Reliability-Centered Maintenance: Designing for Sustainability

An Airline Business Perspective

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What Is Sustainability?

- With respect to airline operation:
  - The measure of the ability to meet the flight schedule with minimal interruption and aircraft down time throughout the life of the aircraft fleet

- Sustainability factors:
  - Flight schedule
  - Aircraft utilization
  - Hardware repairability
    - Components can be brought back to acceptable performance level after failure
  - Hardware life limits
    - Components have an acceptable in-service life before becoming Beyond Economical Repair (BER)

What Are the Operational Demands?

- By cabin size:
  - Average utilization for mid-size cabin (i.e.: B-737)
    - Flights per day = 5 per aircraft
    - Flight hours per day = 10 per aircraft
    - Utilization per year = 340 days
      - 3400 flight hours; 1700 flight cycles
  - Average utilization for large-size cabin (i.e.: B-767)
    - Flights per day = 2 per aircraft
    - Flight hours per day = 11
    - Utilization per year = 330 days
      - 3600 flight hours; 660 flight cycles
- Expected performance
  - > 97% on-time departure (within 15 minutes)
  - > 99% dispatch reliability

System Hardware Performance

- Typical rate of fault reports
  - Pilot reports per 1000 flight hours = 35
- Typical component on-wing time
  - Auxiliary Power Unit (APU) = 8,000 operational hours
  - Weather Radar Transceiver = 12,000 flight hours
  - Cabin Pressure Controller = 16,000 flight hours
  - Flight Management Computer = 18,000 flight hours
  - Slat Hydraulic Actuator = 22,000 flight hours
  - Main Landing Gear = 24,000 flight cycles
  - Wheel Anti-skid Transducer = 35,000 flight hours

What Role Does RCM Play?

- Gathering in-service data
  - Aircraft operational reliability
  - Aircraft maintenance history
  - Unscheduled component removals
  - Scheduled component removals
  - Maintenance check findings

- Analyzing the in-service data
  - Surveillance programs to identify operational reliability and maintenance drivers
  - Root cause analysis of hardware / process deficiencies

Product Improvements

- Require combined RCM data for each fleet
  - All airport departure performance
  - All line maintenance station activity
  - All heavy maintenance station activity
  - All component removal and installation activity

- Require a concerted effort
  - Aircraft operators
  - Aircraft maintenance, repair and overhaul (MRO) facilities
  - Component repair facilities
  - Airframe and component OEM support organizations

Facilitation of Product Improvement

- A Product Support Integrator is required
  - Product improvement cannot be done in a vacuum
    - The OEM doesn't really know what the operator is doing
    - The operator isn't sure what the MRO is doing
    - The MRO can't say what the component repair facility is doing
  - The aircraft operator's Reliability Engineering is typically in the best position to become a Product Support Integrator
    - They have access to aircraft operational and maintenance data
    - They have understanding of aircraft operational demands and maintenance processes
  - The Product Support Integrator fills the gaps between
    - Aircraft operator
    - Aircraft / component OEMs
    - MRO / component repair facilities

Product Support Integrator Structure

- Centralized organization of skilled analysts
  - Root cause analysis
    - Identify specific root cause
      - Failure mode specifics (What, When and How)
    - Not generalized system or component effect
      - “This component causes a lot of delays” just doesn’t cut it
  - Analysis depiction
    - Present data and analyses to spur resolution
  - Problem-solving and resolution facilitation
    - Ask the right questions
    - Provide the right data
    - Establish and lead cross-functional teams to include:
      - Aircraft operator
      - MRO facilities
      - Component / Airframe OEM
      - Component repair facilities

Product Support Integrator Specifics

- Requirements
  - Personnel qualifications
    - Airline maintenance operations
    - Line and shop maintenance
    - Reliability Engineering root cause analysis
  - Analysis tools
    - Customized software and analytic processes
- Hands-on approach
  - Collect hardware and perform failure analysis
    - Component and aircraft hardware
  - On-site visits of component repair facilities
    - Observe test and repair processes
  - On-site visits of line and heavy maintenance facilities
    - Observe repair processes and aircraft system installations

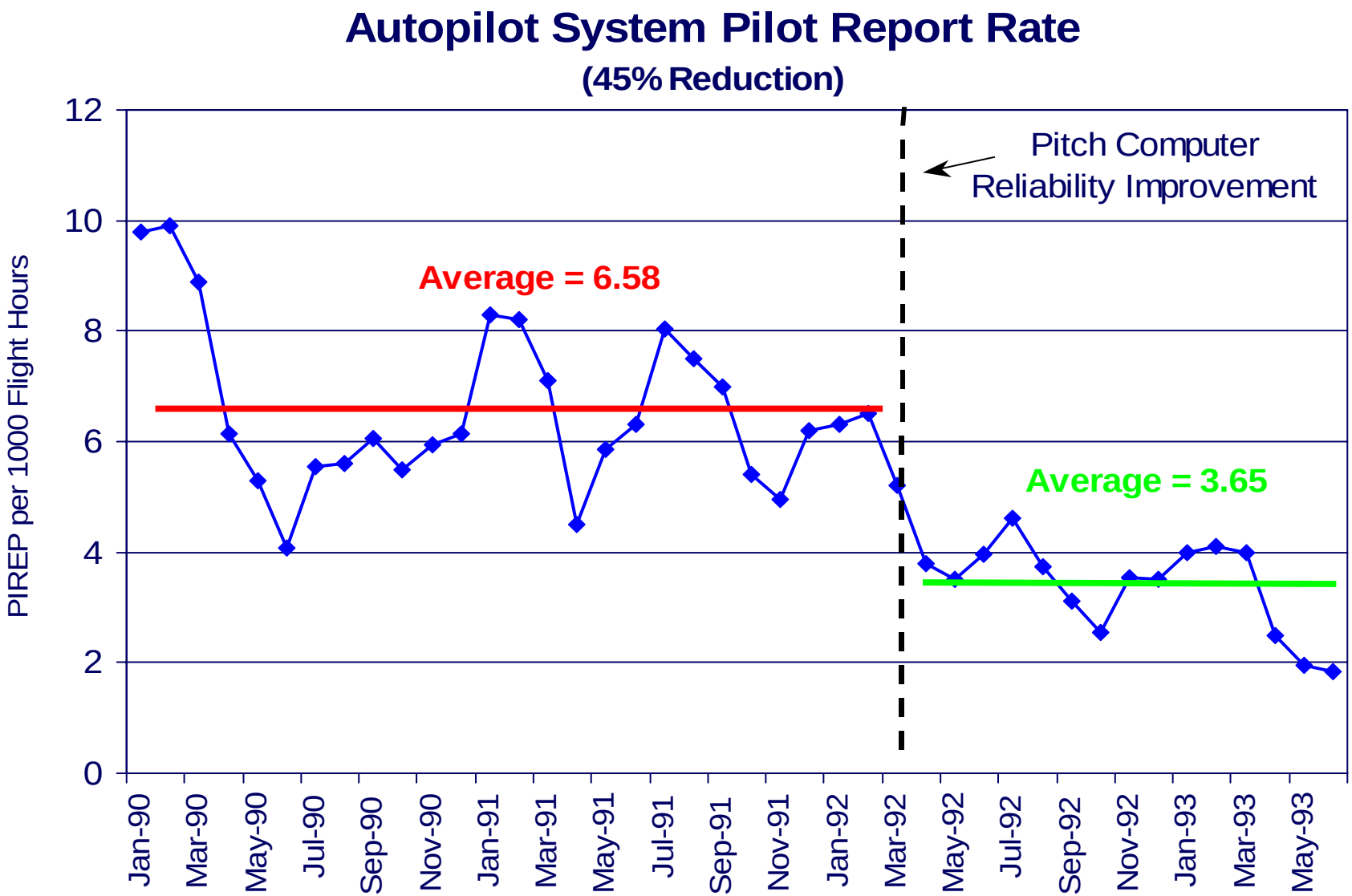
Product Support Integrator Process

- Present root cause analyses and recommendations to appropriate parties
- Facilitate collaboration
- Assist with resolution process
- Monitor results
- Provide feedback of success or failure
- Share “lessons learned”
- Participate in developing in-service specifications for new design

New Design Specifications

- The improved in-service performance becomes the new “norm”
- New performance expectations are applied to new design specifications
  - System and aircraft operational reliability
  - Component on-wing performance
  - Cost of ownership over the life of the aircraft
- Warranty is based on performance
  - Individual component Time Since Installed (TSI) by flight hours or cycles instead of aggregate Mean Time Between Unscheduled Removals (MTBUR) or Mean Time Between Failures (MTBF)

Typical Product Improvements



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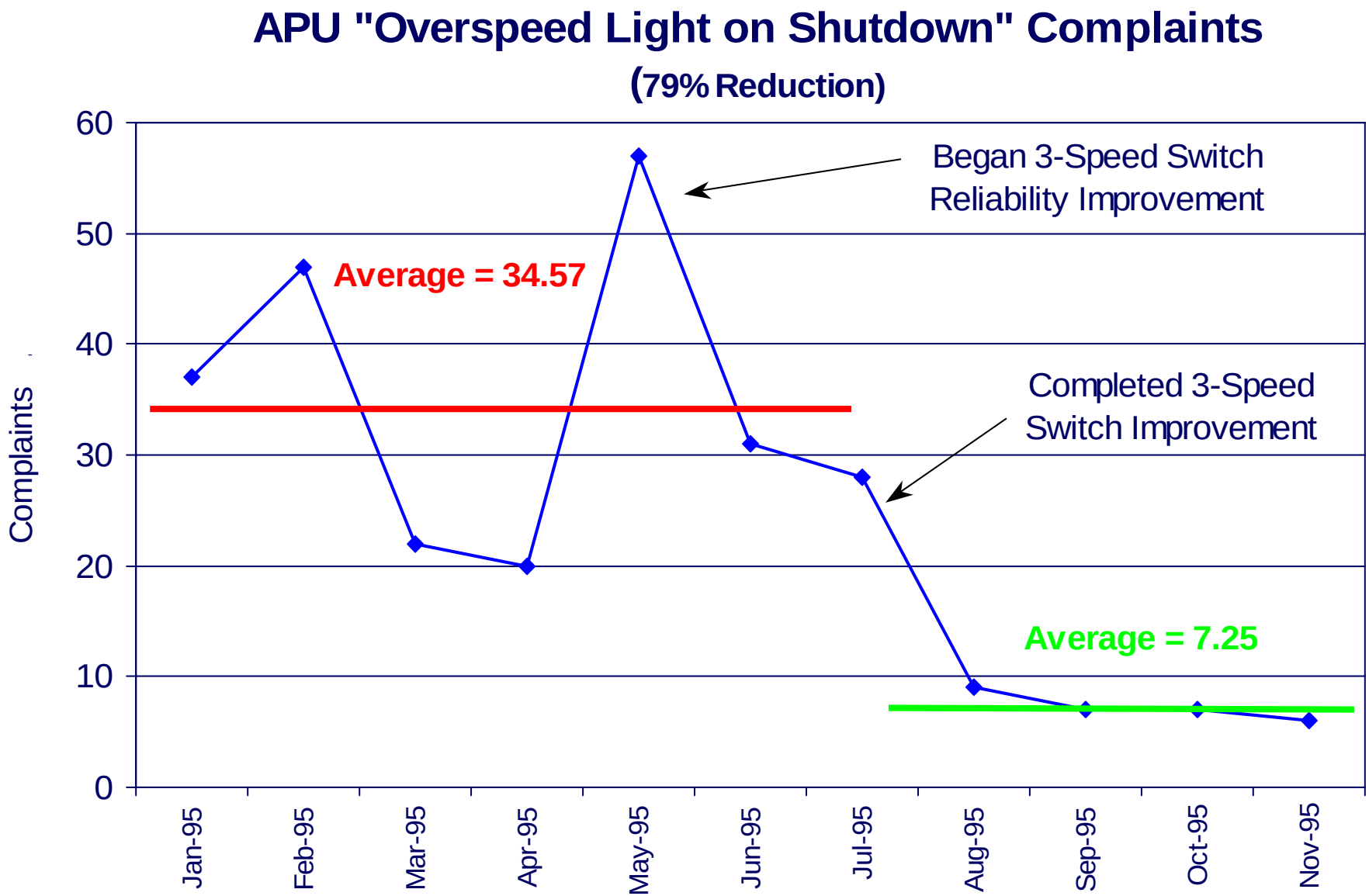
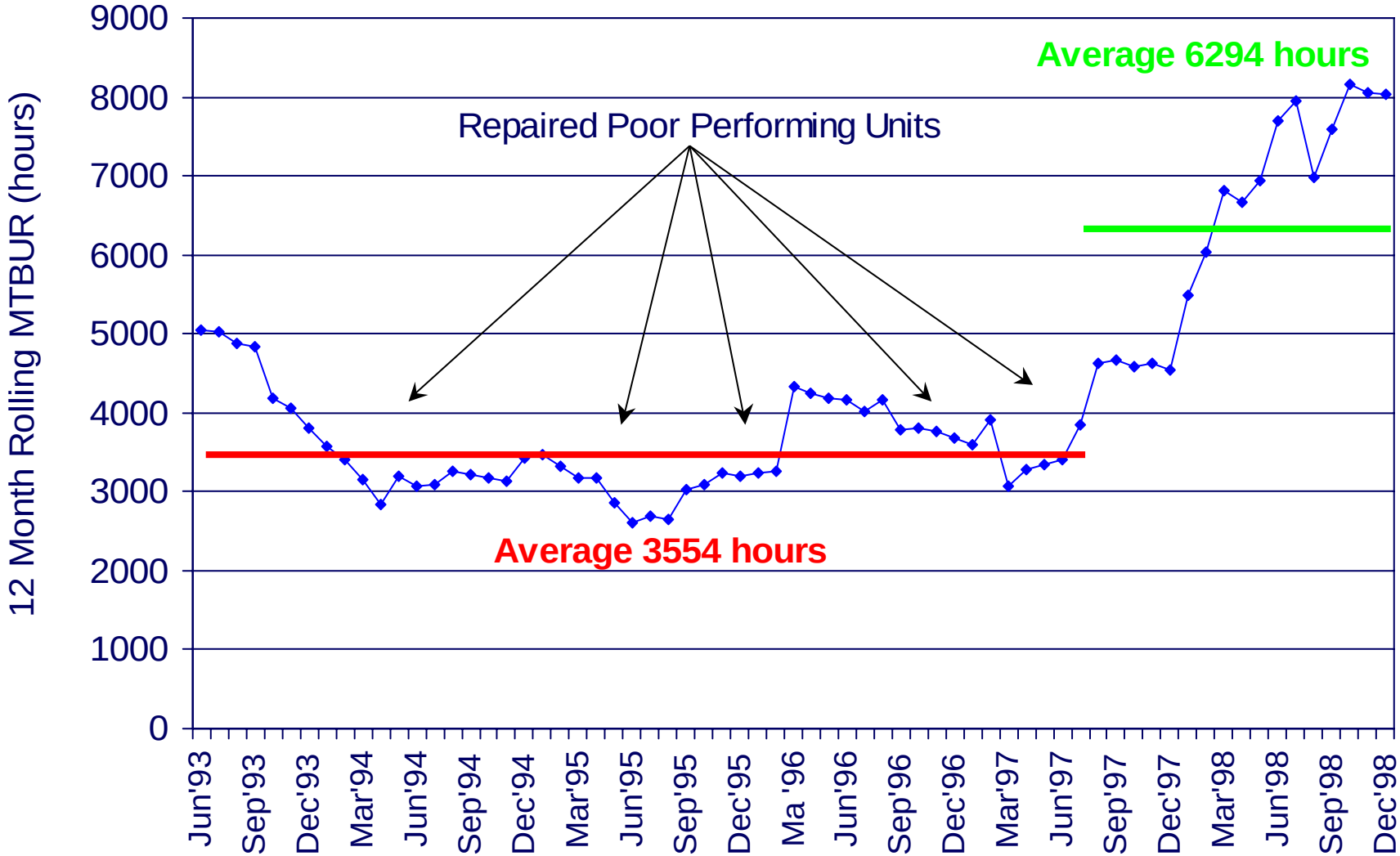
Typical Product Improvements



Typical Product Improvements

Flight Control Computer MTBUR

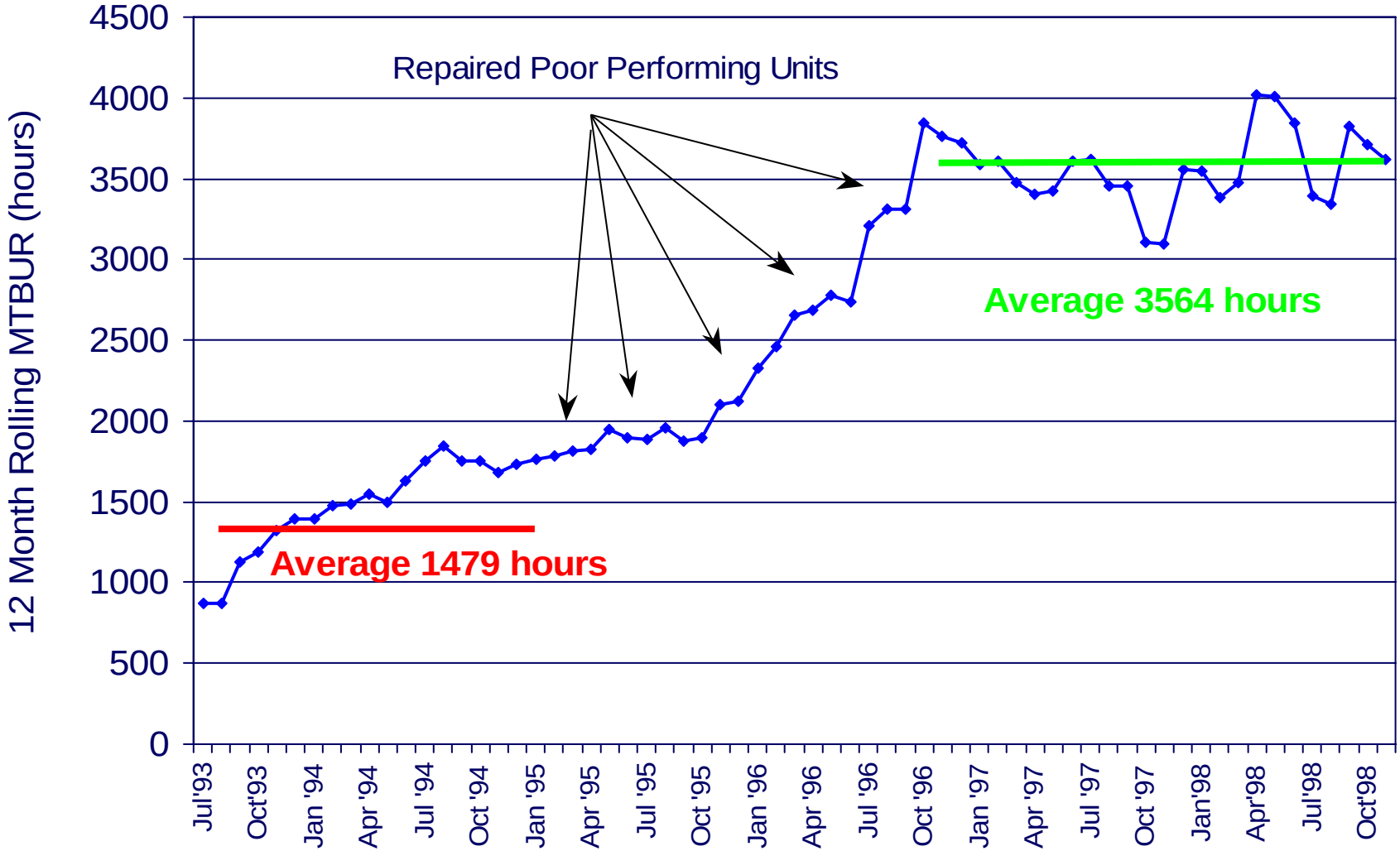
(77% Increase)



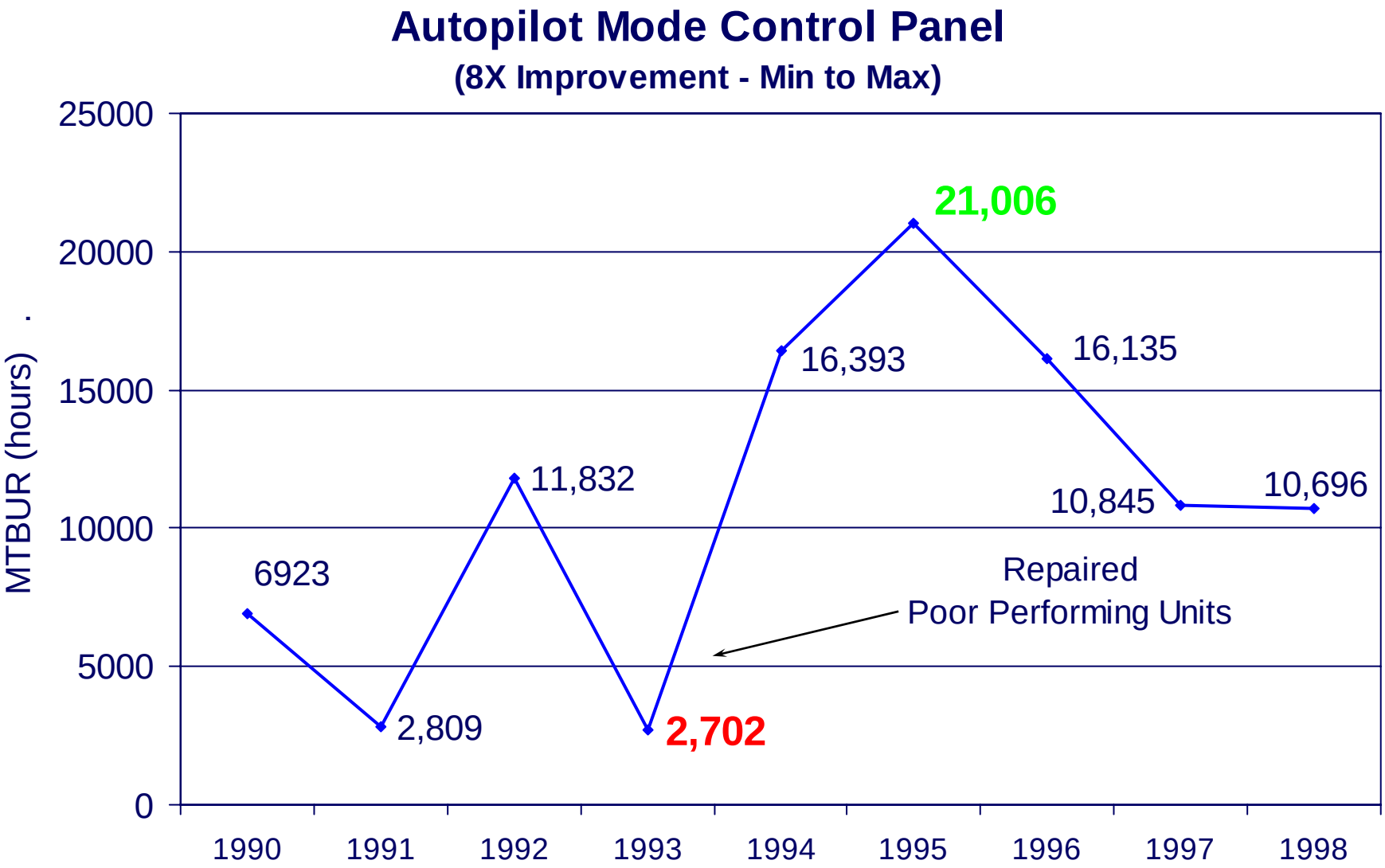
Typical Product Improvements

Flight Augmentation Computer

(141% Improvement)



Typical Product Improvements



Bottom Line: To Design for Sustainability

- Basic Requirements:
  - Fleet data must be collected and combined
    - Aircraft operational performance
    - Line and heavy maintenance activity
    - Component installation / removal data
  - Centralized Product Support Integrator
    - Utilizing RCM with effective analysis tools and processes
    - Facilitating resolution of in-service reliability issues
- New design specifications must be geared toward improved performance
  - System operation expectations
  - Individual component by serial number
  - Cost of ownership over the life of the aircraft
- An effective warranty program used as “enforcer”

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