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Impact of System Integration on Reliability and Maintainability

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Reliability Impacts

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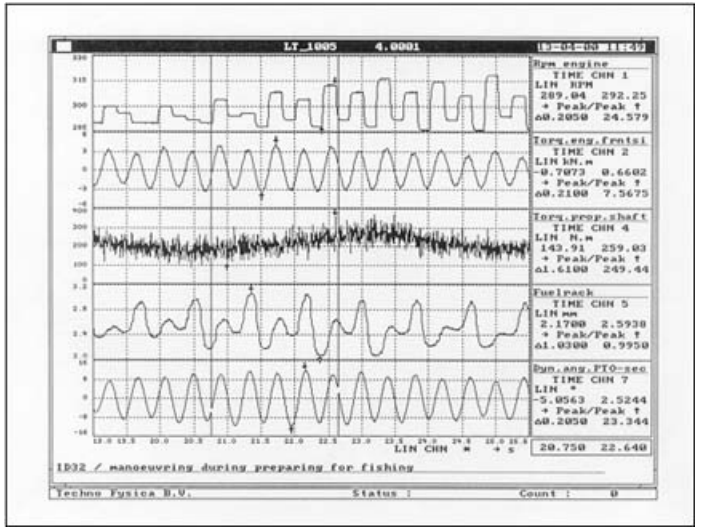
- Software on hardware
- Classic hardware complexity
- Subsystem optimization
- Full-range performance assumptions
- Operating environment
- New technology
- Maintenance environment
- Storage environment
- Cultural environment
- Other systems
- Changes
- Software complexity

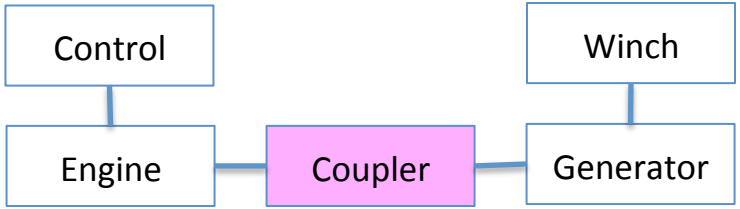
Software Impacting Hardware

- Computer equipment supply contract
- Reliability not met
- Lawsuit follows
  - Prime blames hardware sub
  - Hardware sub blames software
- Which hardware and which software?
  - Hard drives
  - Operating system
- Was hardware reliability a requirement for OS? (Unknown)

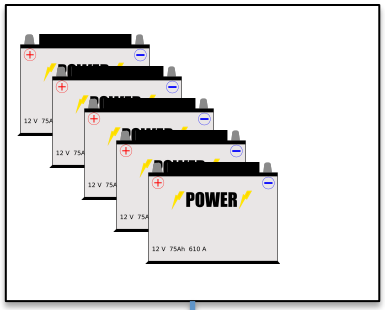
Classic Complexity

Fishing Vessel Problem
Normal operations good
Low load net operations not good

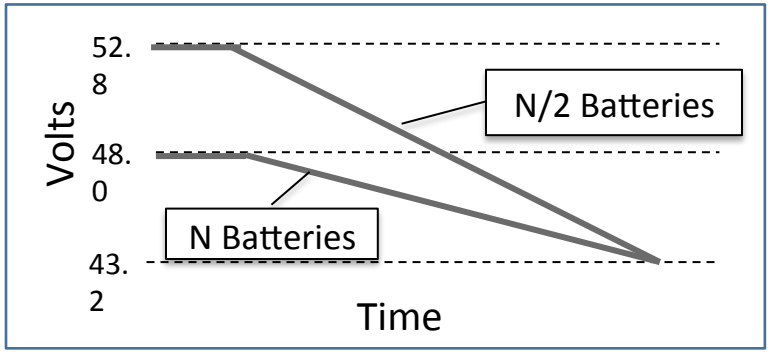




Subsystem Optimized



Communications Facility
Battery Back-up Optimized
Electronics Reliability Impacted



Decreasing number of batteries and meeting time requirement by changing normal operation voltage

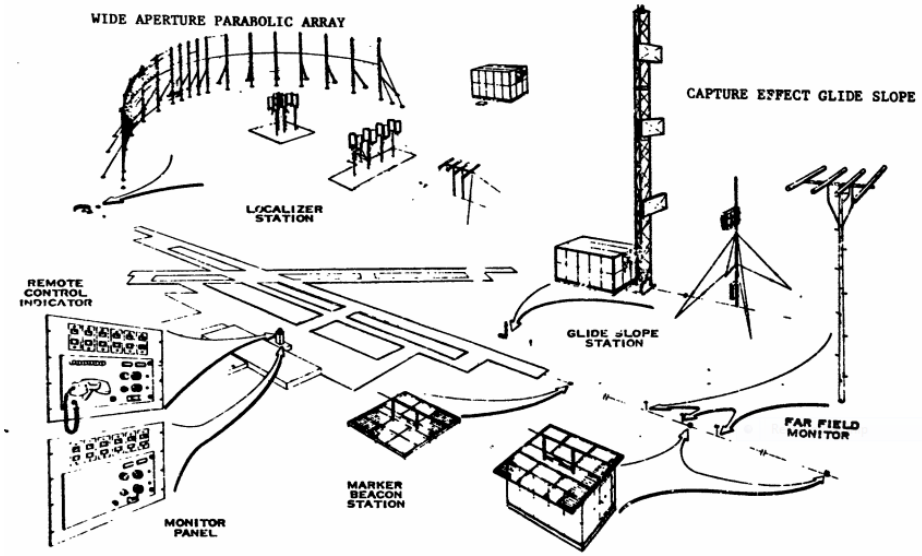
Full-Range Performance Assumed

Secondary to Battery Problem

- Nominal environment performance assumed for full-range environment
- Usually tested for temperature, vibration, etc.
  - May be missed by designer only using data sheet information for selection
- Other factors can impact reliability as well
  - In this case, power voltage

New Technology and Operational Environment

- First application of solid state devices in external airport environment
- More susceptible to lightning effects than prior tube-based designs



Maintenance Environment

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Other than temperature, etc.

- Electronic racks reliable at most sites
- Army sites wax floors often
- Wax dust builds up in air intake filters
- Reliability drops

Storage Environment

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- Shelters worked well in operations
- In long term storage moisture turned glue dots acidic
- Exterior aluminum panels fell off

Culture Environment

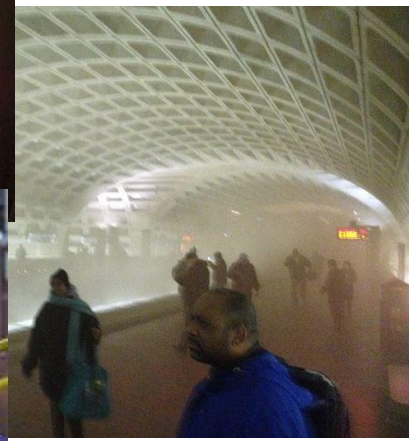
- In-flight information and entertainment system with availability clause
- Lack of technical training for crew
- Lower performance

Legacy Systems

- New business system designed for modern computers
- Some customers had older equipment
- Lots of failures and complaints

Changes

- New DC fire department radios not fully integrated with Metro
- Delays in response to fire and train stranded in tunnel

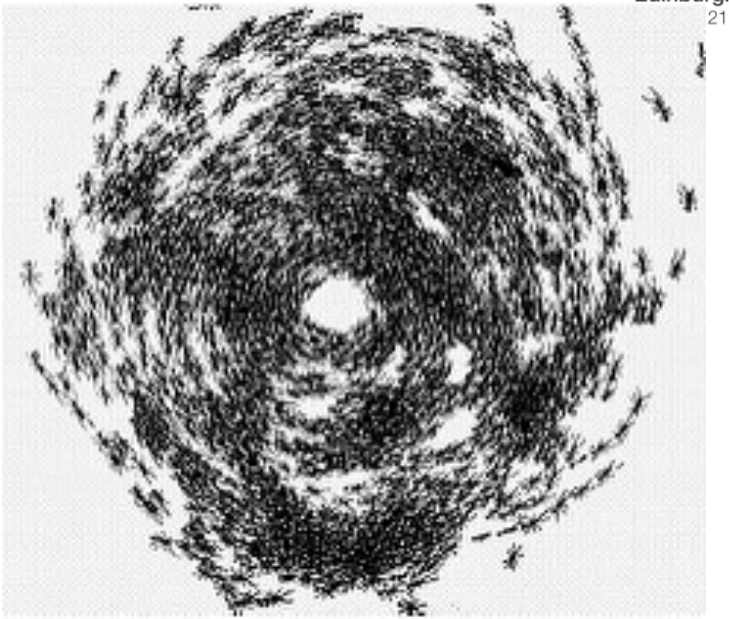


Software Changes

- Update to pilot map navigation app
- Duplicate map for Reagan National
- Problem for app
- 54 flights delayed

Software Complexity

- Facebook outage
- Complex interaction among multiple layers
- Caught in a massive do-loop



Integration and Maintenance

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Target rich environment

- Maintenance access
- Commercial examples
- User maintenance
- Maintenance policies

Maintenance Access

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Radar Scope

- Repair requires swinging circuit board up
- Works when scope is alone
- Hits console when installed
- Example of Conway's Law

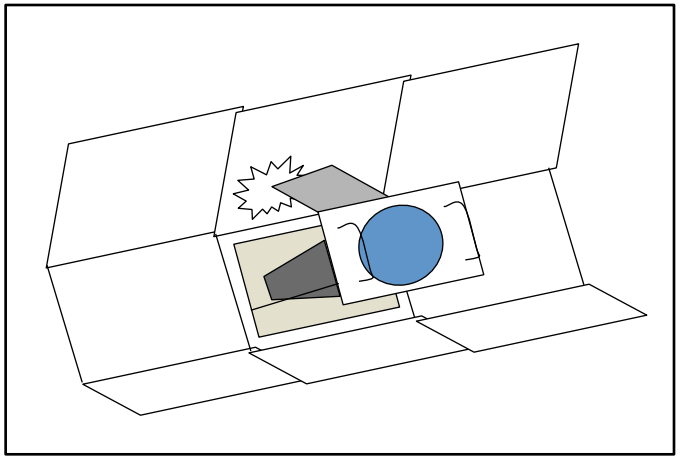


Figure 3. Interference impacting maintenance access

Commercial Examples

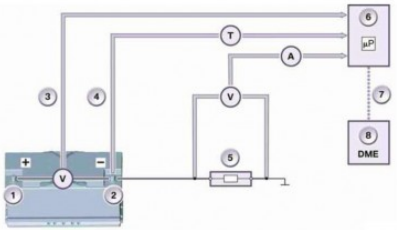
Cars provide multiple examples

- Drop engine to replace sparkplugs
- Disassemble fender to replace headlight
- Remove wheel to replace battery

Customer Maintenance

BMW Intelligent Battery System

- Monitors status and provides input to motor electronics
- New battery must be registered – can't just replace yourself
- May need to replace IBS due to motor electronics upgrade



Index	Explanation
1	B+
2	B-
3	Battery Voltage Measurement
4	Battery Temp Measurement
5	Current Measurement
6	Microprocessor
7	BSD
8	DME/ECM

Maintenance Policies

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Tactical Telephone Switch

- Original BIT Requirement
  - 1 LRU 85% of the time
  - ≤3 otherwise
- Cannot return unused LRUs to local supply
- Higher stockage and transportation
- Redesigned BIT for >95%

Why?

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- Focus of integration is on assembly in standards, textbooks, and handbooks.
  - Emphasis on parts fitting and interacting in operational functions
  - Some concern for enabling systems
  - Limited discussion of impact on non-functional factors

So…

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- Expand the scope of what integration addresses to cover full set of requirements
- Increase emphasis on early integration activities including analysis
- Include topics such as security
- Pay more attention to software that can propagate failures throughout system
- Add emphasis on integration with the external environments

Questions?