

#### GOAL OF QUARKNET PROJECT:

- Replace APACS system, iFIX console, 4-mation software with new hardware and software
- Confirming existing wire connections
- Determining which wires and modules are necessary to the continued operation of the slow controls system and therefore need to be kept in the transition to a new system and which are not and therefore can be discarded
- Remove the unnecessary wires and modules
- Replace with new and improved hardware and software that moves Fermilab away from iFIX which costs a considerable sum of money each year
- Document our progress / improve documentation

#### NEXT STEPS:

- Order and install Maple hardware
- Implement Mapware 7000 and new console to replace iFIX
- Transition detectors from APACS to Maple
- Incorporate gas shed and motion tables into new Maple system

#### END GOAL:

- One comprehensive system which manages all processes at Fermilab Test Beam Facility

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SEE EXCEL SHEET:

<https://drive.google.com/open?id=1xkOZvX715xMHwCq34nliRn-sy6vC2h9O>

- VERIFIED INFO
  - Downstream 15 pair cable to APACS color (all devices)
  - Downstream 15 pair cable to APACS pair # (all devices)
  - APACS channel or ps terminal (all devices)
  - Labels to place on cables at APACS end (all devices)
  - All other columns were not verified
- NOTES
  - For all\* devices, APACS channel or ps terminal is numbered as +/- CH(#)
    - e.g., +CH4, -CH5, 22+, etc.
  - Channel number is consistent with 4-mation address, but inconsistent with I/O module port number
    - e.g., R01S08 SAM 22+ corresponds to address R01S08C22 in 4-mation, but plugs into port 43 on the I/O module itself
    - If +CH(#N), port number is 2N - 1
    - If -CH(#N), port number is 2N
  - \*EXCEPTIONS: EV-DS1-V, EV-DS2-V, EV-DS3-G, EV-DS4-G, DS-VAC-PMP, EV-US11-V, EV-US12-V, EV-US13-G, EV-US14-G, US-VAC-PMP
    - For these devices, channel number is consistent with both 4-mation address and I/O module port number
    - E.g., R01S10 SDM+ CH20 corresponds to address R01S10C20 in 4-mation and plugs into port 20 on the I/O module itself
  - \*EXCEPTIONS: TE-DS9-G, TE-US19-G
    - For these devices, APACS channel or ps terminal is labeled as channels 11A, 11B, 11C, 12A, 12B, 12C
    - In 4-mation, channels 11A, 11B, and 11C are all combined into a single reading under address R01S09C11
    - Likewise, channels 12A, 12B, and 12C are all combined into a single reading under address R01S09C12
    - On the I/O module itself, the above channels correspond with ports as listed below
      - 11A = 41      12A = 45
      - 11B = 42      12B = 46
      - 11C = 43      12C = 47
  - Regarding pair numbers
    - Numbers assigned to pairs of wires appear to be arbitrary
    - No numbers could be identified

- Instead, it was verified that wires which were in the same numbered pair were in fact paired together
- UNVERIFIED INFO
  - Cannot determine fuse numbering system
  - Cannot verify Upstream 15 pair cable to APACS pair # for devices
    - EV-US11-V
    - EV-US12-V
    - EV-US13-G
    - EV-US14G
    - US-VAC-PMP
  - Cannot verify Labels to place on cables at APACS end for devices
    - EV-US11-V
    - EV-US12-V
    - EV-US13-G
    - EV-US14G
    - US-VAC-PMP
- INCORRECT INFO
  - For device PT-DS8-G under Labels to place on cables at APACS end, the excel sheet notes that the label PT-DS8-G is placed on the yellow and red cables which plug into R2S04 VIM +/- CH5 respectively
    - In actuality, this label is placed on all four cables (red, yellow, red, brown), the other two of which connect to Fuse 3 and power supply common
  - For device PT-US18-G under Labels to place on cables at APACS end, the excel sheet notes that the label PT-US18-G is placed on the yellow and red cables which plug into R2S04 VIM +/- CH10 respectively
    - In actuality, this label is placed on all four cables (red, yellow, red, brown), the other two of which connect to Fuse 5 and power supply common

SEE EXCEL SHEET:

[https://docs.google.com/spreadsheets/d/1yptbYTt6APIDYe\\_XeZDohAwTYgSwBSrK7ru1Fop\\_Brk/edit?usp=sharing](https://docs.google.com/spreadsheets/d/1yptbYTt6APIDYe_XeZDohAwTYgSwBSrK7ru1Fop_Brk/edit?usp=sharing)

- LOGIC BEHIND CREATION

- Given the wiring details excel sheet, there is an expectation of which channels should be active and returning readings and which should be dead
  - In this scenario, dead means returning FALSE if a boolean or returning a static value if a real number (returned values viewed on 4-mation)
  - Otherwise, the channel is considered alive
  - All channels listed on the wiring details excel sheet were expected to be alive and returning values
  - All other channels not on the excel sheet were expected to be dead
- Given these expectations, this excel sheet was created which logged all instances in which channels defied expectations and logged all channels which were necessary to the continued operation of the system as specified in the wiring excel sheet
  - e.g., R01S02 channels 24-27 were still returning dynamic values in 4-mation despite not being listed on the wiring excel sheet
  - These readings indicate that the module is alive when its exclusion from the wiring excel sheet would seem to indicate that it should be dead
  - Therefore, it was logged on the excel sheet linked above
  - e.g., R01S09 channels 11-12 were still returning values in 4-mation, indicating that the module is alive, and its inclusion on the wiring excel sheet confirms that it should be alive
  - Therefore, it was logged on the excel sheet linked above as it was necessary to the continued operation of the machine
- In this fashion, the excel sheet linked above tracks targeted channels of each module and notes whether it should be dead and if it is in fact dead
- If a channel should have been dead and was dead, the individual channel was not logged on the excel sheet
  - If an entire module should have been dead and was dead, it was noted as such on the excel sheet
- If a channel was not dead and should not have been dead, it was noted as working as intended and kept as crucial to the continued operation of the machine
- Only one module included channels which appeared to be dead when they should have been alive
  - R01S10 included channels which were included on the wiring excel sheet and therefore should have been alive
  - However, all readings were booleans which returned false

- Nonetheless, seeing as these channels were included on the wiring excel sheet and recognizing that a returning of false did not necessarily indicate a dead channel, it was decided to keep all channels in R01S10
    - If a channel was not dead and should have been dead, further investigation was required
  - UNDEAD CHANNELS
    - In the scenario that a channel was not dead when it should have been dead, delving into the iFIX console and 4-mation was a necessity to determine if these channels were necessary to operate the beam and necessary to keep
    - In 4-mation, the tag corresponding to the channel address was located in addition to the description of the channel provided by 4-mation
    - Our interests lied in maintaining all channels necessary to the operation of the MTest Cerenkov Beam
      - Channels which pertained to RICH detectors or E907 detectors were therefore deemed useless and unnecessary
      - Having been deemed as such, these channels could be safely unplugged and disconnected
    - If the channel description pertained to RICH detectors or E907 detectors, the channel was marked as useless and ready to be unplugged
    - If the channel tag was found in the iFIX console in pages which controlled and monitored the E907 detectors or Pixel Box, these channels were similarly marked as useless and ready to be unplugged
    - In this fashion, the channels listed in the above linked excel sheet were organized into those that needed to be kept and those which could be discarded
  - SEEMINGLY IMPORTANT???
    - Some channels were still returning readings and were therefore alive when their exclusion from the wiring excel sheet seemed to indicate that they should have been dead
    - However, some of these undead channels were deemed important enough to keep based on their tags, descriptions, and placement within the iFIX console
      - e.g., R02S01 channel 10 is tagged as MTest Ethane Gas Shed Sensor
      - e.g., R02S04 channel 12 is tagged as MTest Flammable Gas Alarm
      - While not explicitly listed on the wiring excel sheet, these channel tags seem to indicate that these channels have great enough significance where it is worthwhile to preserve them as important to the continued operation of the beam
      - These channels were kept

- SIMPLIFYING 4-MATION CODE

- At this point, there was a list of which channels were to be kept and which were to be discarded in the transition to a new system which would replace iFIX
- It was then necessary to determine where these channels resided within 4-mation code to determine what blocks and networks within 4-mation were necessary to keep and which could be deleted
- Using 4-mation, the 4-mation tag which corresponded to each important channel could be located
- CTRL-F could then be used to search the entire 4-mation resource for all instances of where this tag appeared
- The larger networks and individual blocks in which these tags appeared were marked as necessary to keep
  - e.g., R02S04 channel 5 was determined as necessary to the continued operation of the beam
  - Its corresponding tag in 4-mation was %MT\_PTDS8G
  - Using CTRL-F, this tag was located in the larger network of MT\_BCKOV\_2 - MT\_BCKOV\_2 as well as within the smaller block of IO\_FOR\_BCKOV2 - IO\_FOR\_BCKOV2
  - This information was recorded, and this network and block were marked as necessary to keep

- HARDWARE

- Looking into hardware, it was decided that the channel type of each channel which was to be kept was necessary to determine which modules could be purchased to eventually replace the existing iFIX and APACS system
- Channel types included Voltage In, Discrete Out, Analog In, RTD
- Two channels had connections to an ACNet system near the APACS system
- This was noted in the excel sheet as well

## HARDWARE + SOFTWARE:

- NEEDS
  - Integrated HMI + PLC
  - I/O Modules with room for future expansion
    - 2 analog inputs
    - 2 RTD inputs
    - 10 discrete outputs (sourcing)
    - 15 voltage inputs
    - Expandability
  - Website interface OR Modbus
- MAPLE HARDWARE + SOFTWARE
  - HMC 7070A-M 7.0" HMI + PLC
    - 5 I/O expansion ports
    - Ethernet
  - HMC7-MIO-08
    - 4 analog inputs
    - Support voltage and current modes as well as RTD and thermocouple modes
  - HMC7-MO-03
    - 16 digital sourcing outputs
  - HMC7-MI-03(x2)
    - 8 analog voltage inputs
  - MLC3-E
    - Add up to 16 I/O expansion modules
    - Communicates with HMC via MAPWARE and ethernet
  - MAPWARE 7000
    - Offers website interface and remote control

REMOVAL:

- Unplugged the following
  - R01S02 (all channels)
  - R01S03 (all channels)
  - R01S04 (all channels)
  - R01S05 (all channels)
  - R01S06 (all channels)
  - R01S07 (all channels)
  - R01S08 (all channels EXCEPT 22 and 23)
  - R01S09 (all channels EXCEPT 11 and 12)
  - R01S10 (all channels EXCEPT 8, 9, 17-24)
  - R02S01 (all channels EXCEPT 10 and 16)
  - R02S02 (all channels)
  - R02S03 (all channels)
  - R02S04 (channels 13-15, kept the rest)
  - R02S05 (all channels)
- Removed the following modules
  - R01S02
  - R01S03
  - R01S04
  - R01S05
  - R01S06
  - R01S07
  - R02S02
  - R02S03
  - R02S05