# ECU Communication and Networking

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Advisor Aleksander Malinowski
Sponsored by Komatsu America

# Presentation Outline

- **Introduction**
  - Problem Statement
  - Functional Requirements
- Engineering Effort to Date
- Planned Work
  - Solutions
- Division of Labor
- Schedule
- Parts List

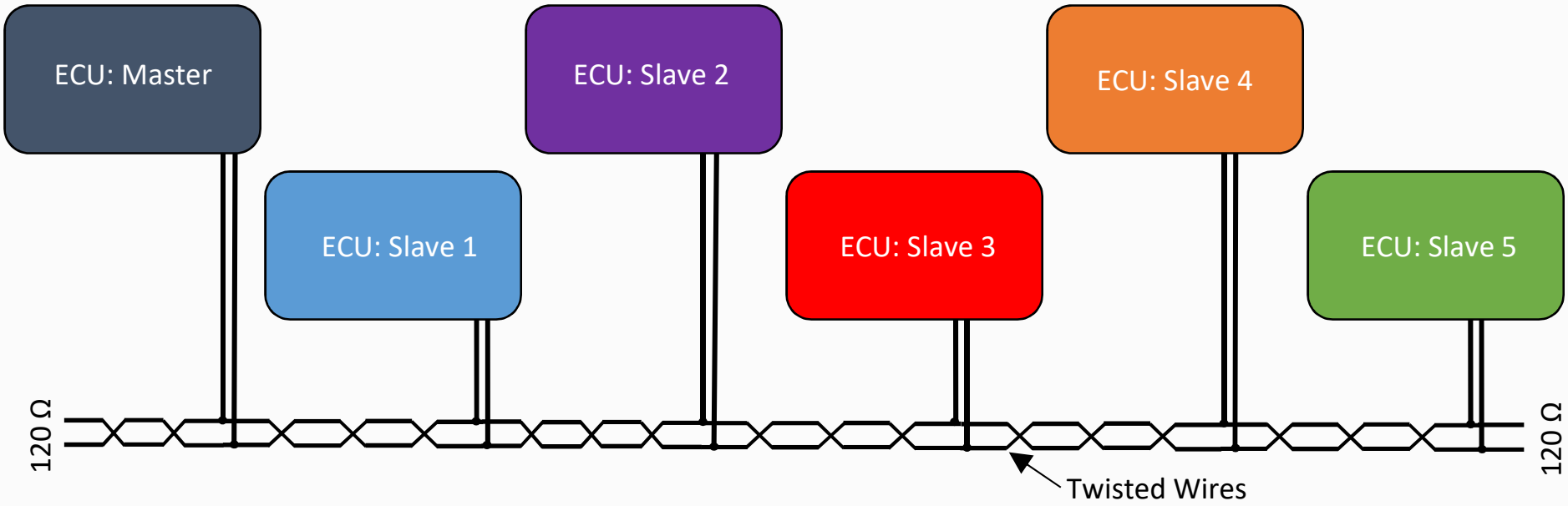
# Problem Statement

- Komatsu cannot uniquely identify and track their ECUs, there is no accountability for which ECUs are on which truck.
- ECUs in a network do not usually know which other ECUs are in the network.
- If an ECU fails then someone has to go on-site with a laptop and manually program the new ECU with information about how it is installed.
- Currently, there is not a method to securely send ECU information across the network.

# Functional Requirements

- Simulate a CAN network of ECU's utilizing master slave topology
- Obtain each module's ID number and truck frame number
- Retain information and update modules
- Determine a way to make this communication secure

# Diagram of CAN network



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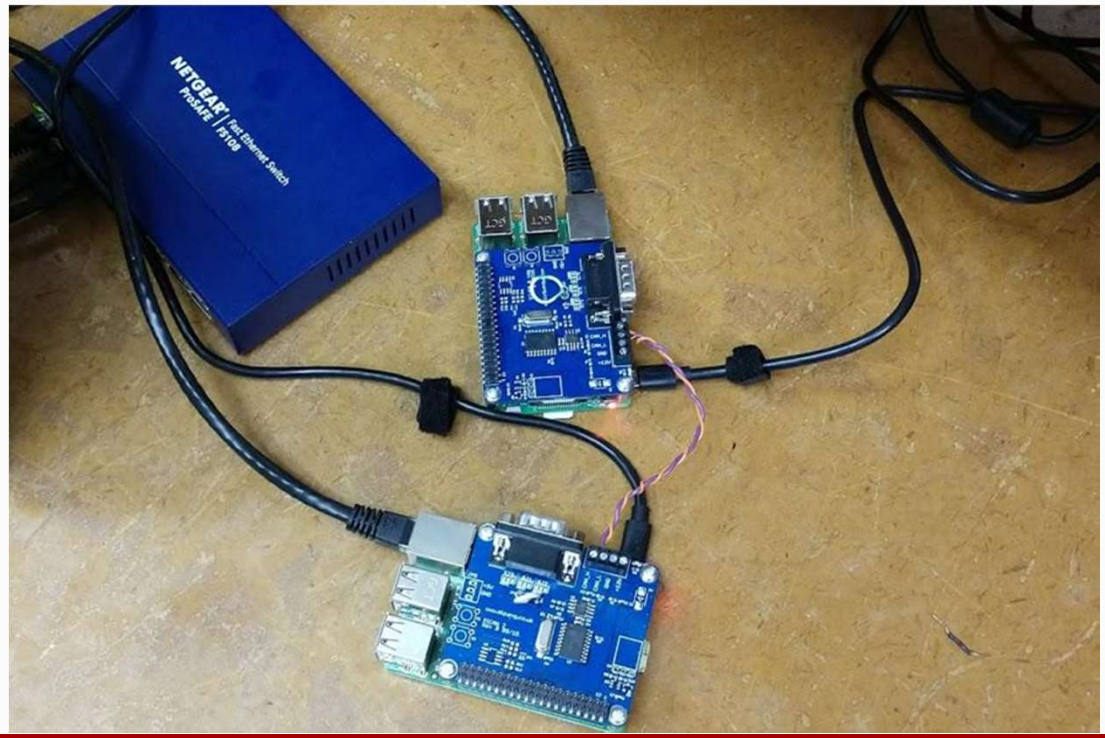
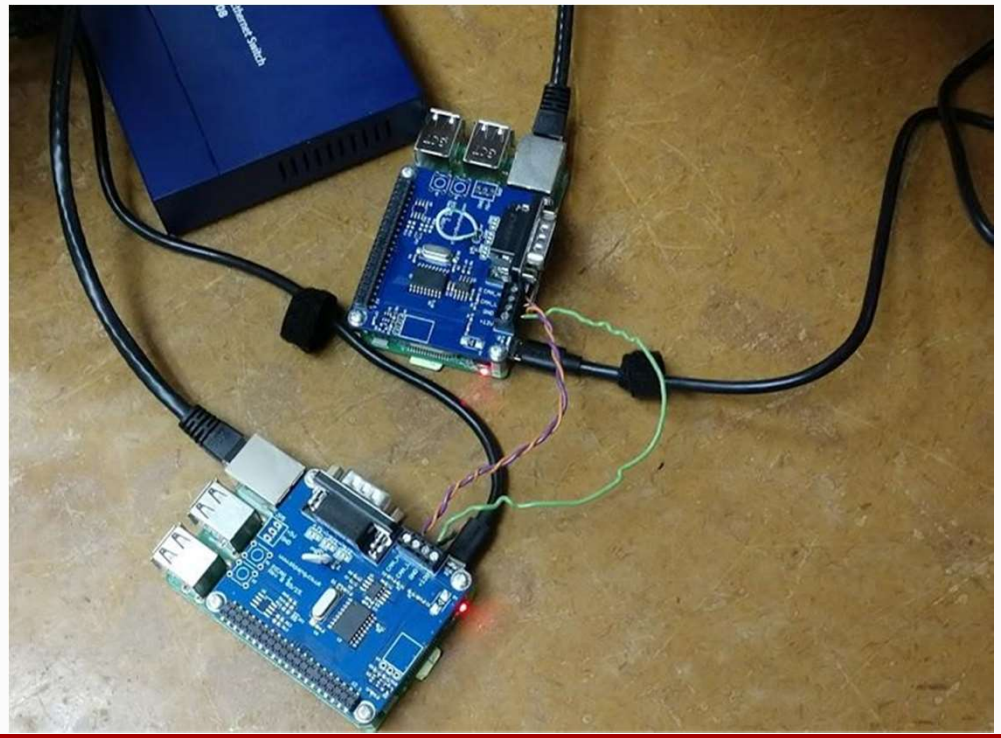
# Engineering Effort to Date

- 3 Meetings at Komatsu
  - Sep 19th
  - Sep 28th
  - Oct 5th
- Short Demo
  - Nov 16th
- Proof of concept for a small network
- Planned for feature implementation

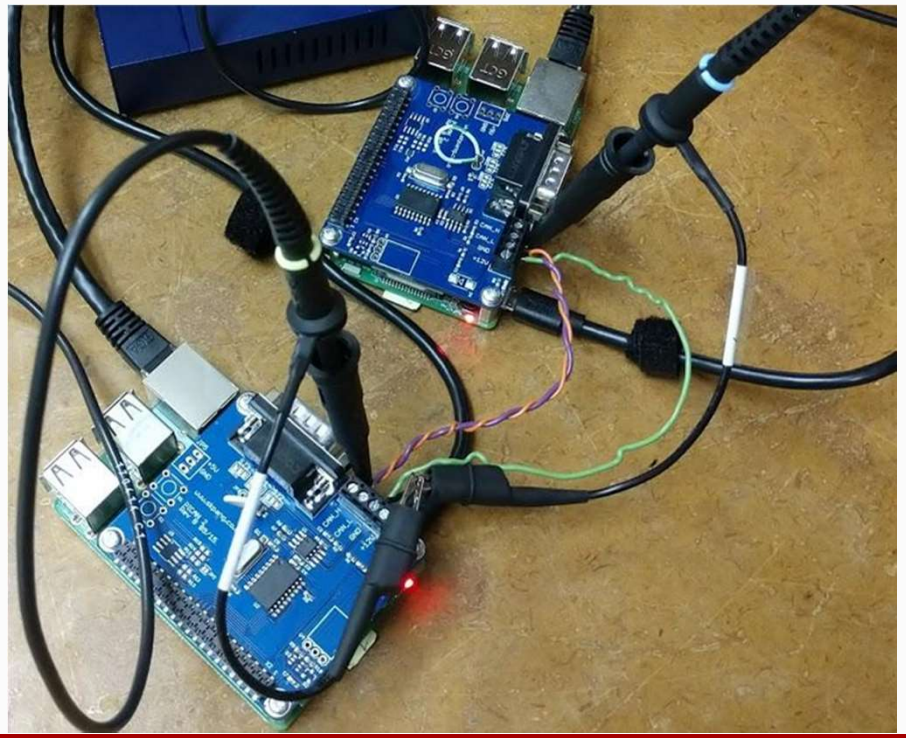
# Lab Setup



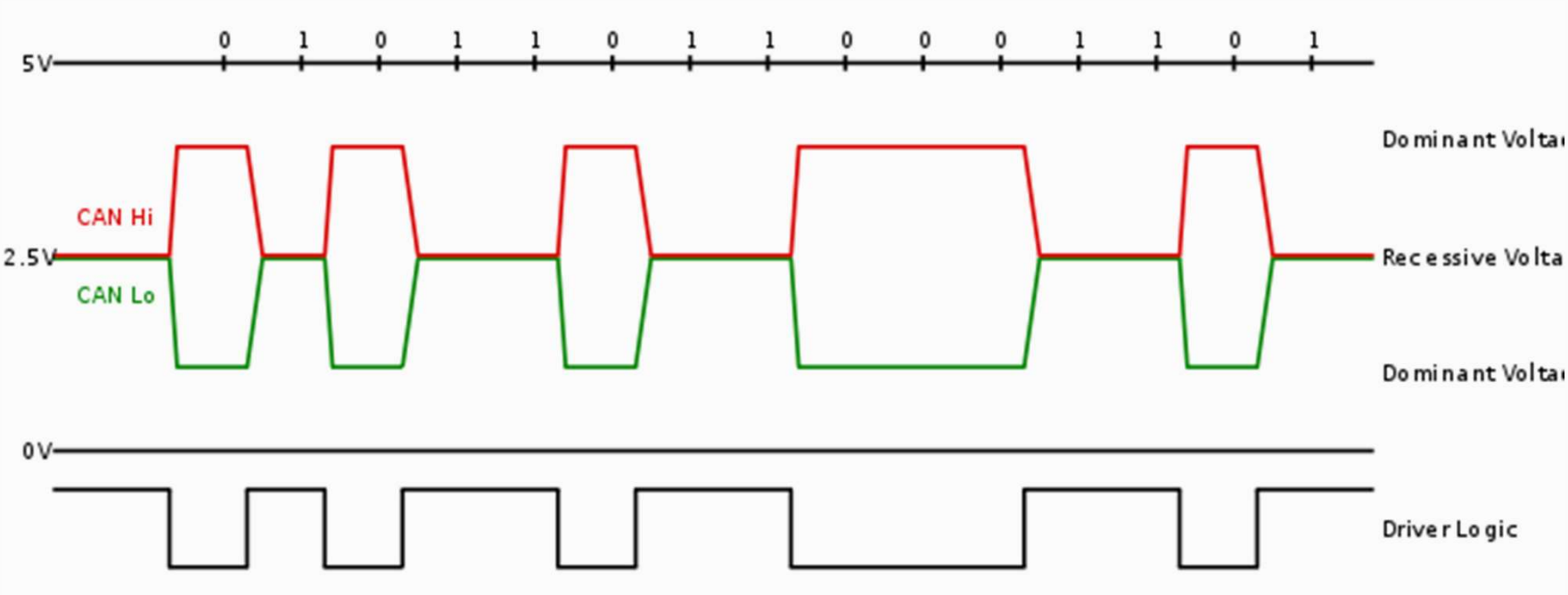
# Lab Setup



# Lab Setup

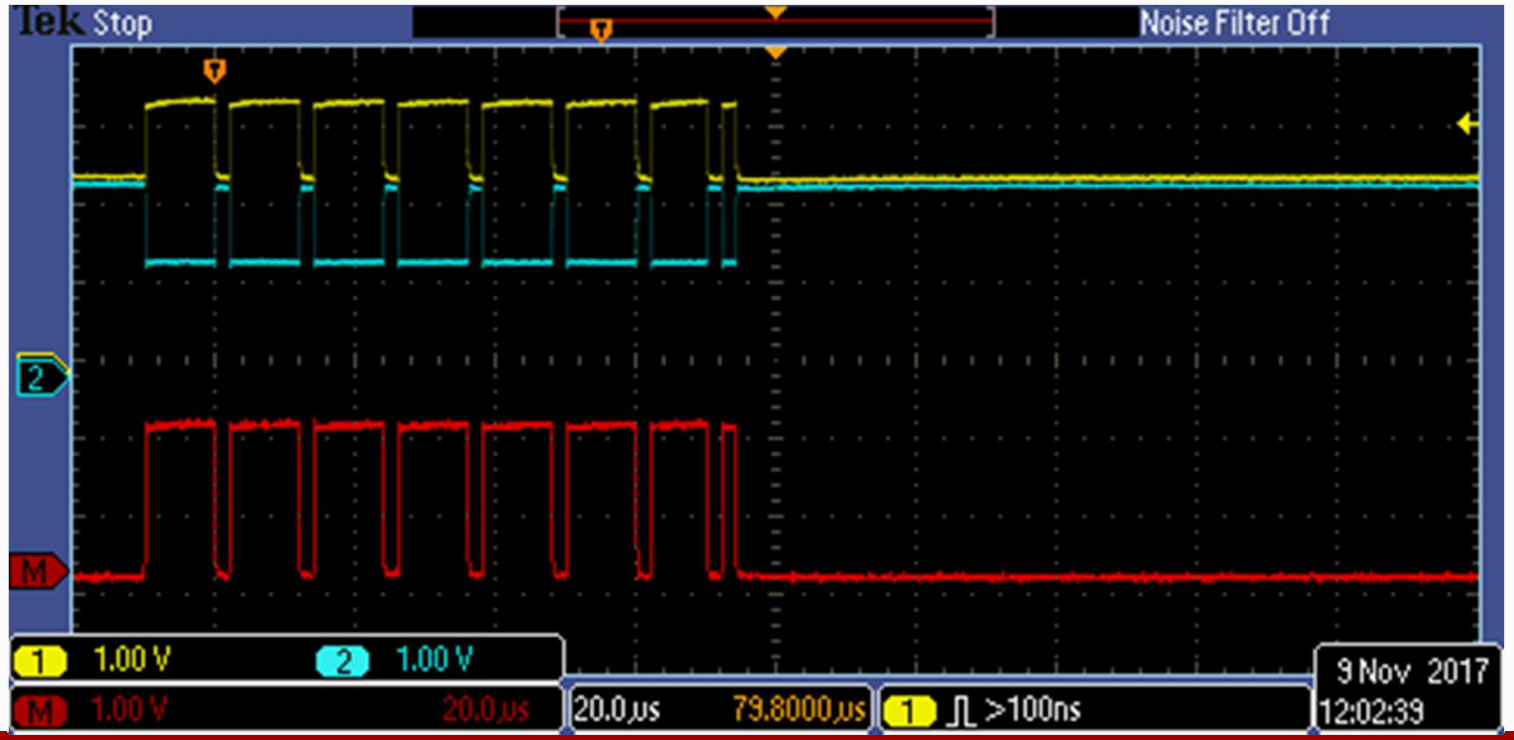


# CAN Bus Communication

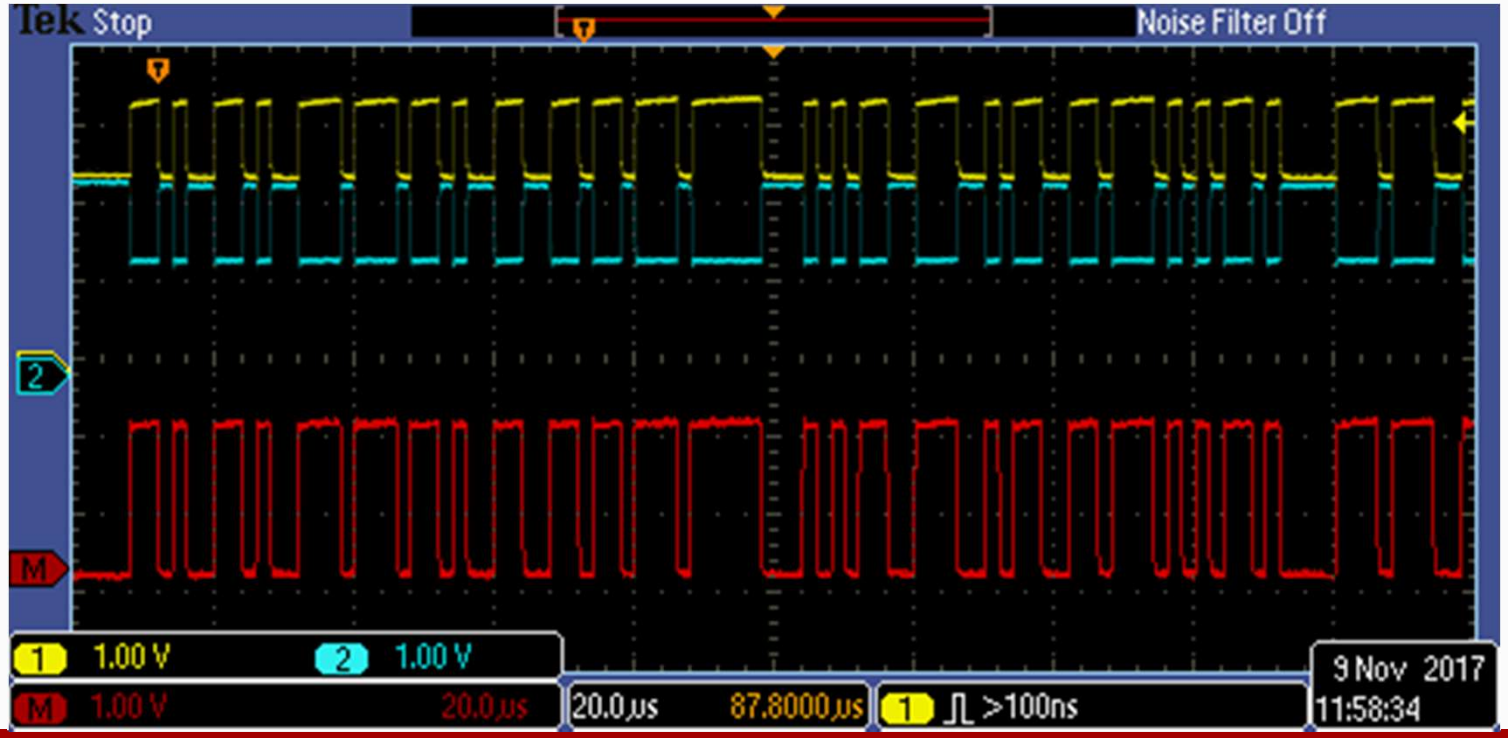



Public Domain image under CC-SA

# CAN Bus Communication



# CAN Bus Communication



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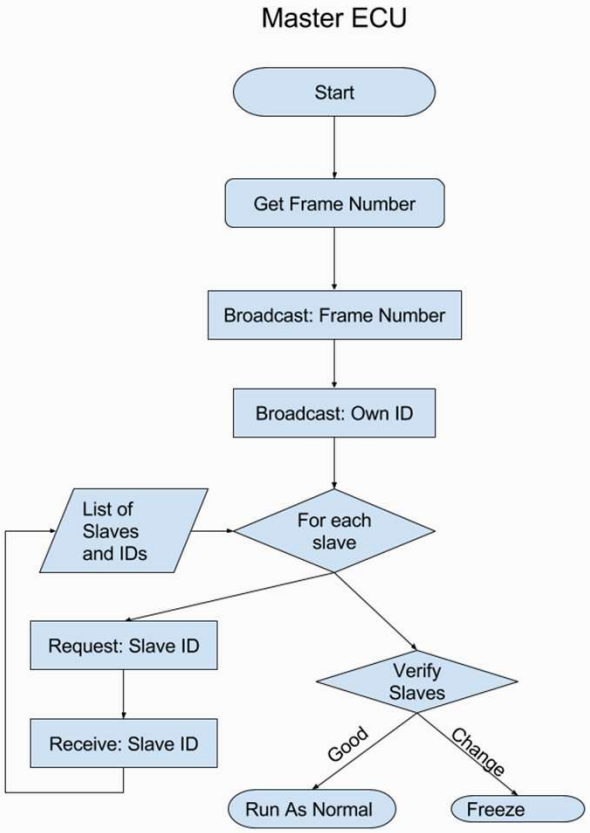
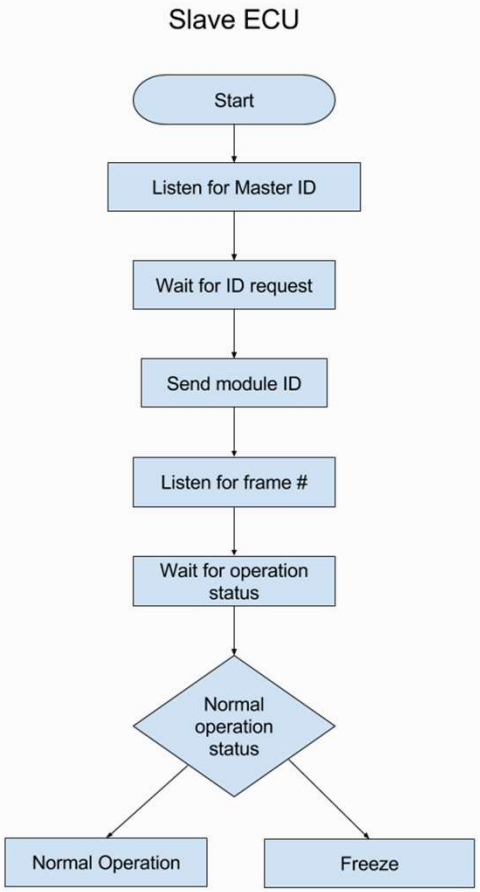
# Planned work

- Expanding the network to more ECUs
- Discovery of peers
  - Obtain serial numbers of each ECU and truck frame ID
- Recovery of lost peers
- Implement message security and redundancy
  - Blowfish algorithm
  - Lossy network simulation

# Network Expansion

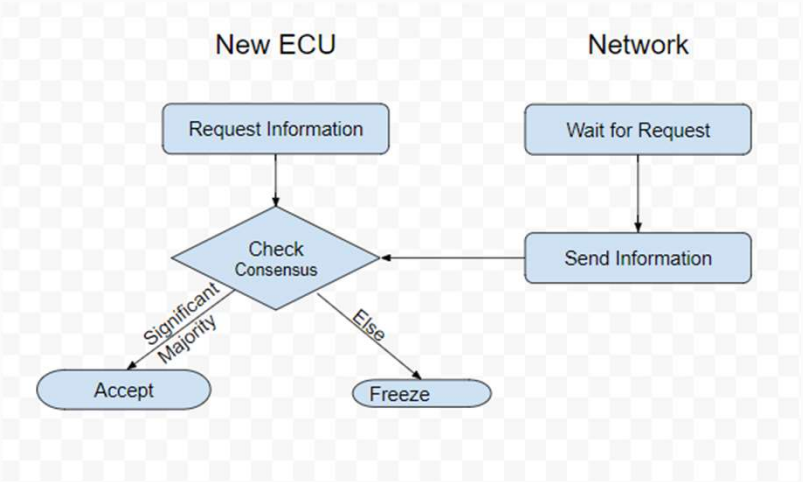
- The actual truck has more than two ECUs
  - Planned for six, one master to five slaves
- Traffic Handling
  - J1939
  - CANopen SDO protocol


Master ECU
Start
Get Frame Number
Broadcast: Frame Number
Broadcast: Own ID
List of Slaves and IDs
For each slave
Request: Slave ID
Receive: Slave ID
Verify Slaves
Good
Change
Run As Normal
Freeze


Slave ECU
Start
Listen for Master ID
Wait for ID request
Send module ID
Listen for frame #
Wait for operation status
Normal operation status
Normal Operation
Freeze

# Recovery of Lost Peers

- What happens when you change one of the ECUs
  - New ECU checks with Network
  - Consensus for Significant Majority



# Further goals

- Traffic security
  - AES Encryption
    - Block size is larger than packet payload (128 bit)
    - Key size is minimum 128 bit
    - Larger memory footprint
  - Blowfish Algorithm
    - Block size is the same size as packet payload size (64 bits)
    - Key size is variable from 32 to >256 bits
    - No effective cryptanalysis exists
- Handling of a lossy connection

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# Division of Labor

- Zach will be in charge of application layer implementation
- Christian will be in charge of the physical layer

- When the software development begins, utilizing a tool such as Trello will enable us to divide the labor to achieve goals

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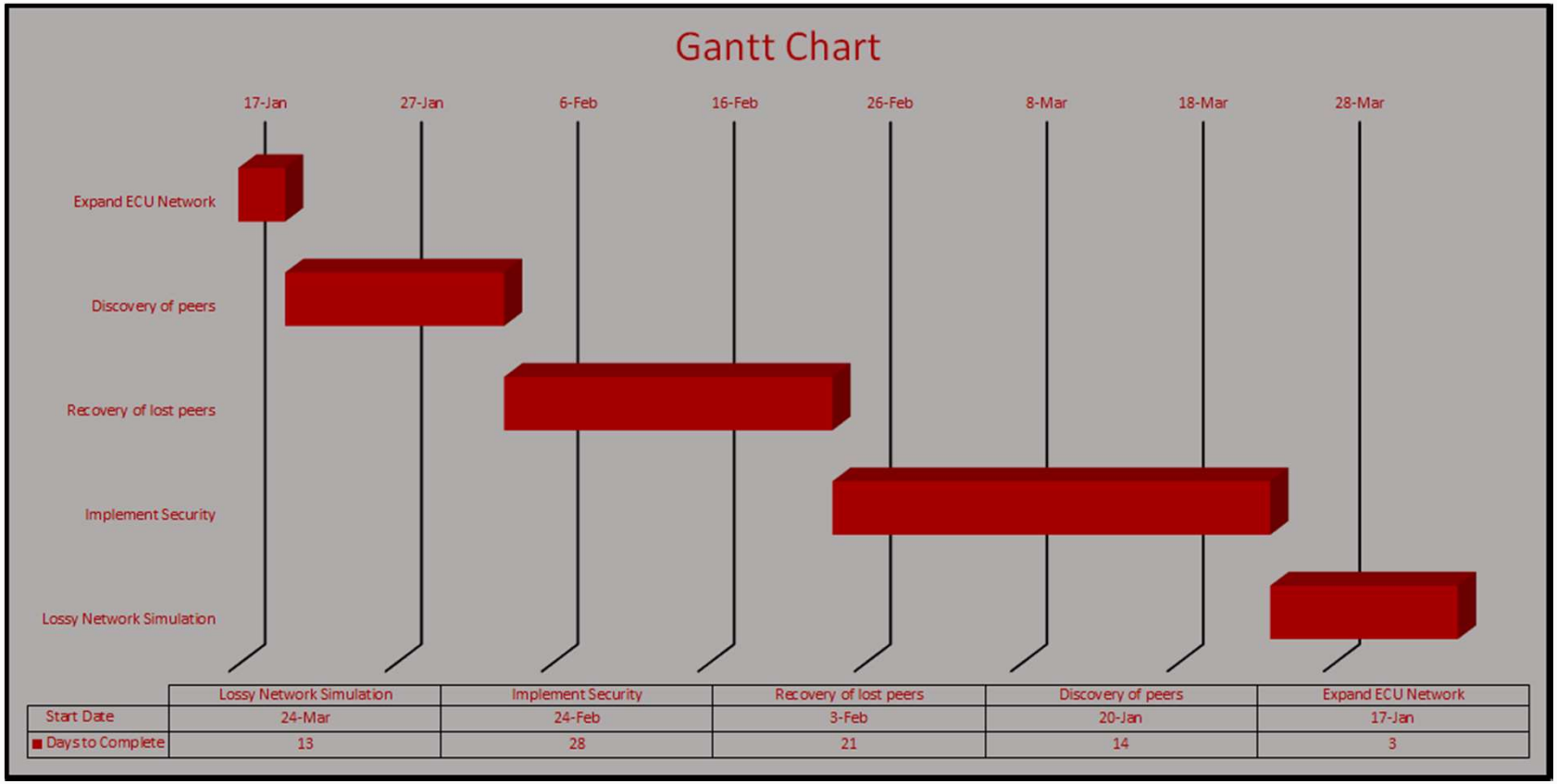


| | Lossy Network Simulation | Implement Security | Recovery of lost peers | Discovery of peers | Expand ECU Network |
|---|---|---|---|---|---|
| Start Date | 24-Mar | 24-Feb | 3-Feb | 20-Jan | 17-Jan |
| Days to Complete | 13 | 28 | 21 | 14 | 3 |

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# Parts List

| Quantity | Description | Price | Ext. Price |
|---|---|---|---|
| 6 | Raspberry Pi3 Model B | $35.10 | $ 210.60 |
| 12 | 8GB micro SD cards | $7.11 | $ 85.32 |
| 1 | USB HUB for Data | $24.99 | $ 24.99 |
| 1 | USB HUB for Power | $15.99 | $ 15.99 |
| 1 | 3 foot USB 2.0 (6 Pack) | $8.99 | $ 8.99 |
| 6 | USB to TTL Serial | $6.99 | $ 41.94 |
| 1 | Ethernet Switch | $23.28 | $ 23.28 |
| 1 | Ethernet Cables 2 Feet (10 pack) | $13.99 | $ 13.99 |
| 6 | CAN Interface for Raspberry Pi | $47.95 | $ 287.70 |
| | | | |
| | Shipping | | $ 0.00 |
| | | | |
| | | | |
| | | Subtotal: | **$ 712.80** |

# ECU Communication and Networking

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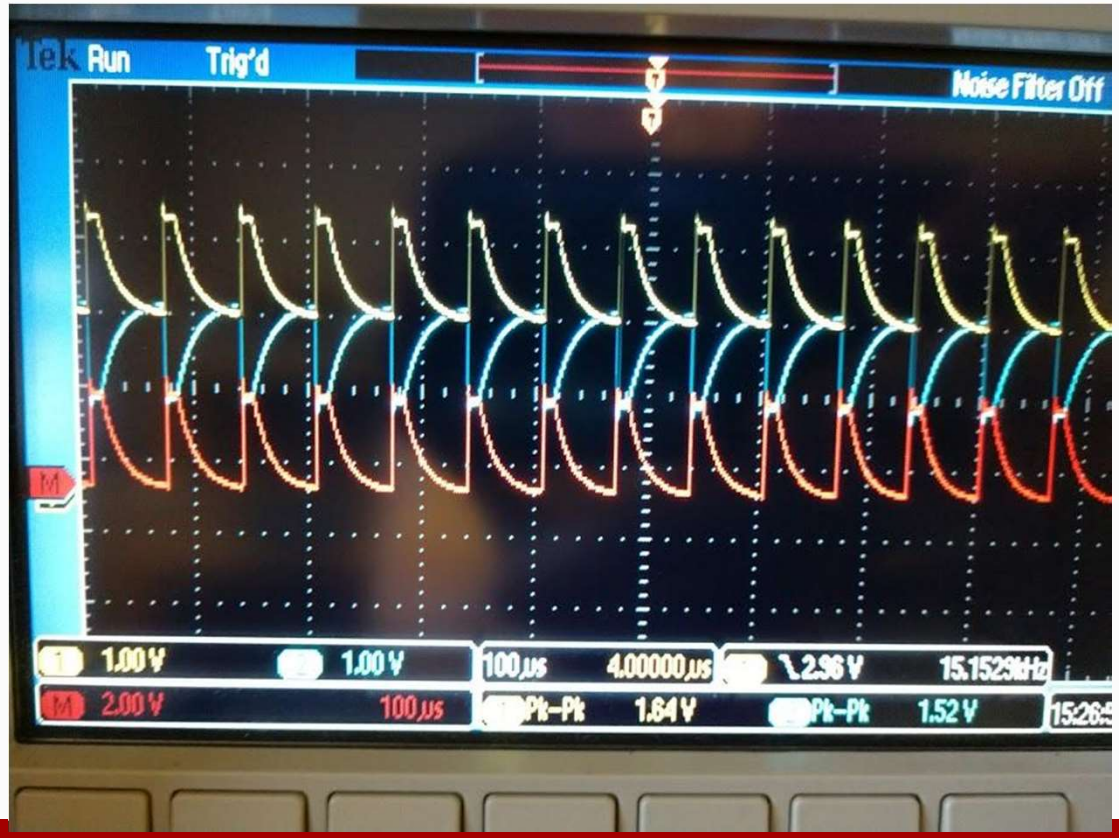
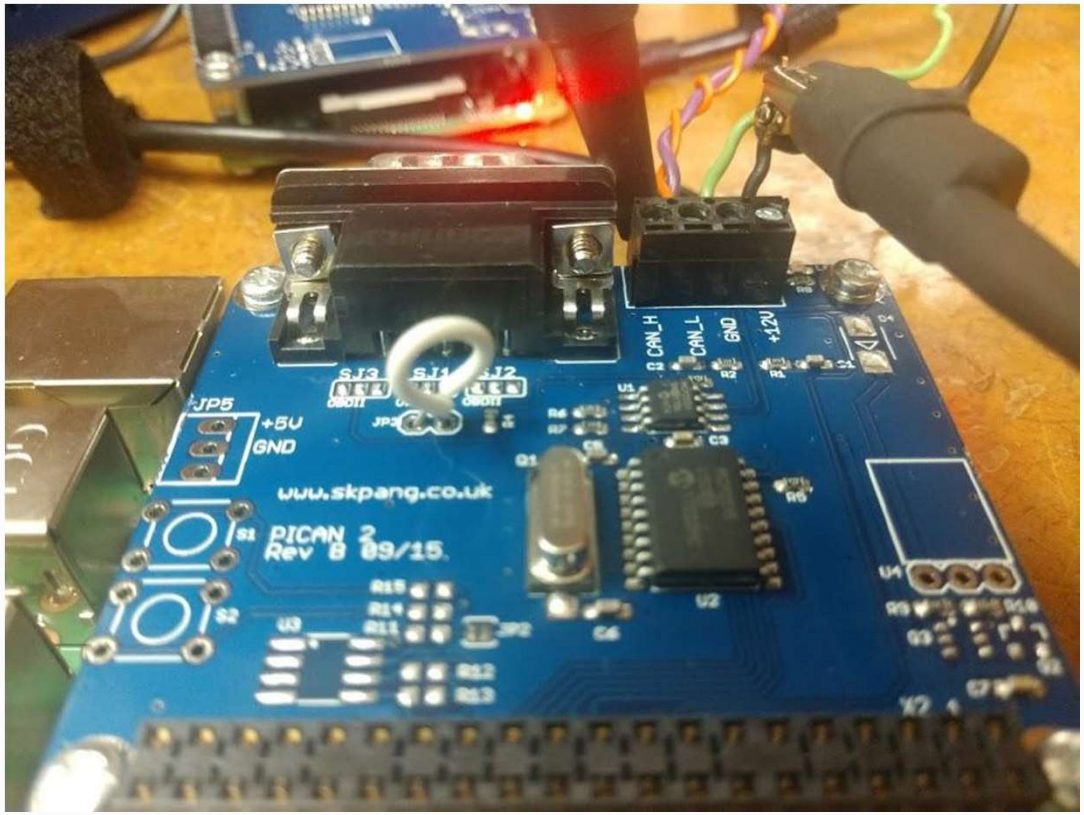
can0 000 [0]
can0 000 [0]
can0 123 [8] 45 67 89 AB CD EF 01 23
can0 123 [8] 45 67 89 AB CD EF 01 23
can0 123 [8] 45 67 89 AB CD EF 01 23
can0 123 [8] 45 67 89 AB CD EF 01 23
can0 123 [8] 45 67 89 AB CD EF 01 23
can0 123 [4] DE AD BE EF
can0 123 [8] DE AD BE EF CA FE BA BE
can0 123 [8] DE AD BE EF CA FE BA BE
can0 123 [8] DE AD BE EF CA FE BA BE
bi2 $ ./cansend can0 000#
bi2 $ ./cansend can0 000#
bi2 $ ./cansend can0 123#456789abcdef0123
bi2 $ ./cansend can0 123#456789abcdef0123
bi2 $ ./cansend can0 123#456789abcdef0123
bi2 $ ./cansend can0 123#456789abcdef0123
bi2 $ ./cansend can0 123#456789abcdef0123
bi2 $ ./cansend can0 123#deadbeef
bi2 $ ./cansend can0 123#deadbeefcafebabe
bi2 $ ./cansend can0 123#deadbeefcafebabe
bi2 $ ./cansend can0 123#deadbeefcafebabe
bi2 $


Tek Run
Trig'd
Noise Filter Off
1.00 V
1.00 V
100 µs
4.00000 µs
2.96 V
15.1523MHz
2.00 V
100 µs
Pk-Pk 1.64 V
Pk-Pk 1.52 V


CAN_H
CAN_L
GND
+12V
JP5
+5V
GND
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PICAN 2
Rev B 09/15