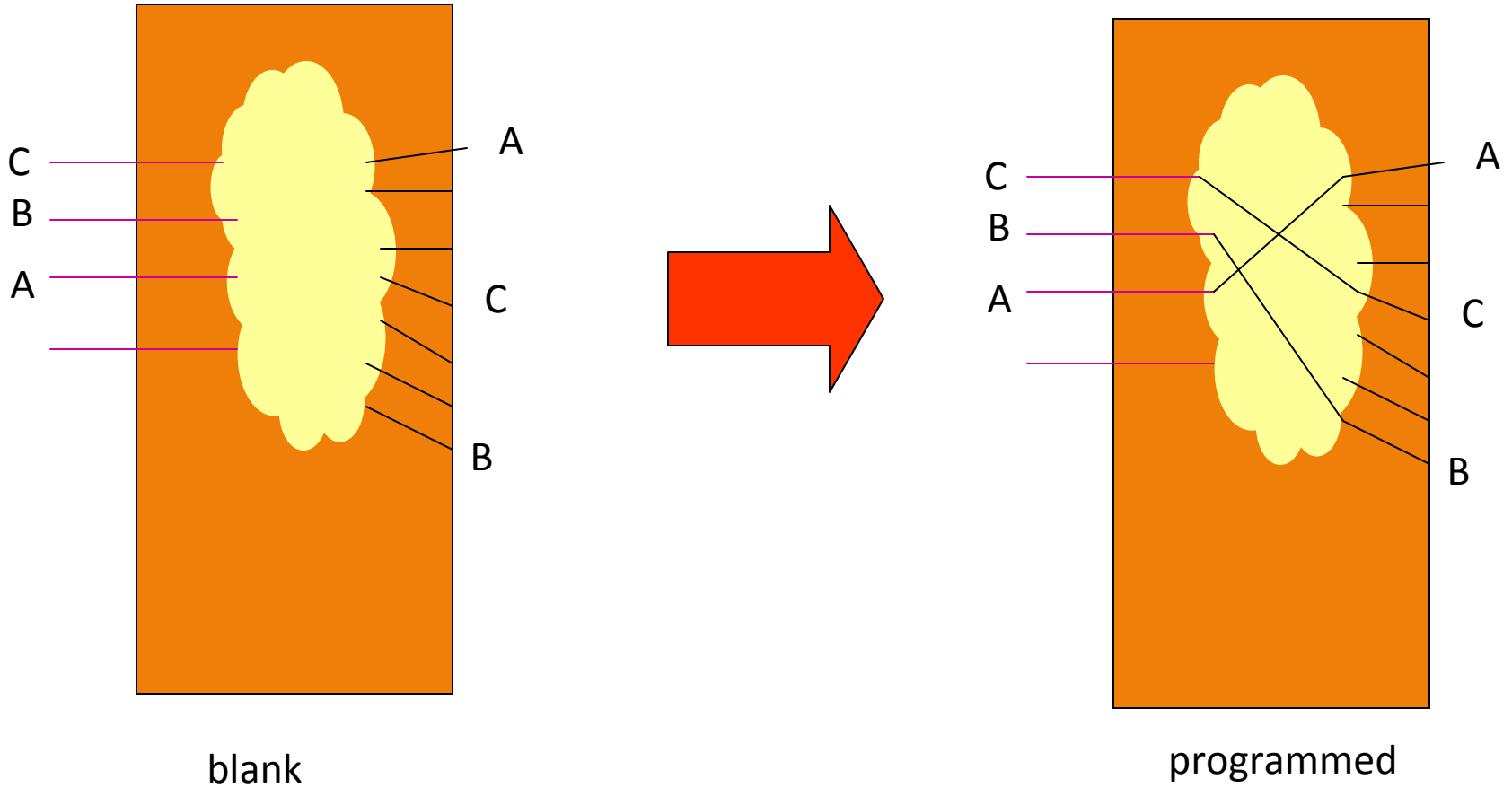
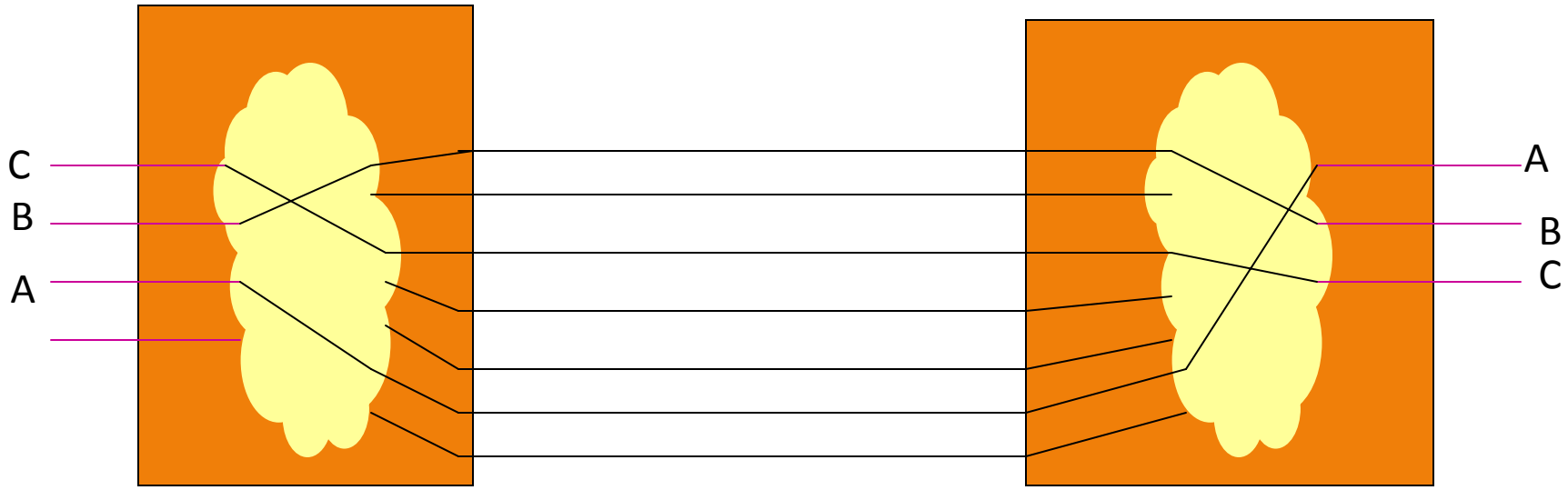
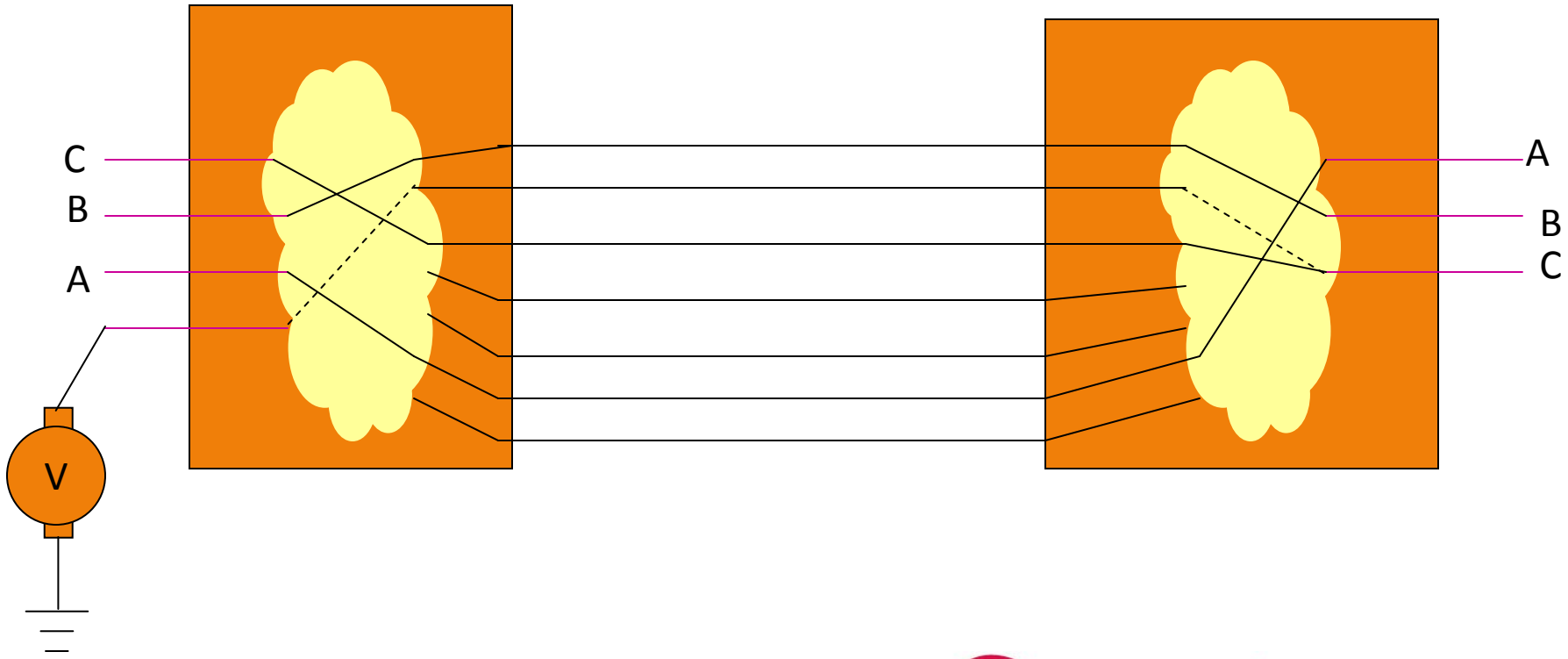
Adaptive wiring concept



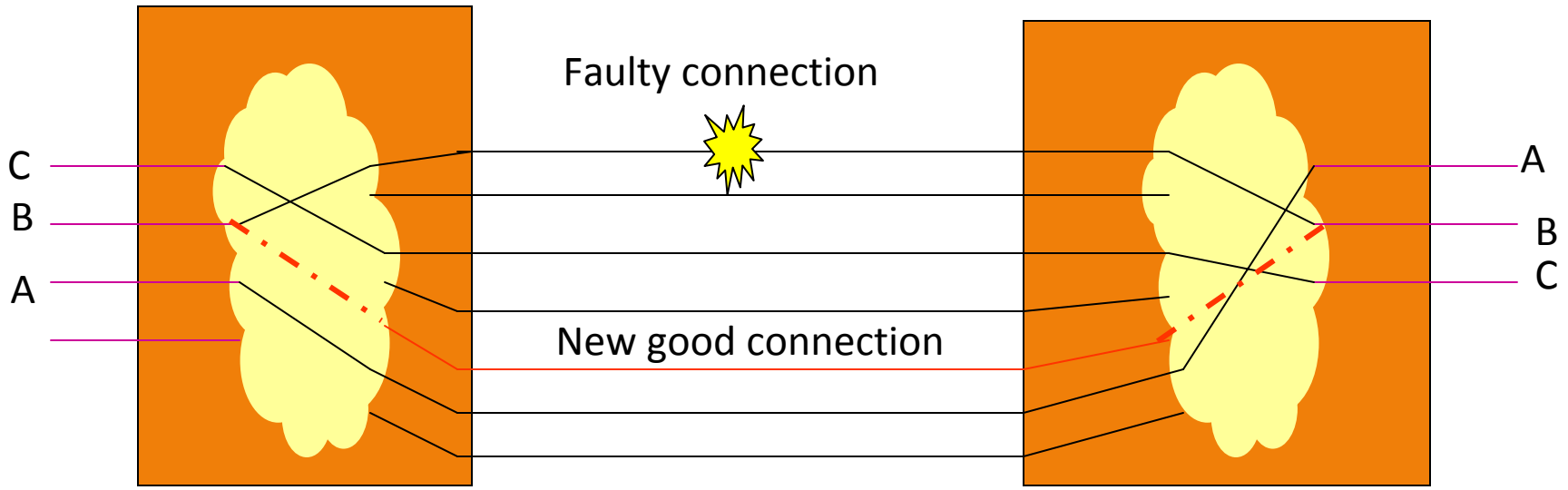
Segmented (extended) adaptive panel



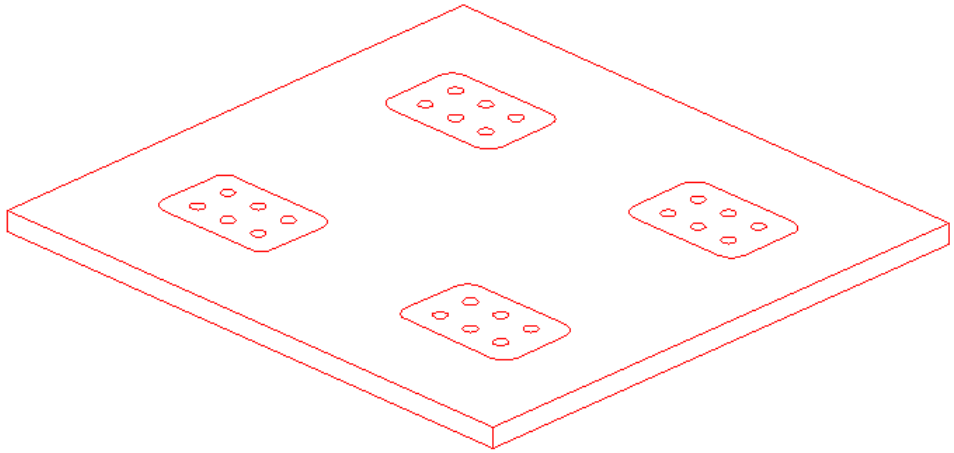
Temporary probes can be inserted

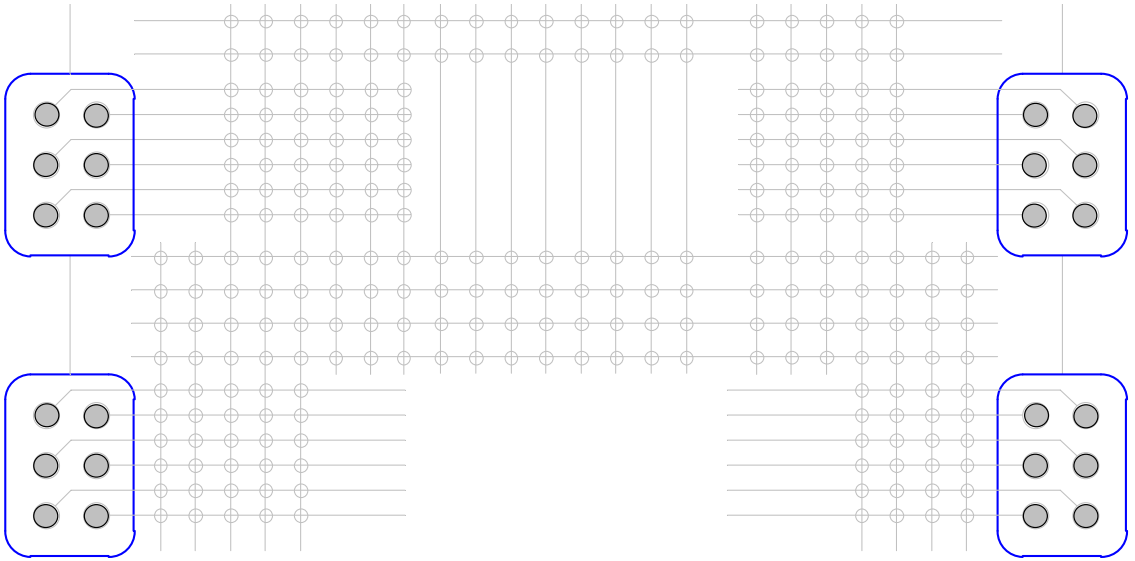


Fault management

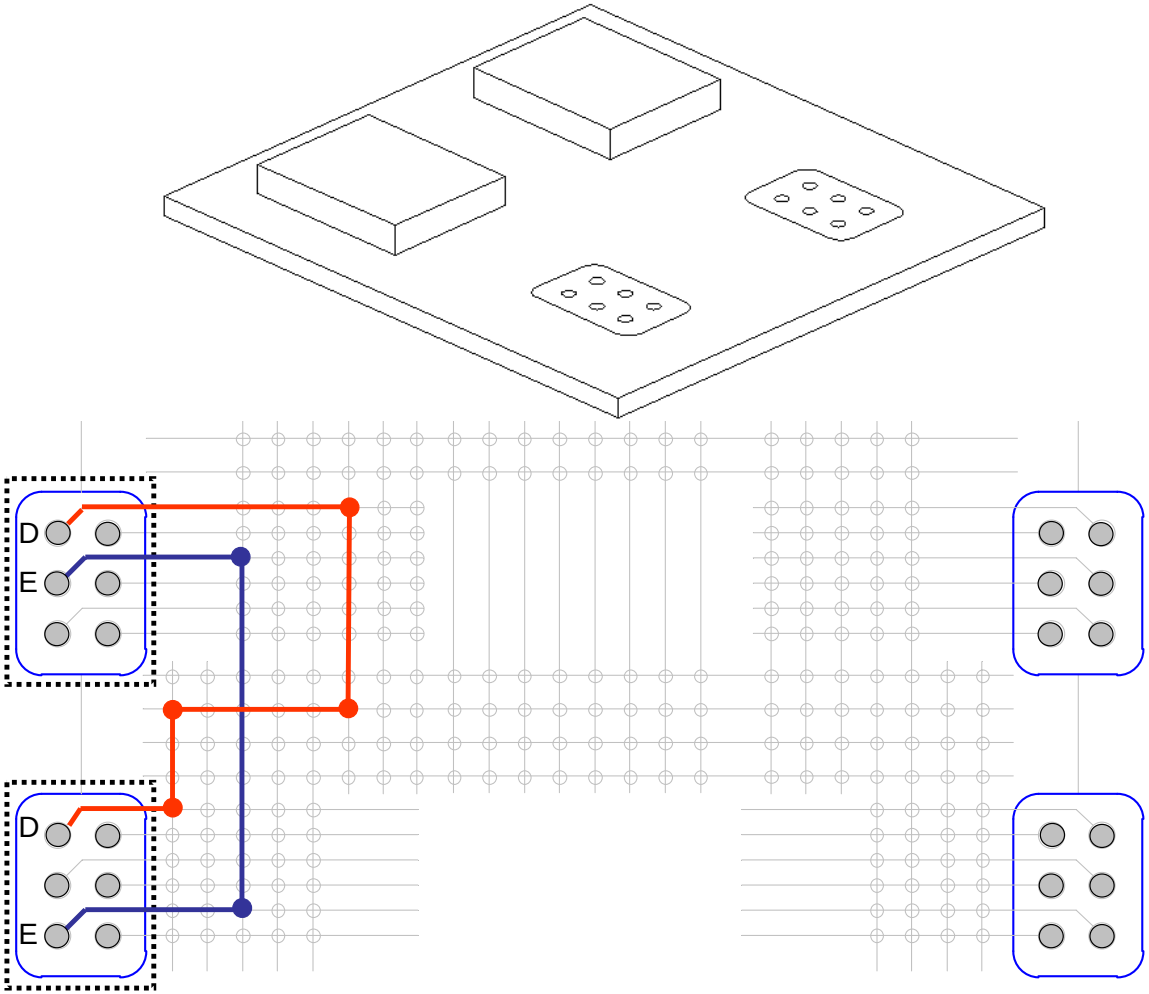


Physical Embodiment





Placement and routing (two modules)



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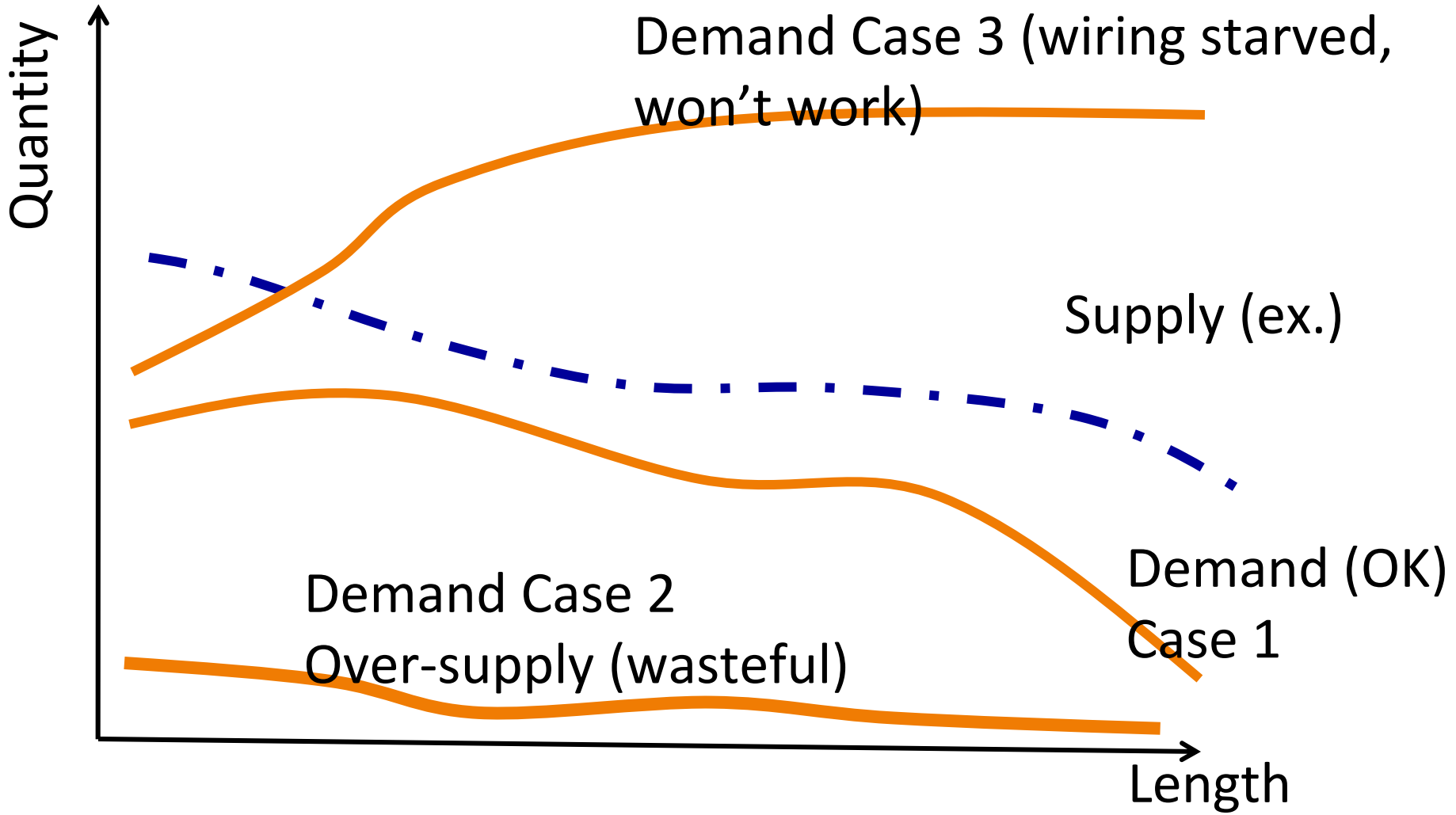
Challenges

- Bistable / multistable / persistent, low-power
- Electrical performance
  - Low resistance
  - Bandwidth
  - High-isolation (low crosstalk)
- Hot-switching
- Compact
- Low-cost

Wiring Supply / Demand



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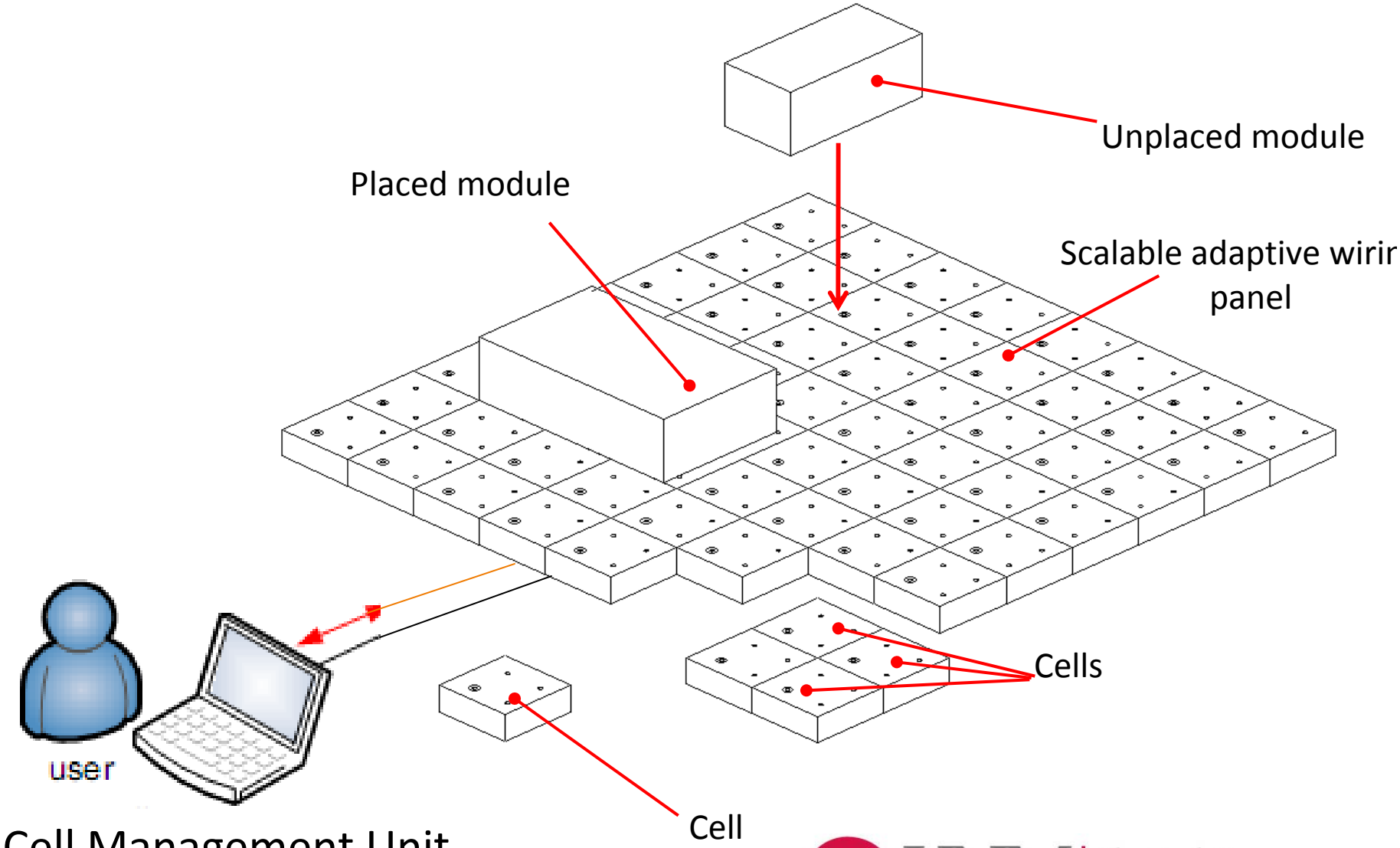
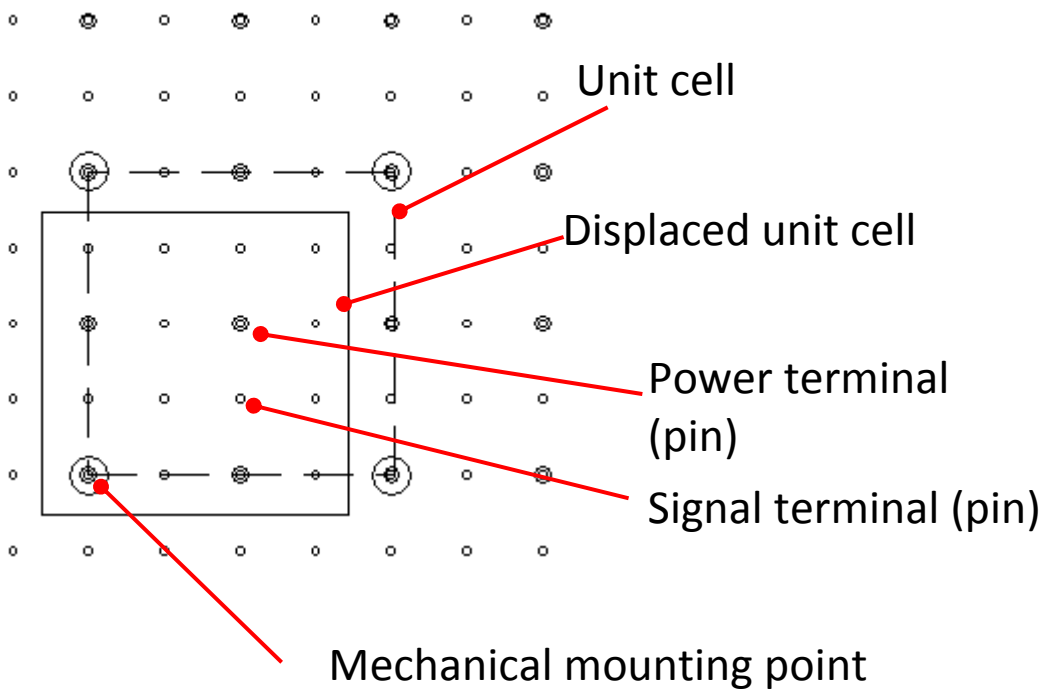
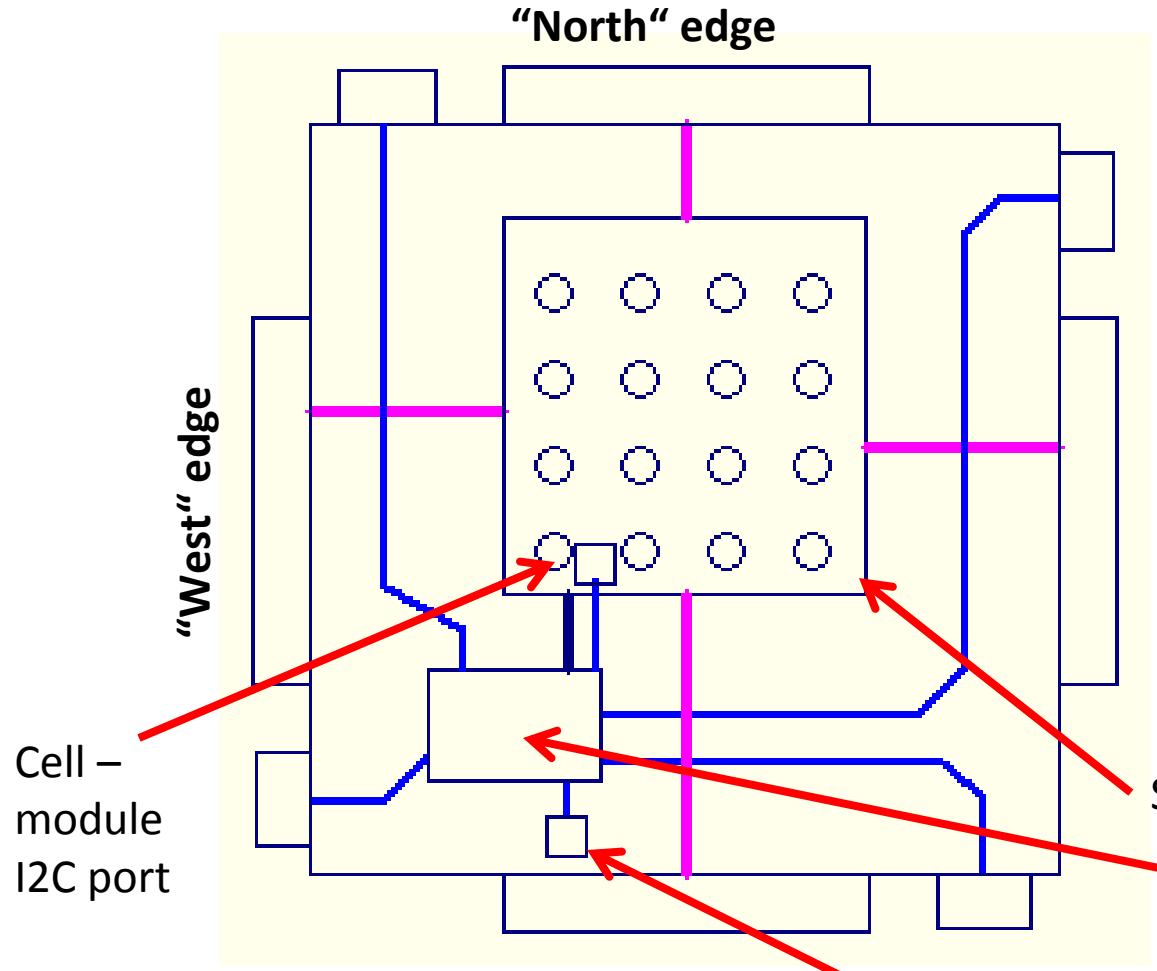
Simplified Depiction



“Unit cell”


Unit cell
Displaced unit cell
Power terminal (pin)
Signal terminal (pin)
Mechanical mounting point

Unit cell details



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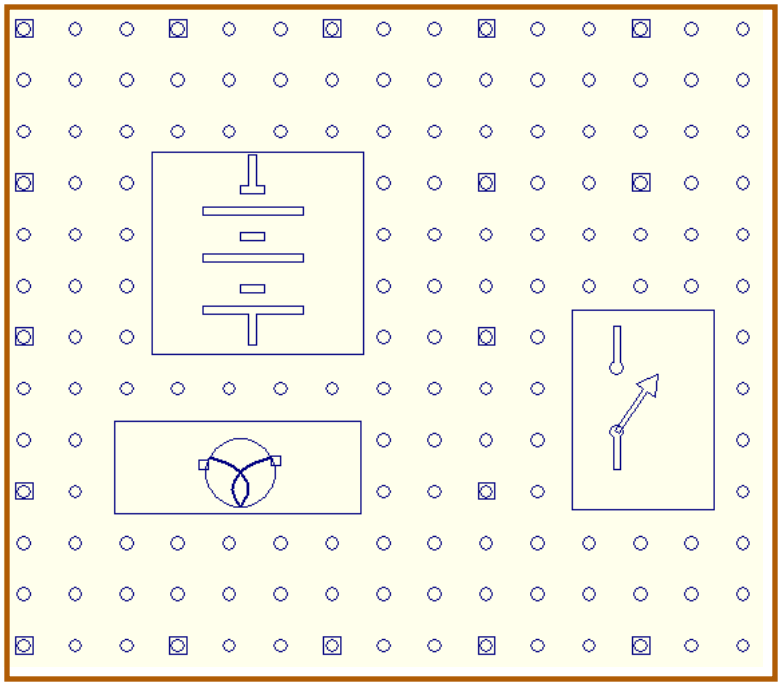
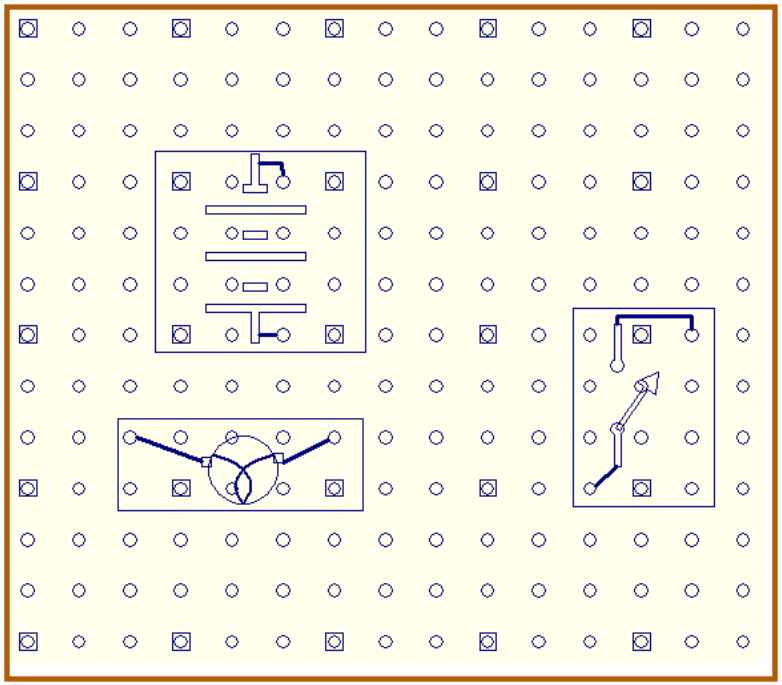
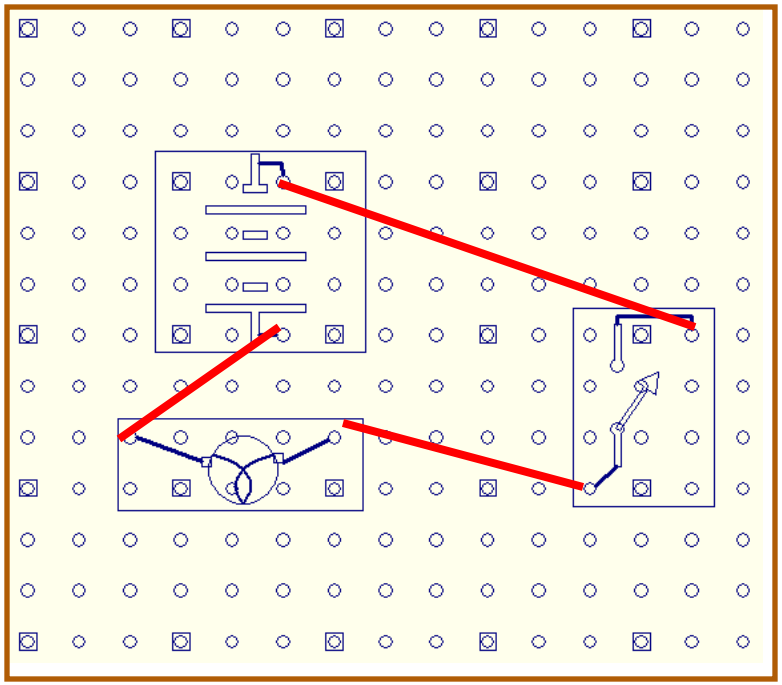
Adaptive Wiring Panel with modules



Interior details of module connections to panel



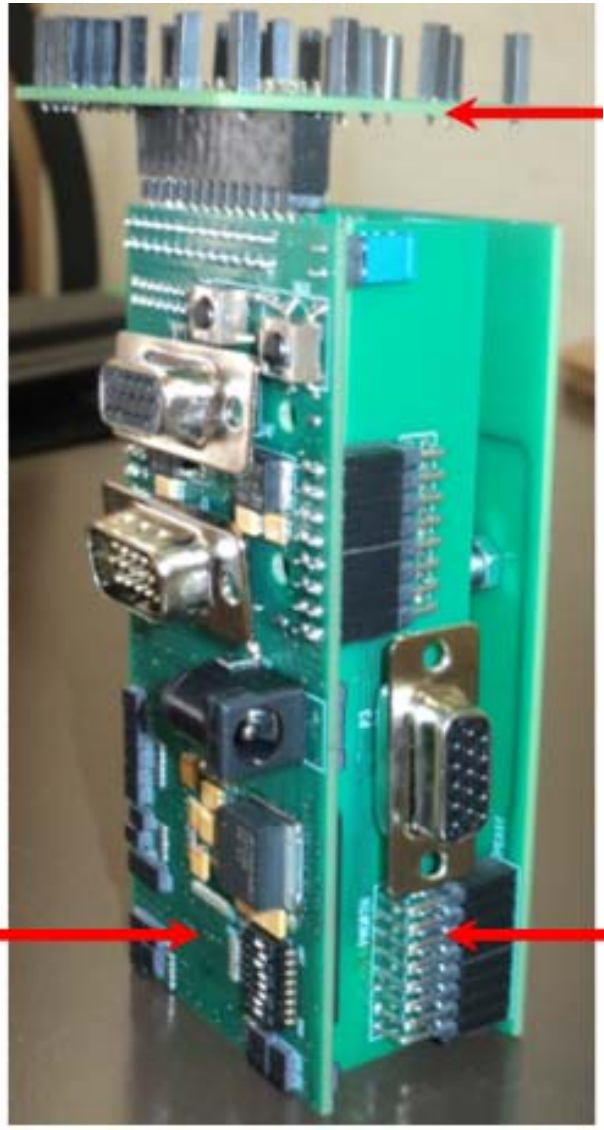
Example Wiring Problem



Cell Implementation

- Cells are self-contained (5cm x 5cm)
- Contains local routing (~70 relays)
- Communicate using six I2C busses
  - 4 neighbors (N-E-W-S) (local)
  - 1 cell-to-module
  - 1 cell-to-host (global)

Current Hardware (one cell)



Top board (adaptive surface)

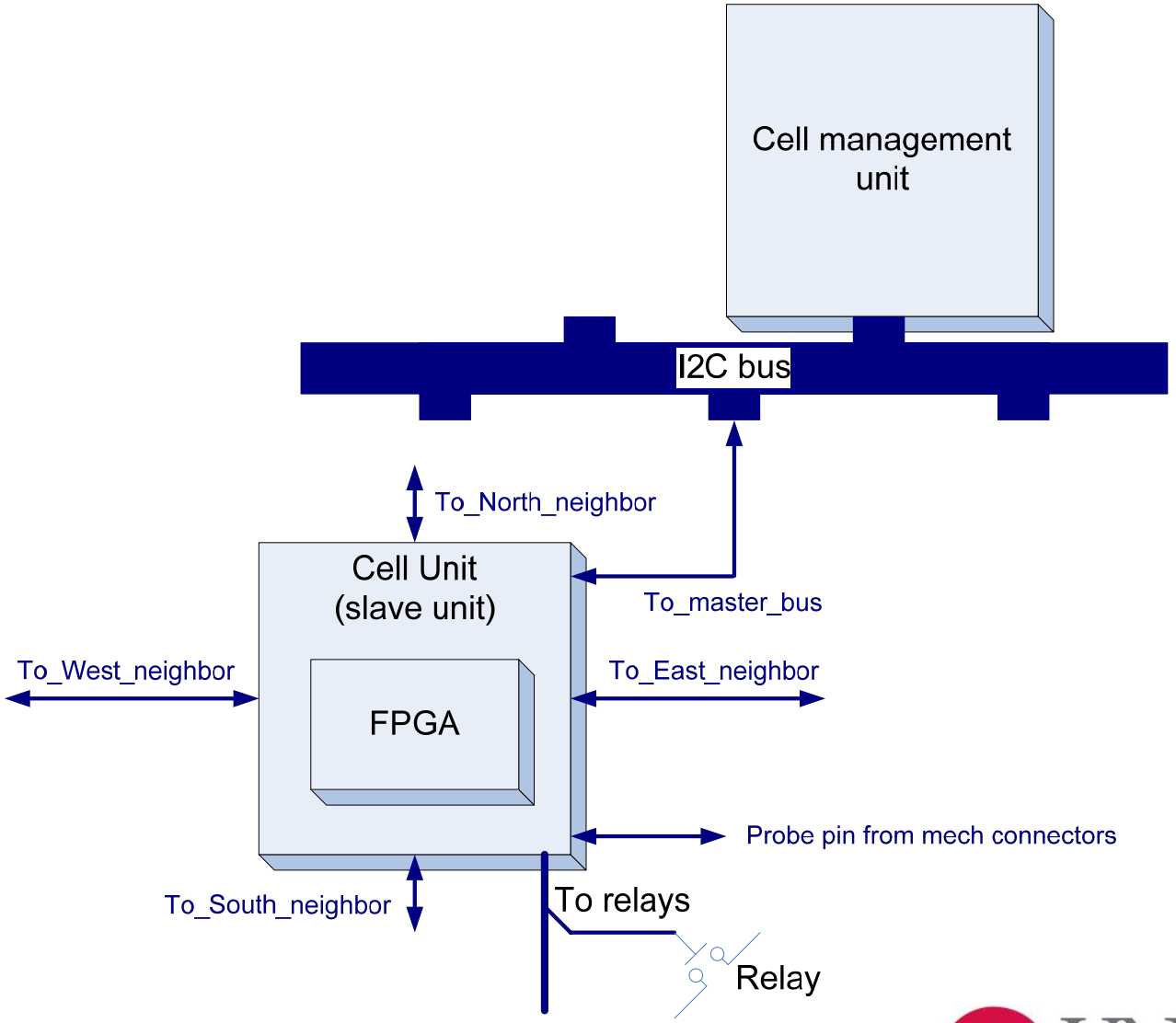
South cell board

East Cell Board

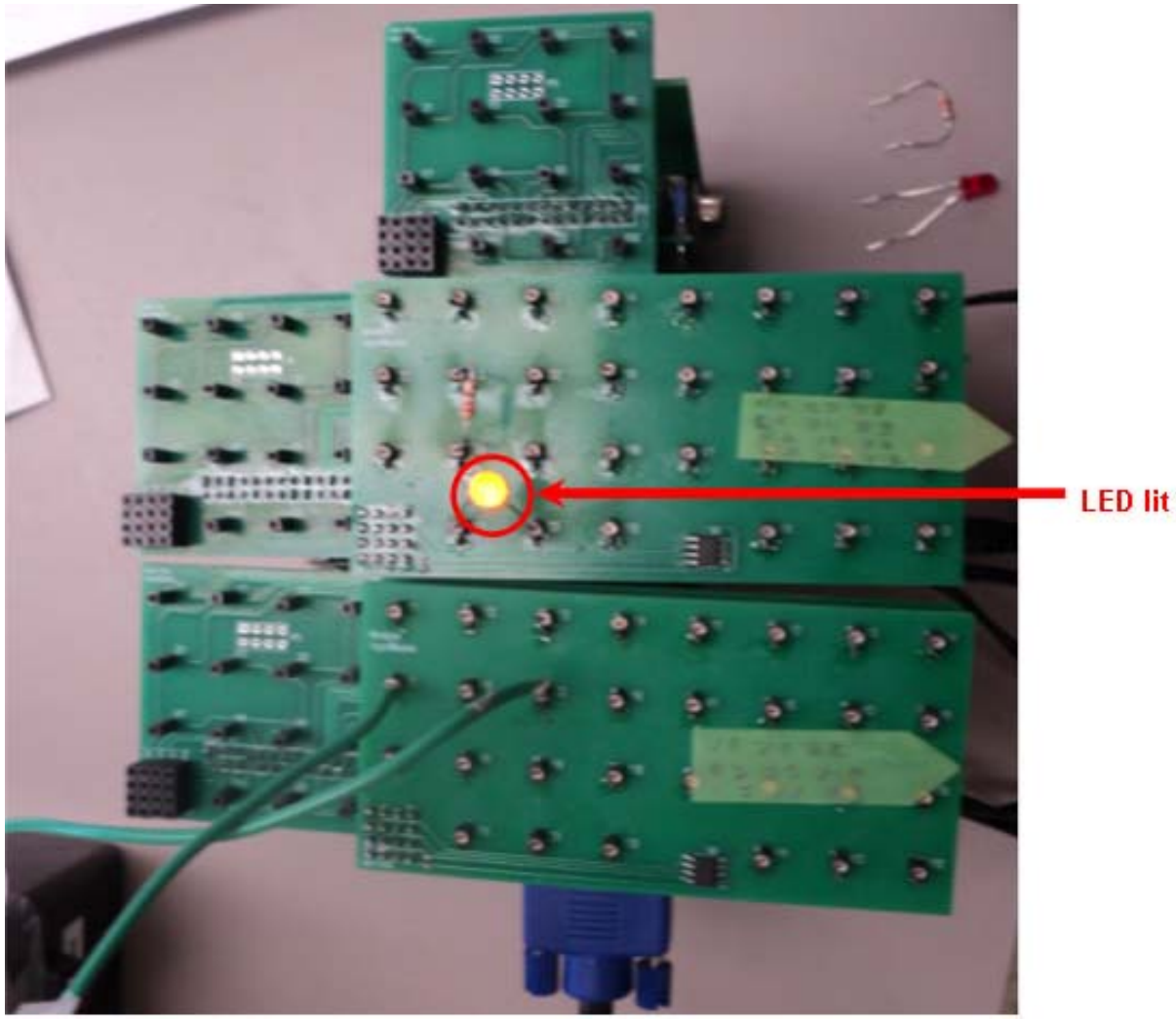
Cell Management Unit

- **Manages global panel of cells**
  - **Computes connections**
  - **Manages cell and modules**
  - **Implements dynamic changes**
- **Implements wiring harness as netlist**
- **Netlist programmed SPICE language**
- **Route algorithms**
- **Graphical User Interface (GUI) simplifies user interaction**

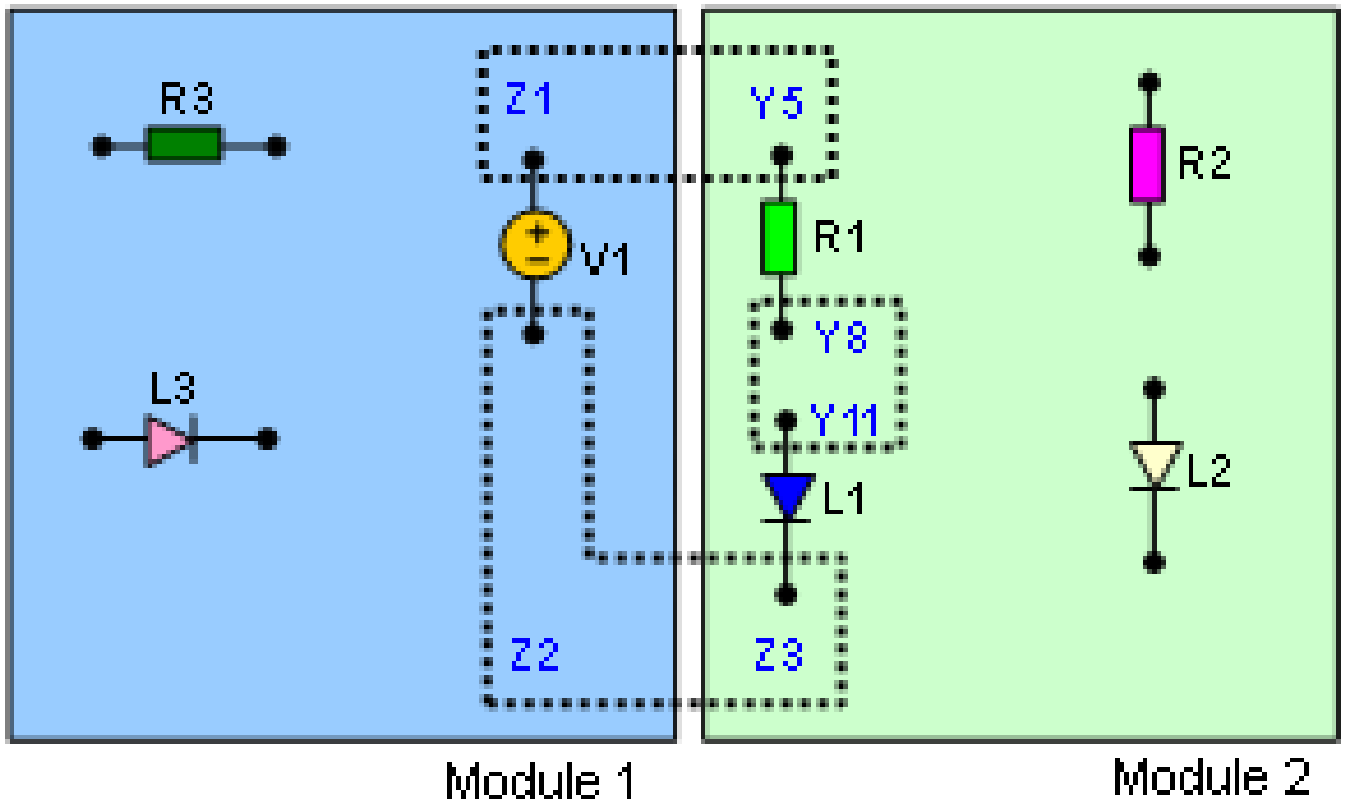
Cell management Unit



Five cells, two modules



Example Problem

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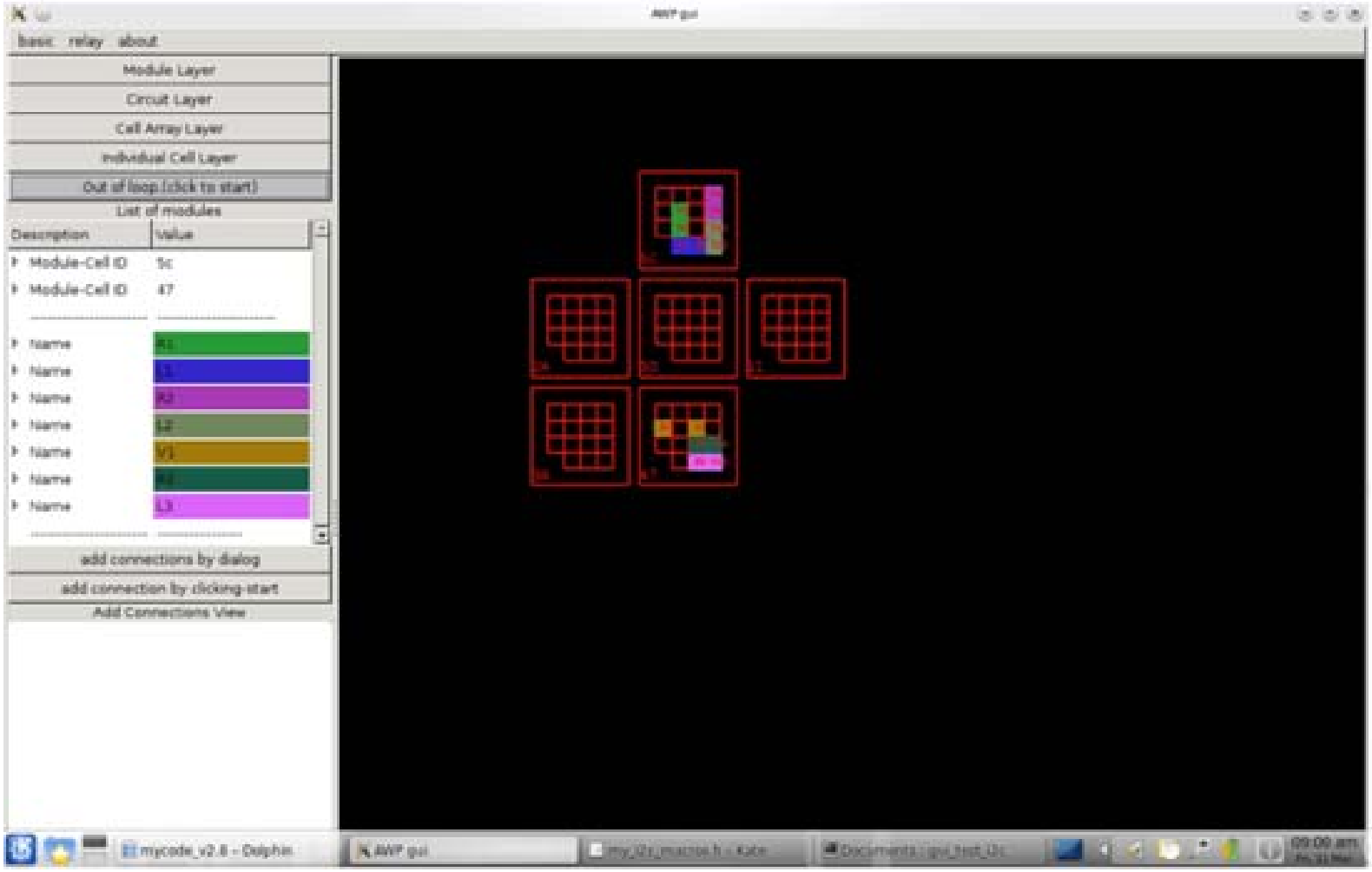
Circuit list:
R1 Y5 V1 Z1
R1 Y8 L1 Y11
L1 Z3 V1 Z2
```

Graphical User Interface



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Future Work

- Increase demo to 64 tiles (8 cells x 8 cells)
- Development of MEMS switches (90% reduction in size, weight, and power)
- Improved hierarchical routing algorithms
- Self-healing demonstrations
- Multi-panel manifold
- Extension of ideas to three dimensions

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Conclusions

- **Adaptive wiring can have significant advantages over fixed designs (speed, flexibility, robustness)**
- **Adaptive wiring architecture has been described**
- **Cellular version of adaptive wiring harness has been designed and partial panel has been demonstrated**
- **Within next year a full scale version will be available for further study**

Acknowledgments

- **Financial support**
  - **AFRL Space Vehicles**
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