Technology, Productivity and Information on P&H Mining Equipment

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Where are we coming from? A little over 5 years ago:

- Analog electronic motion controls
- Simple PLC systems for logic and sequencing
- Simple fault message displays
- Only communications link: Dispatch® system to send truck from shovel

Today--after Technology Changes: Drives

- **Full microprocessor control on both armature and field, continuous interactive operation for optimal cycling**
- **Retrofit applications: between 2 and 6 second cycle time reductions**
- **New machines: move 115 tons in fastest available time**

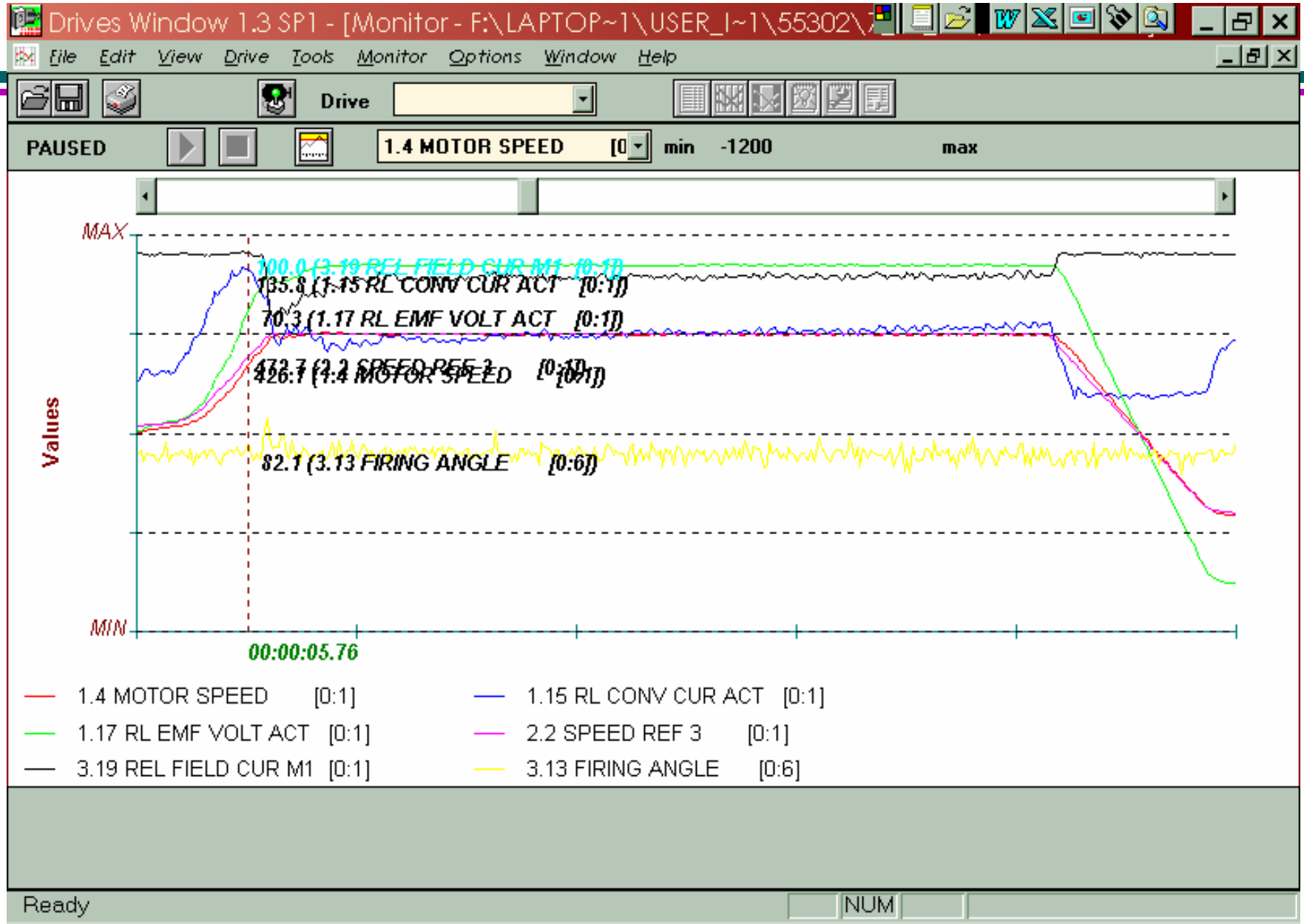
New Machine Digital Drive Control Cabinet

- Armature, field, and RPC controls
- PLC
- Built-in GUI for troubleshooting PLC and drives

Today--after Technology Changes

- **PLCs with extensive machine limit systems and protectives**
- **Diagnostics available for temperatures**
- **Drive faults diagnostics built-in**
- **Color touch-screen operator and maintenance HMI units**
  - » **on-line help, built-in troubleshooting aids reduce downtime**

Drive Monitor

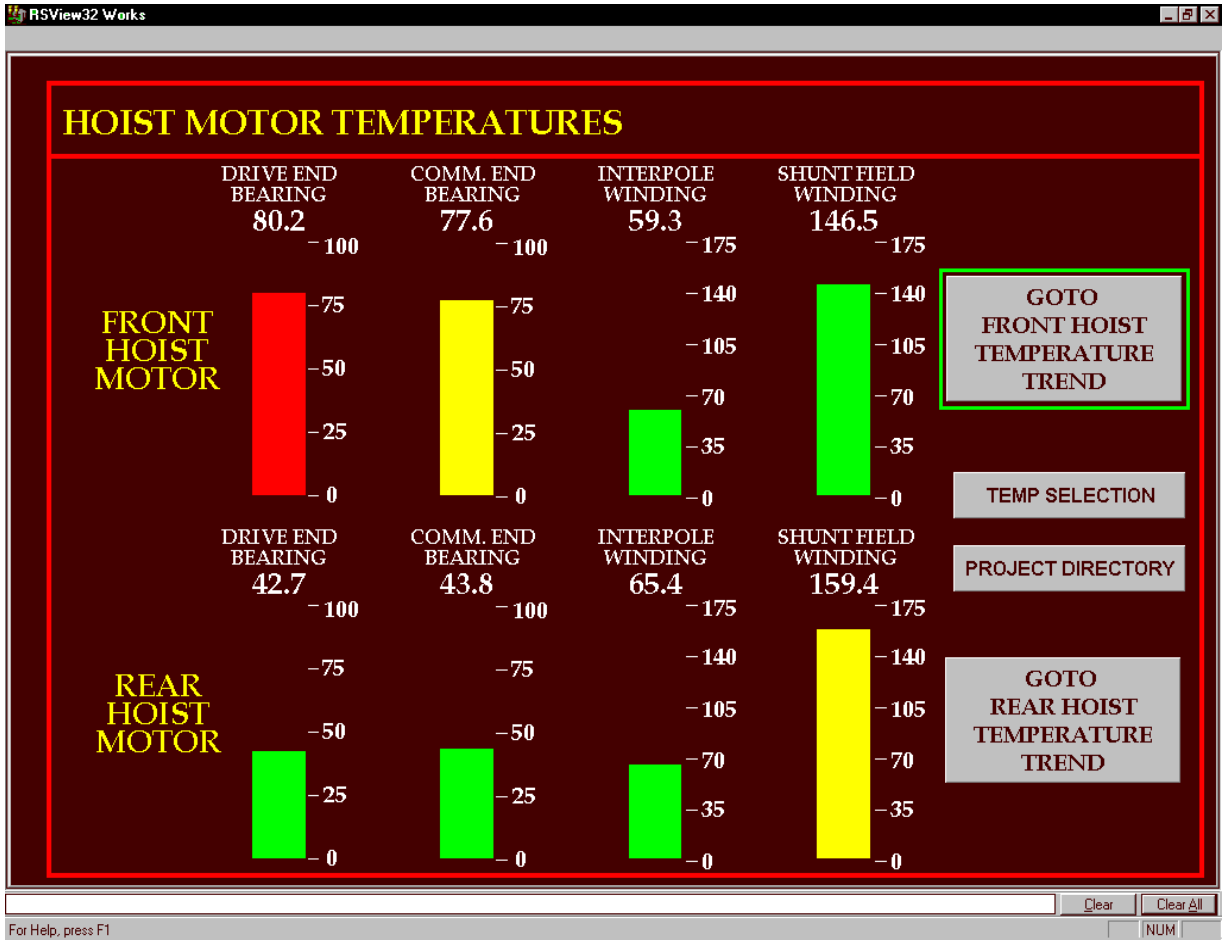


PLC Equipment

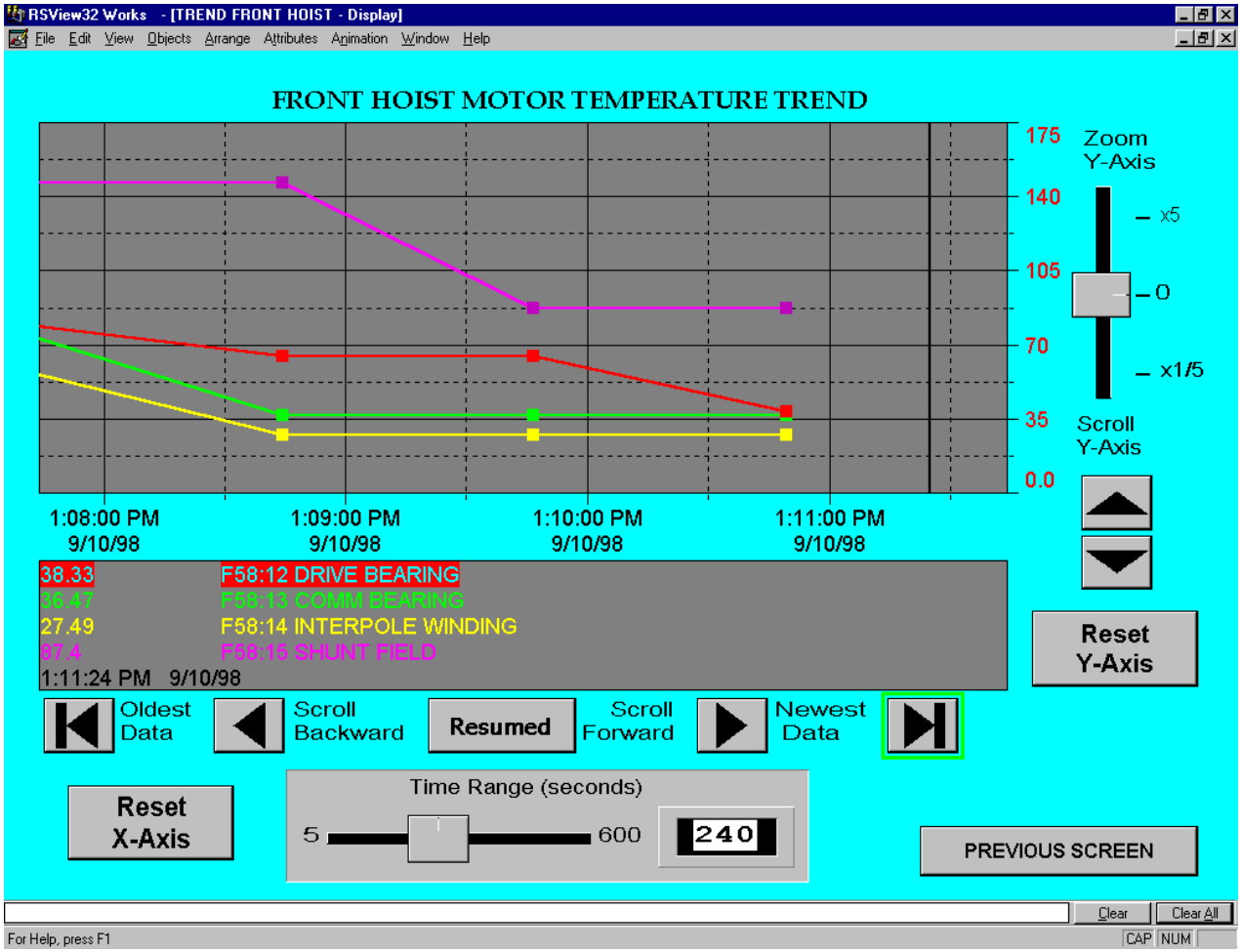
- PLC processor
- Appropriate I/O--rack style or Flex
- Interface to drives
- Interface to OAP

Temperature Display

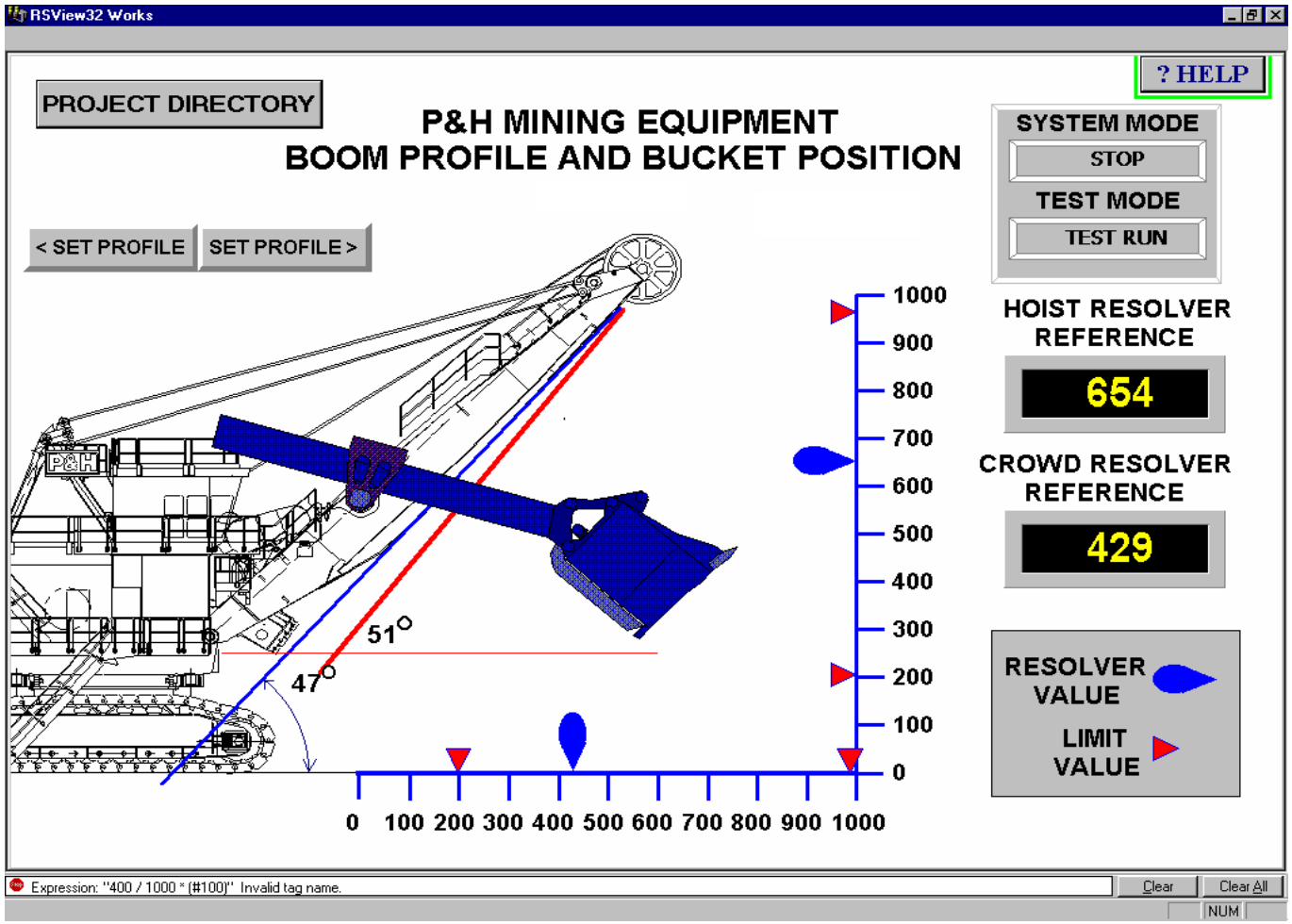
- All new motors equipped with four RTDs
  - » Drive End Bearing
  - » Opposite Drive End Bearing
  - » Main Field coil
  - » Interpole



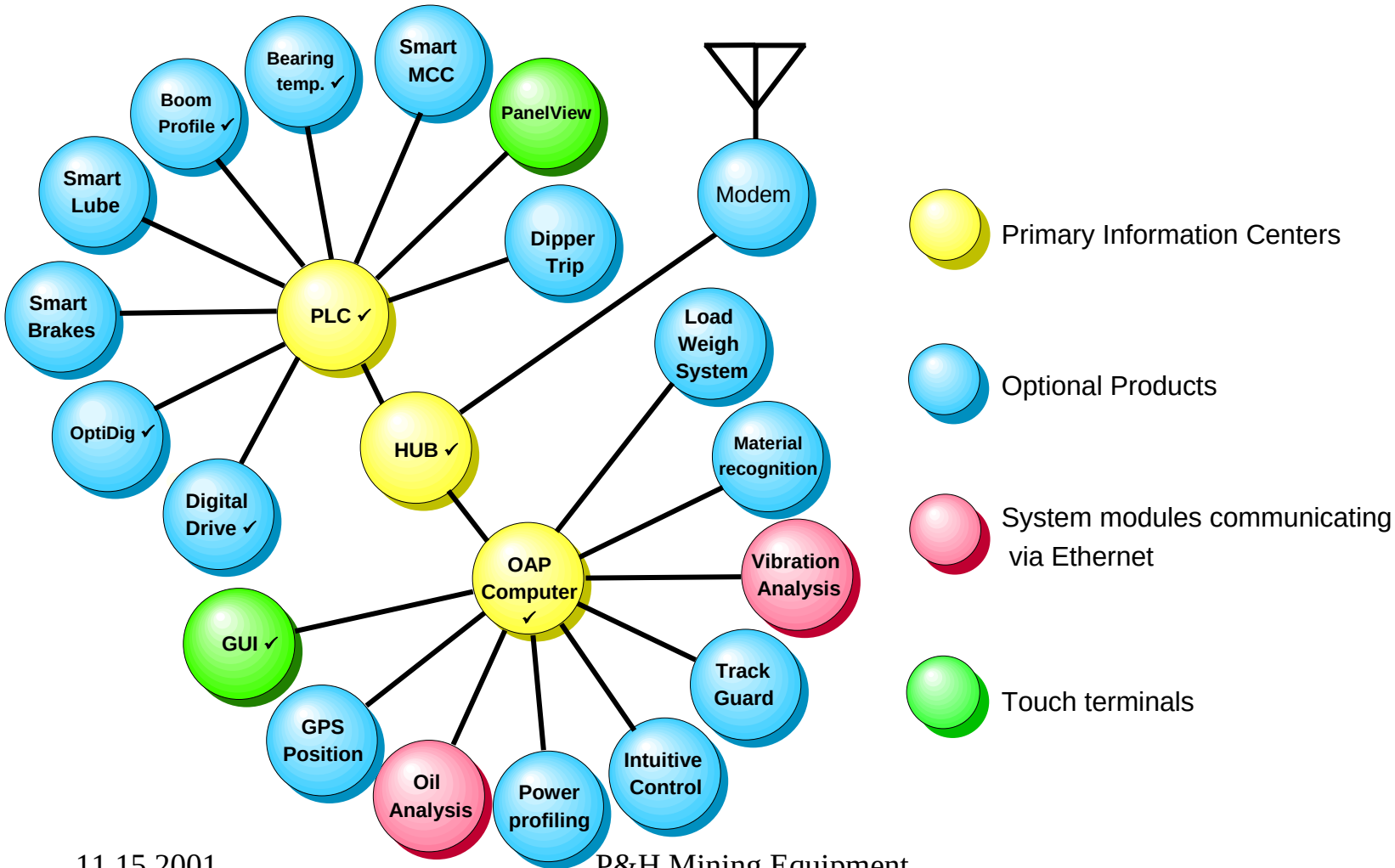
Temperature Trending



Motion Limits and Boom Protection



Integrating Technology

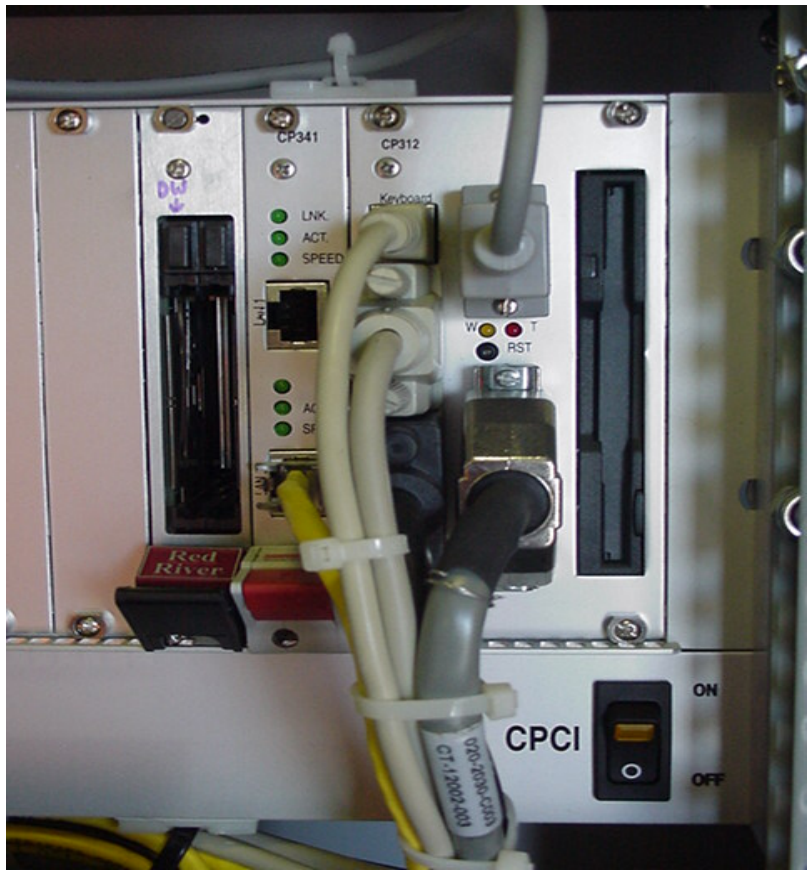


Electric Mining Shovel shown, similar for Draglines and Blast Hole Drills

Today--after Technology Changes

- **Open Architecture Processor (OAP) for data**
  - **adds pre-processing and data collection ability**
- **On-board, on-the-fly payload weighing**
- **Ability to send data off-board**
  - ***= optional***

Open Architecture Processor



- **Allows high speed data processing independent of critical machine control**
- **Access to other mine systems via ethernet connection**

Replacing "on-off" sensors with transducers

- Allows more flexible response to changing conditions
- Resistance Temperature Detectors (RTDs) vs. temperature switches
- Pressure transducers vs. switches for air and lube pressure
- Resolvers vs. limit switches for position, e.g. Automatic Boom Soft Setdown (ABSS)
- Transducer vs. no sensor for Lube Level

Lube level transducers

Transducers generate more data flow

- **Transducers vs. on-off switches**
  - » ***words of data*** **vs. one single bit**
  - » **trending and histories mean *files of words* vs. one single bit**
- **What do we do with all this data?**
- **Storing it and transmitting it both have downsides**

More Data

- **Digital Drives and additional PLC functions provide increased information when an alarm or fault occurs**
  - » **on-line diagnostics shorten MTTR, but generate more data**
- **Additional functionality to assist productivity, e.g. OptiDig^{tm} stall prevention**

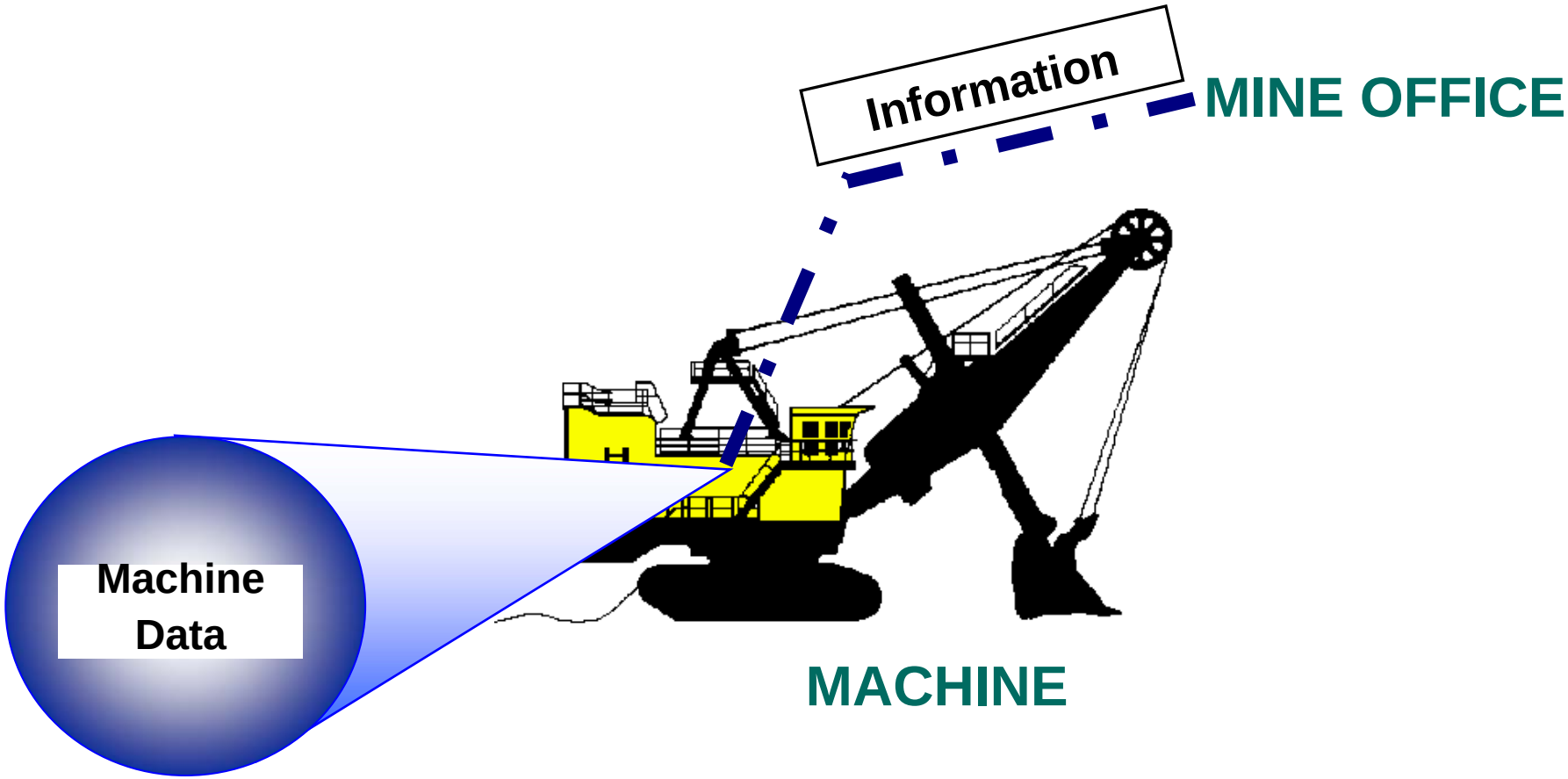
Future Directions

- **Continued work toward on-line predictive diagnostics (vibration data, oil analysis)**
- **More monitoring of machine/operator aspects to balance maximum productivity against increased maintenance, e.g. OptiDig^{tm},Track Guard^{tm}**
- **Work on Smart Brakes and Smart Motor Control Centers**

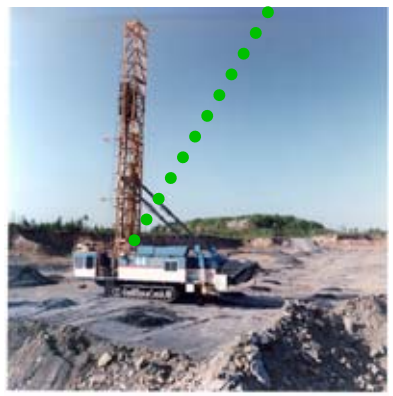
Future Directions - cont'd

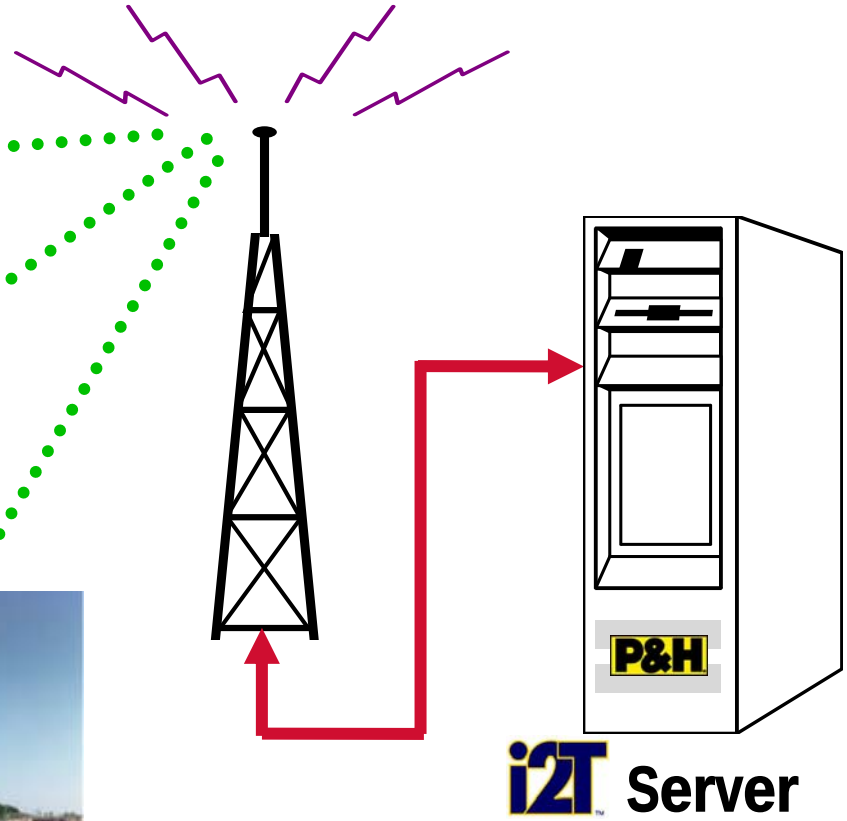
- **Work on adaptive controls for drives taking into account :**
  - **power system conditions**
  - **material changes**
- **All of these have *data flow* implications!**

i2T: Remote Communications



Link to Server





i2T: Integrating Information

- Linking information - - i2T Remote Communications
  - Internal to machine
  - Machine to Mine Office
  - Mine Office to internal LAN, P&H, . . .
- Common platform for:
  - Multiple options (LWS, Remote Communications, . . .)
  - Universal solution to Shovels, Draglines, Drills

How do we move data off-board? "Push" vs. "Pull"

- P&H i2T approach has been to "pull" data off-board from on-board
- Only transmit specifically requested data
- Requires person at off-board side to request data
- Requires separate radio channels due to bandwidth/size of data stream

"Push" vs. "Pull" (continued)

- **Why not "push" commonly desired data into an off-board database?**
  - **Requires on-board pre-processing**
  - **requires a communication pipeline with capacity**
- **"Pull" makes sense when dealing with long streams of data**
  - **example: motor currents and voltages, temperature logs, fault information**

Mining Information for Multiple Users

- Management
- Production
- Mine Planning
- Maintenance
- P&H (MinePro, Engineering, Service, Management,…)
- …

Information Challenges

- Mobile equipment - stationary office
- Global communications disparities
- Remote locations
- Insufficient qualified personnel
- Mines do not want several different communications systems--one network should service all pit equipment

Collaboration

- **Need Industry consensus on data file format.**
- **Mine-specific requirements identified and variations minimized.**
- **Trust.**

Conclusion

- **P&H wants to be part of the solution.**
- **In-pit radio systems <u>are not</u> a P&H core competency.**
- **i2T Products are a <u>start</u> toward better information management.**
- **The Industry (Miners, OEM's, 3rd Parties) need to collaborate toward mine-wide integration.**
- **Mines, however, need to be the drivers!**

Tell us what <u>YOU</u> want.