Embedded Diagnostics, Prognostics and Maintenance for Environmental Control Systems

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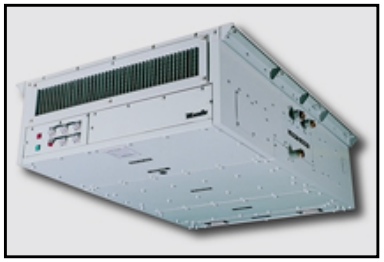
Presentation Outline

- Background
- Objective
- Overview
- Status
- Concluding Remarks

Background

- Environmental control is pervasive in military operations



FCU

AHU

FDECU

IECU

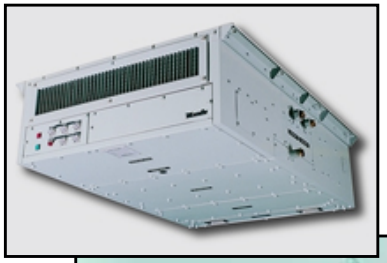
CHAMP

LECU

SPLIT PACK

Background

- Level of equipment upkeep varies considerably
  - Navy Fan Coil Unit -
    - Operation is checked using the “hand” test
    - Units frequently operate without an air filter
  - CP EMEDS -
    - Startup and upkeep is time consuming
    - Teams check the equipment twice a day
    - Operational deficiencies take time to identify and locate
- Growing interest in diagnostics and prognostics

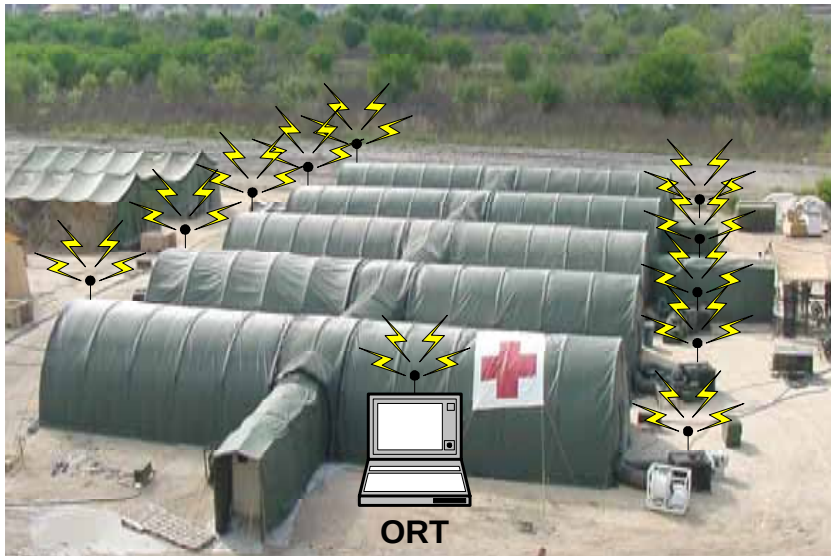


FCU

FDECU

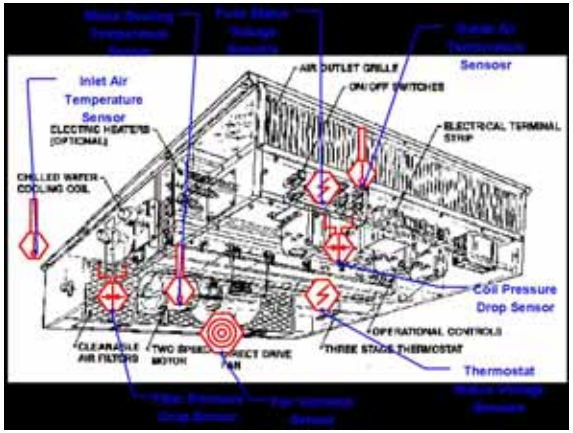
Next Generation ECU

- Embedded diagnostics and prognostics
  - Condition Based Maintenance approach
  - Low cost hardware
  - Reduced life-cycle cost
- Centralized equipment monitor and control
  - Operator interface via computer
- Integral link to equipment's technical manual
  - Faster maintenance action

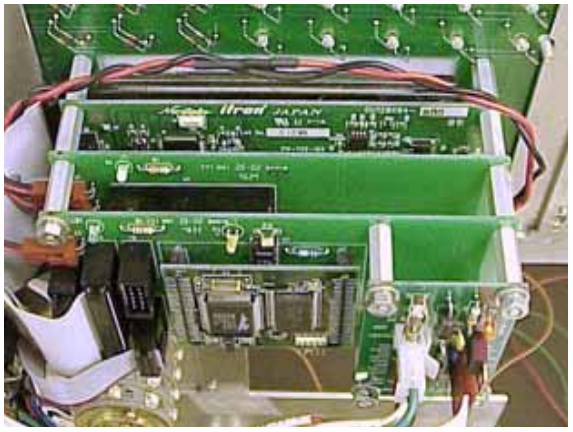


CP EMEDS

Technology Integration



FCU Diagnostics

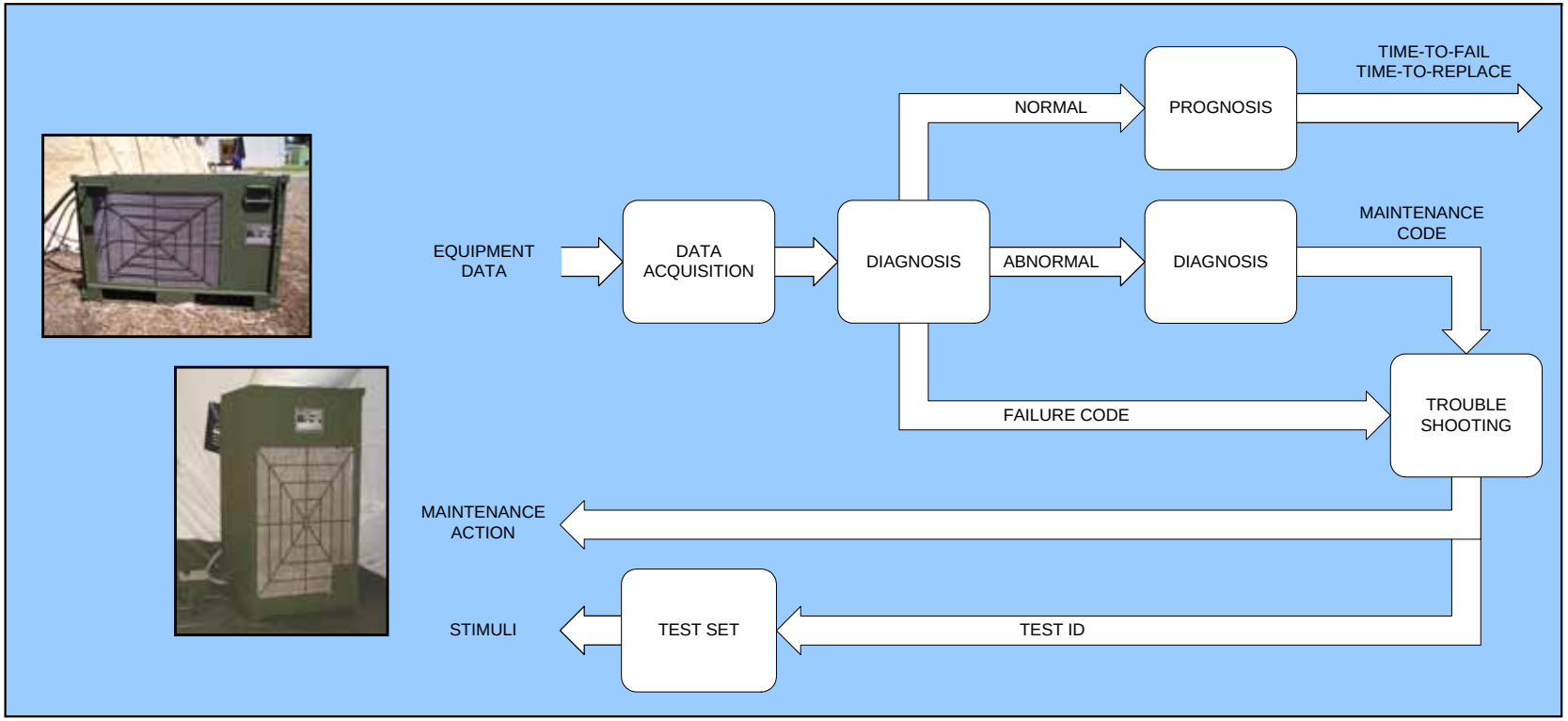


CBPS Processor

Telelogistics

NEXT GENERATION ECU

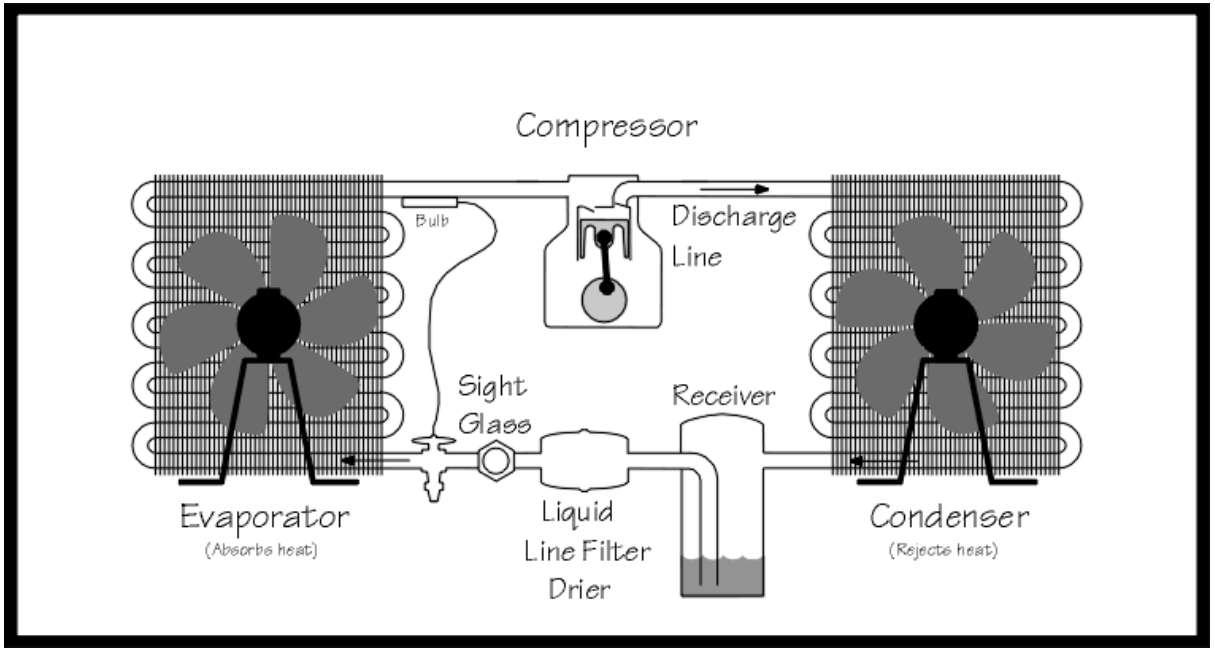
DP&M Approach



- Data acquisition
- Initial Diagnosis - Normal versus Abnormal operation.
  - Prognosis - Time-to-fail, time-to-replace.
  - Diagnosis - Faulty component or ranked ambiguity set.
    - Troubleshooting and Repair - IETM.

Resolution Level

- Condenser side
  - Compressor
  - Condenser coil
  - Condenser fan
- Evaporator side
  - Evaporator coil
  - Heater element
  - Circulation fan
  - Air filter
- Control box



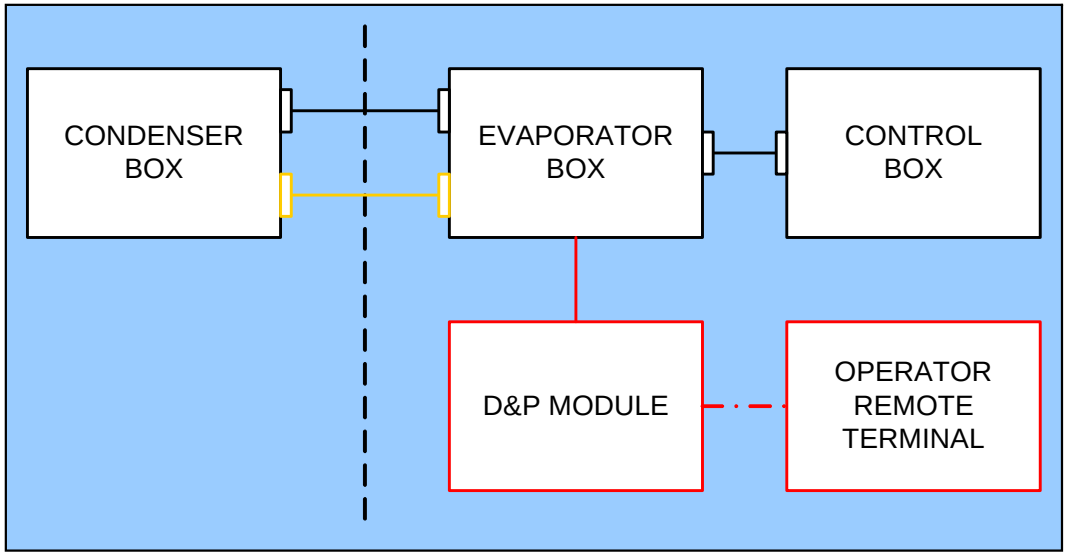
Conditions of Interest (Typical)

- Dirty condenser coil
- Dirty refrigerant filter
- Dirty air filter
- Compressor circuit failure
- Heater circuit failure
- Fan / Blower motor failure
- High compressor discharge temperature
- Low refrigerant level

Signals Available (Typical)

- Analog
  - Compressor
    - crankcase temperature
    - suction / discharge temperature
    - suction / discharge pressure
  - Condenser
    - coil temperature
    - inlet / outlet temperature
  - Evaporator
    - supply / return temperature
  - Air filter differential pressure
  - Air temperature - indoor / outdoor
  - Dryer outlet temperature
  - Liquid line temperature
- Discrete
  - Compressor
    - temperature HI
    - pressure LO / HI
    - unit ON / OFF
  - Blower / Fan
    - motor overload
    - unit ON / OFF
  - Heater bank
    - temperature HI
    - unit ON / OFF
  - Cover ON / OFF

DP&M Implementation



SPLIT PACK

- Non-intrusive in operation
- Uses domain expert knowledge
- Input : {$P_{eva,in}$, $P_{eva,out}$, $T_{eva,ref,in}$, $T_{eva,ref,out}$, $T_{eva,air,in}$, $T_{eva,air,out}$}
- Output :
  - Normal state - time-to-replace air filter
  - Abnormal state - condenser unit and evaporator unit “fault code”

Embedded Hardware

- Small form factor
  - 2.75” x 5.50”
- 16 DIN, 24 DOUT (8@1A), and 10 AIN
- Data interface
  - RS-232, RS-485 and Ethernet
- Removable memory card
- 28 VDC power input
- Connectors
  - Signal and power
- NEMA 4 enclosure (optional)

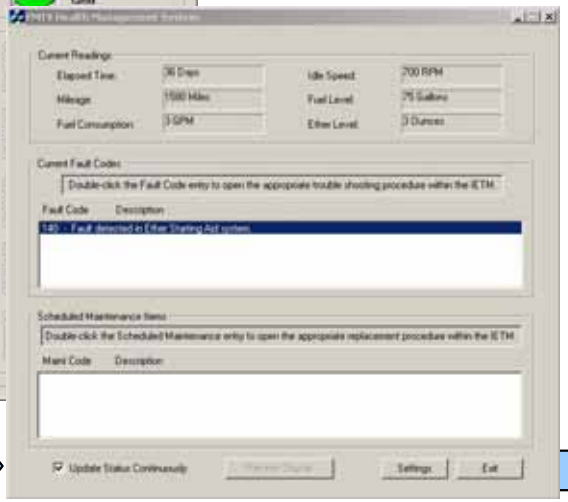
Operator Remote Terminal

- Toughbook notebook PC
  - Integrated wireless LAN
  - Moisture and dust resistant
  - Magnesium alloy case
  - Microsoft Windows XP

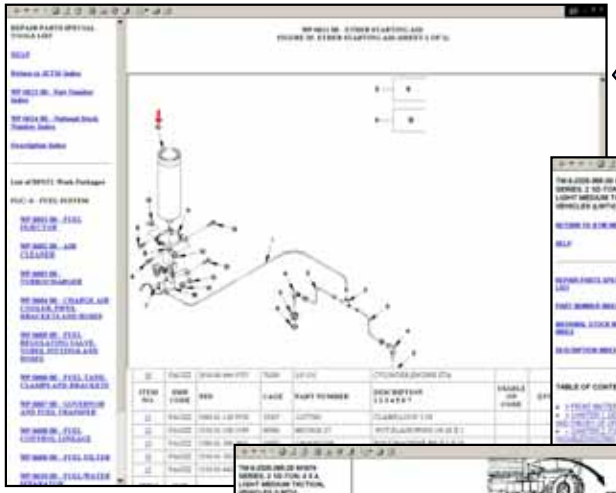
User Interface

Equipment Monitor and Control

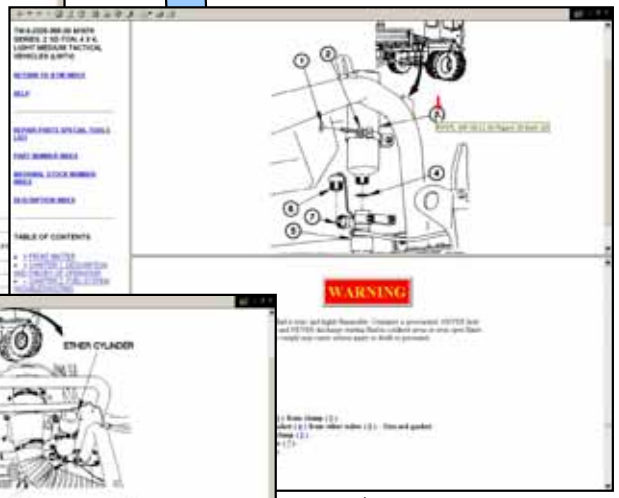
Monitor and Report



Details



Parts Requisition



Maintenance Action

Troubleshoot

Electronic Technical Manual

Concluding Remarks

- DP&M approach is applicable to any ECU
- Integrates past work in diagnostics, embedded processors and telelogistics
- Provides insight into the health of the ECU
- Provides insight into the health of the COLPRO shelter
- Reduces manpower needs
- Reduces time to detect a malfunction
- Reduces time to perform a maintenance action
- Eliminates the need for bulky manuals
- Provides a “heads-up” on up-coming required maintenance
- Reduces parts inventory

Closing Thought

- Even non-CBNR environments can be challenging

Sand storm in Iraq, 2005 (Courtesy of Dave Mikelson and Nick Boone)

END OF PRESENTATION