The “Plus” of CBM+

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The CBM+ Initiative has Immediate Benefits

- Reduction of scheduled preventive maintenance content
- Escalation of preventive maintenance intervals
- Early warning of impending failures through data link
  - Enable scheduling of unscheduled maintenance
- Enhanced diagnostics for troubleshooting
- Optimized logistics support
  - Pre-staging replacement parts for impending failures
  - Less components replaced for preventive maintenance over the life of the equipment

These Benefits are Limited

- Operational Readiness is increased slightly because of less time spent in preventive maintenance
  - Compared to the impact of unscheduled maintenance, preventive maintenance is a small piece of the pie
- Few failures in the field are actually moved to the scheduled environment
  - Only systems / components with measurable degradation are good candidates for predictive failure monitoring
  - The equipment is still out of service for repair
- Enhanced diagnostics will make the maintainers experts in repairing systems
  - But the systems still break with the same regularity
- **Where is the “plus” of CBM+?**

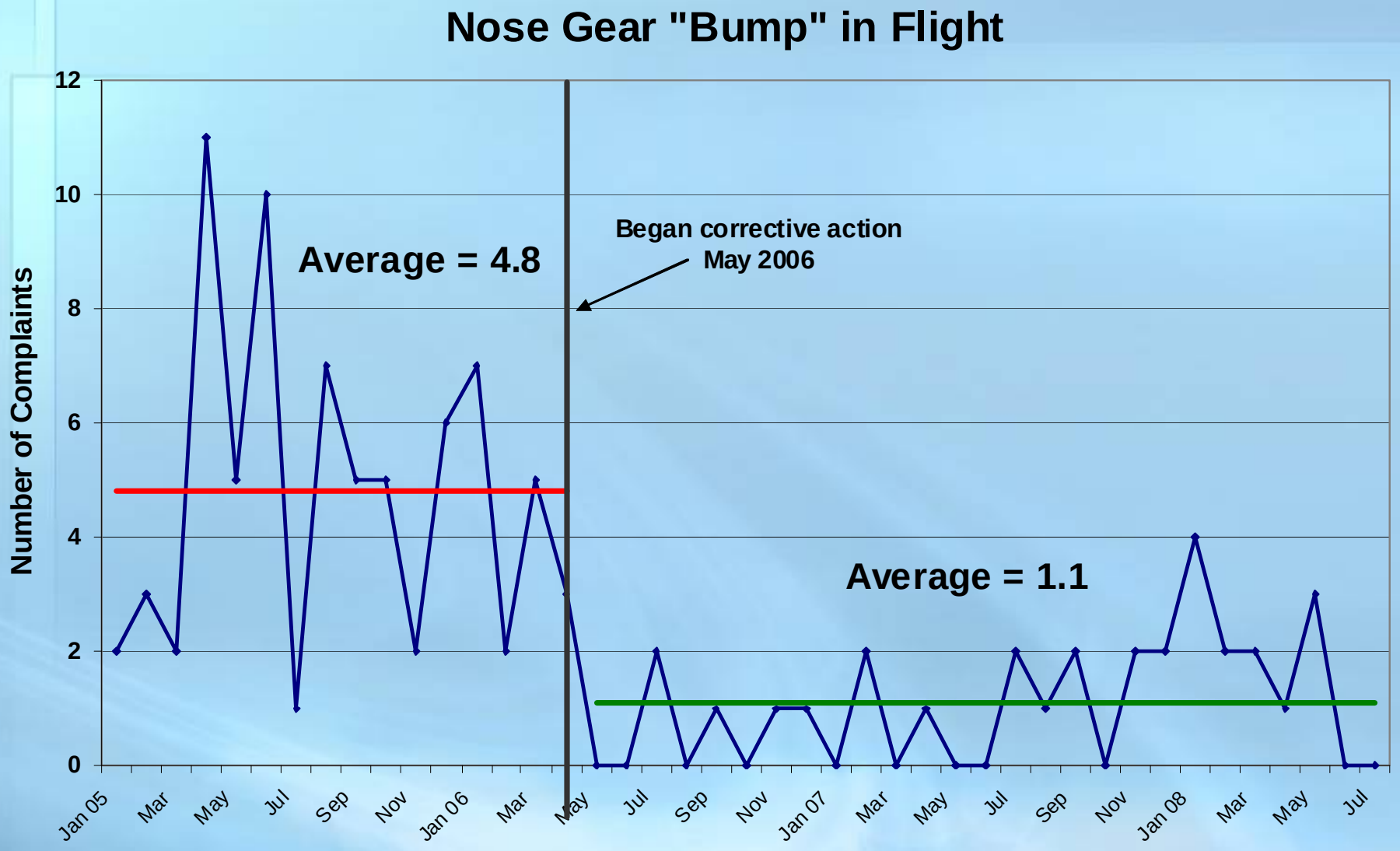
It's In the "+"

- One of the "+" initiatives of CBM+ is Serialized Item Management (SIM)
  - Repairable end items and sub-assemblies that are uniquely tracked, controlled or managed in maintenance, repair and / or supply by means of its serial number
    - This tracking needs to include the recording of data from scheduled and unscheduled maintenance events of the end item and shop repair actions of the removed components / sub-assemblies
    - The data must be collected in a centralized database and easily retrievable
- If these criteria are met, then quantum leaps in reliability and Operational Readiness can be achieved as the following examples illustrate

Problem 1: Nose Gear “Bump”

- Problem
  - During cruise flight, the nose gear would “bump” in the wheel well
  - This occurred sporadically across the fleet
- Impact
  - Flight diversions
  - Repeat complaints
  - Extensive maintenance down time
- Analysis
  - Detailed review of the aircraft maintenance data since delivery and nose gear strut shop history
    - Problem started about 1.5 to 2 years after strut was modified with a new end cap
    - End cap was noted to have backed off, which affected the uplock system and caused the nose gear to automatically re-retract
- Corrective Action
  - OEM changed thread sealant spec for the nose gear strut end cap

Result 1: 77% Reduction of Complaints



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Problem 2: Slats Binding

- Problem
  - During aircraft takeoff, the slats would bind during retraction
  - This occurred when the aircraft was fully loaded and high angle of ascent
  - The airframe OEM stated that this was a global fleet issue
- Impact
  - Flight diversions
  - Repeat complaints
  - Extensive maintenance down time
- Analysis
  - Detailed review of the aircraft maintenance data since delivery
    - In a fleet of 24 aircraft, only 3 had exhibited the problem (not the oldest aircraft)
    - The problems start after 1200 flight hours and got progressively more frequent
- Corrective Action
  - OEM Engineering assessment of the 3 aircraft, reworking their slat mechanical systems

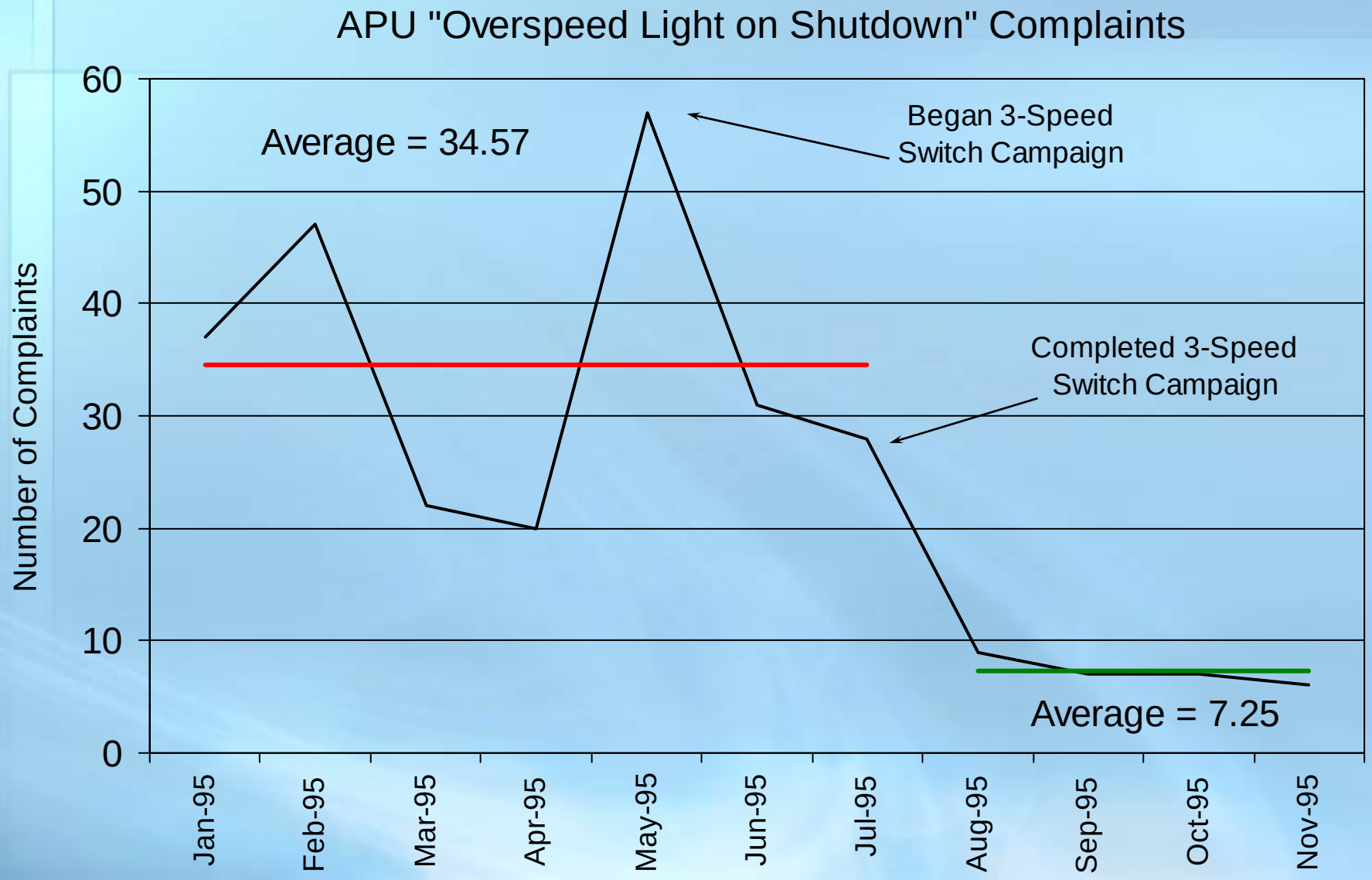
Result 2: Slats Binding Improvement

- Aircraft 1
  - Number of complaints prior to rework (3175 flight hours) = 10
  - Number of complaints after rework = (1612 flight hours) = 1
- Aircraft 2
  - Number of complaints prior to rework (3418 flight hours) = 10
  - Number of complaints after rework = (1178 flight hours) = 1
- Aircraft 3
  - Number of complaints prior to rework (1360 flight hours) = 5
  - Number of complaints after rework (1762 flight hours) = 0
- OEM applied “lessons learned” to global fleet

Problem 3: APU “Overspeed” Light

- Problem
  - High number of Auxiliary Power Unit (APU) “overspeed” light illuminates on shutdown complaints, indicating fault with APU system
  - Numerous variations of a controller (3-speed switch) have been ineffective in improving system reliability
- Impact
  - High number of flight delays and restricted operations
  - Repeat complaints
  - Extensive maintenance down time
- Analysis
  - Detailed review of the aircraft maintenance data since delivery
    - Revealed chronic aircraft caused by installing specific serial number 3-speed switches (Rogue Units) that exhibited repeated infant mortality
    - Though they have failed, Rogue Units always bench check good
- Corrective Action
  - OEM Engineering assessed the Rogue Units, modified the bench test procedure to identify and resolve the aberrant failure modes

Result : 77% Decrease in Complaints



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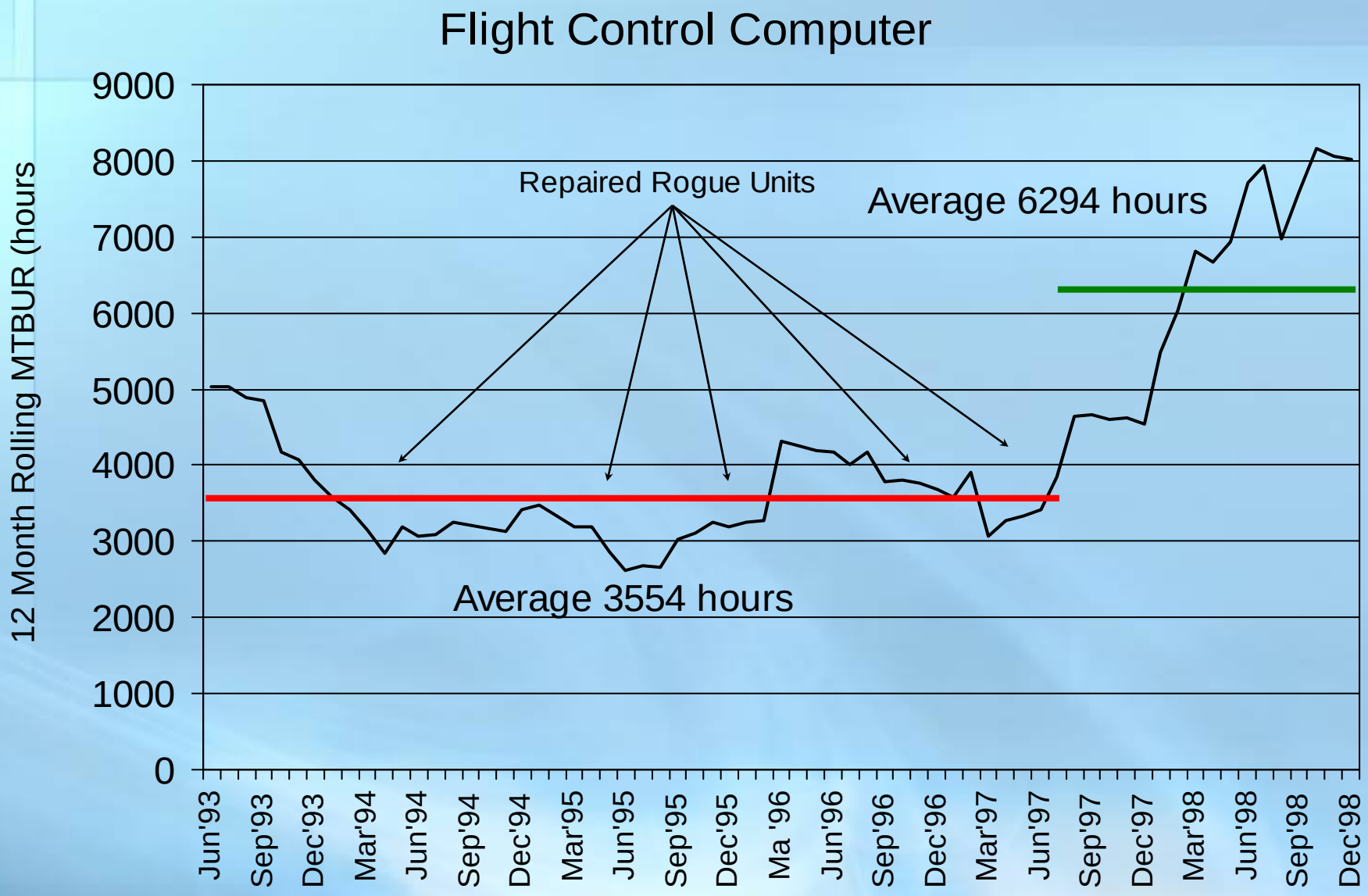
Problem 4: Autopilot Flight Control Computer

- Problem
  - Poor autopilot system reliability
- Impact
  - High number of repeat complaints
  - High replacement activity of autopilot flight control computer (FCC)
  - Extensive maintenance down time
  - Poor logistics support
- Analysis
  - Detailed review of the aircraft maintenance data since delivery
    - Revealed chronic aircraft caused by installing specific serial number FCCs (Rogue Units) that exhibited repeated infant mortality
    - Though they have failed, Rogue Units always bench check good
- Corrective Action
  - OEM Engineering assessed the Rogue Units, modified the bench test procedure to identify and resolve the aberrant failure modes

Result 4: 77% Increase in MTBUR



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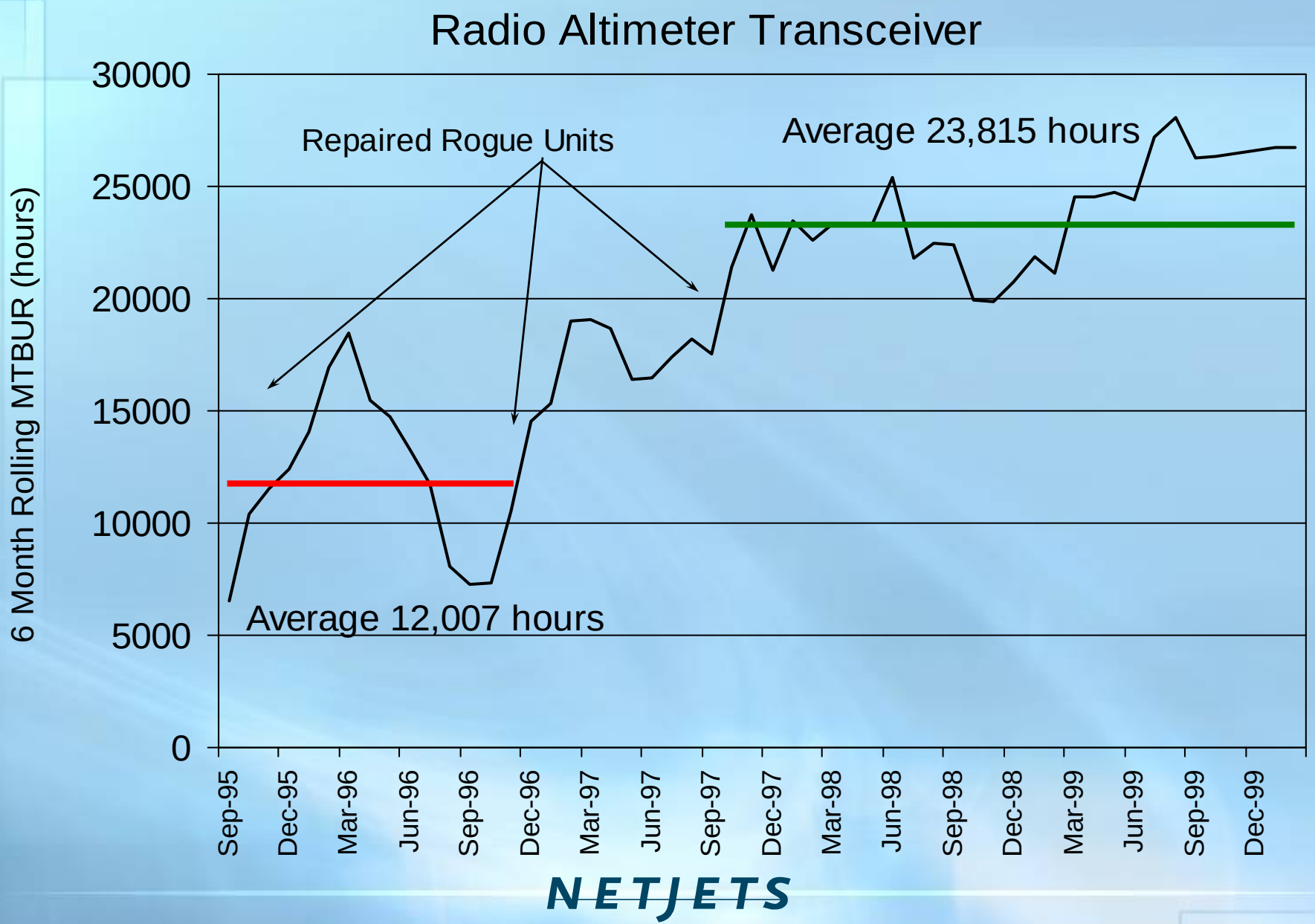
Problem 5: Radio Altimeter Transceiver

- Problem
  - Poor radio altimeter system reliability
- Impact
  - Repeat complaints
  - High replacement activity of transceiver
  - Extensive maintenance down time
  - Poor logistics support
- Analysis
  - Detailed review of the aircraft maintenance data since delivery
    - Revealed chronic aircraft caused by installing specific serial number transceivers (Rogue Units) that exhibited repeated infant mortality
    - Though they have failed, Rogue Units always bench check good
- Corrective Action
  - OEM Engineering assessed the Rogue Units, modified the bench test procedure to identify and resolve the aberrant failure modes

Result 5: 98% Increase in MTBUR



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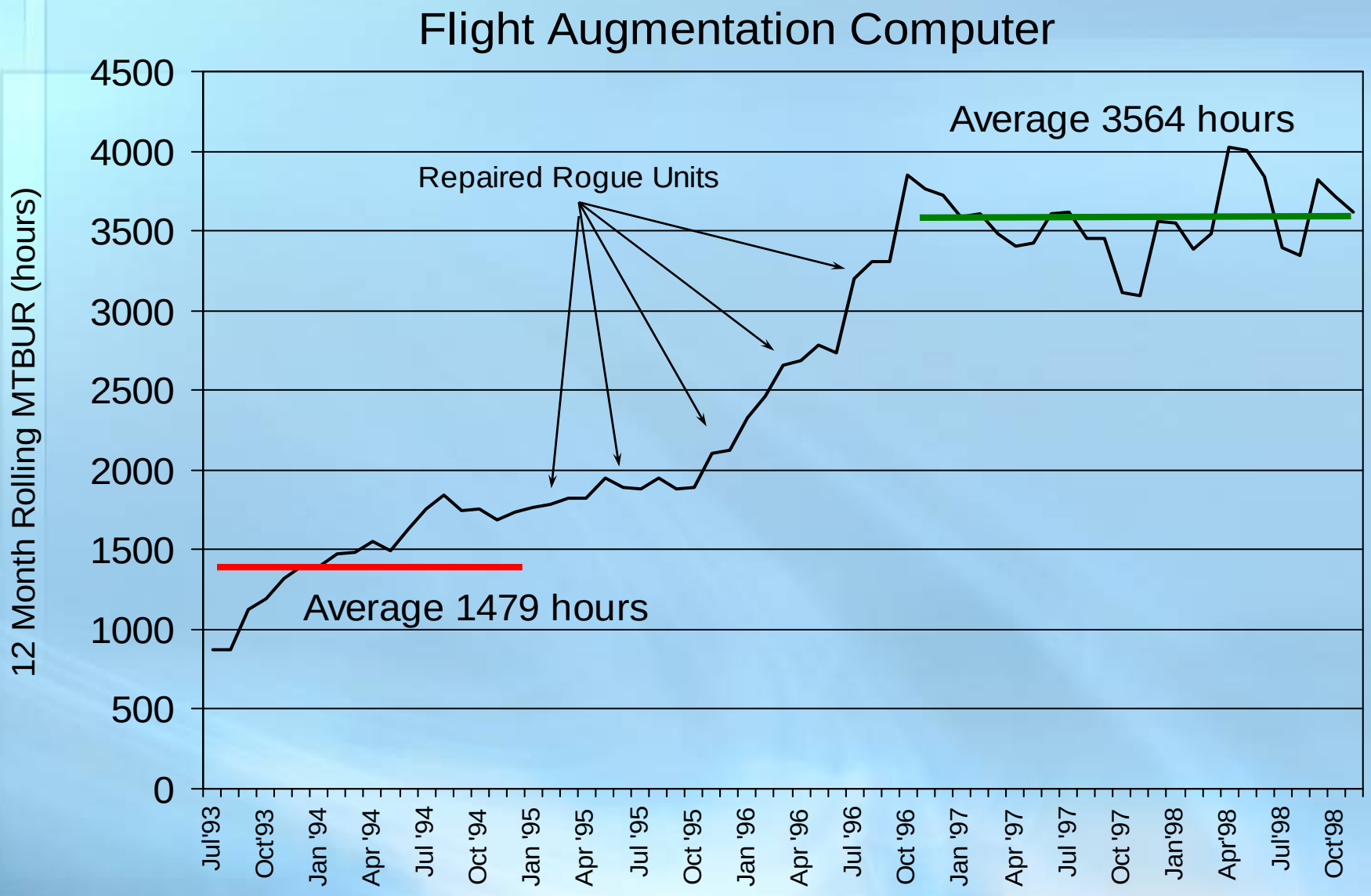
Problem 6: Flight Augmentation Computer

- Problem
  - Poor autopilot flight augmentation system reliability
- Impact
  - High number of repeat complaints
  - High replacement activity of flight augmentation computer (FAC)
  - Extensive maintenance down time
  - Poor logistics support
- Analysis
  - Detailed review of the aircraft maintenance data since delivery
    - Revealed chronic aircraft caused by installing specific serial number FACs (Rogue Units) that exhibited repeated infant mortality
    - Though they have failed, Rogue Units always bench check good
- Corrective Action
  - OEM Engineering assessed the Rogue Units, modified the bench test procedure to identify and resolve the aberrant failure modes

Result 6: Results = 141% Increase in MTBUR



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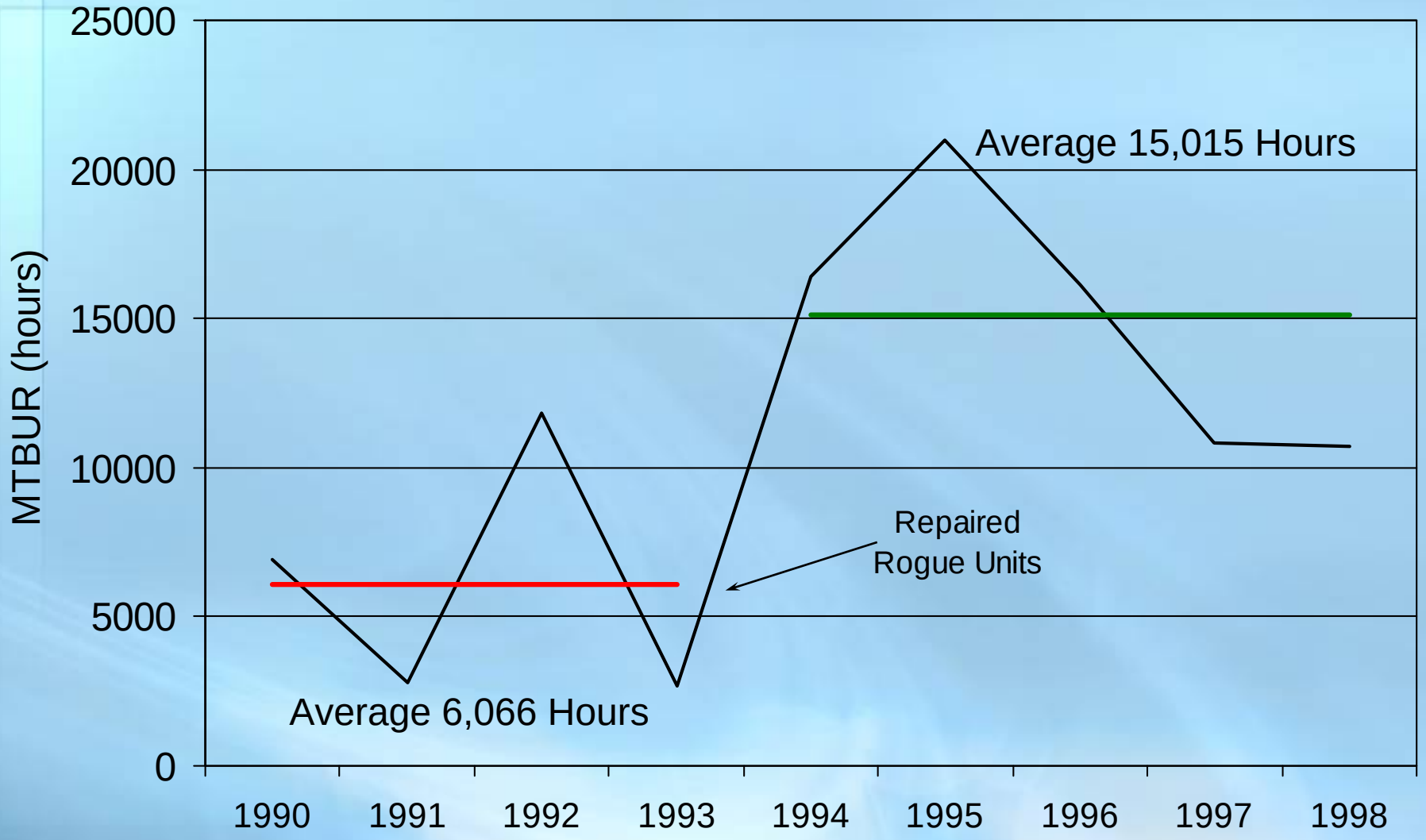
Problem 7: Autopilot Mode Control Panel

- Problem
  - Poor autopilot system reliability
- Impact
  - Repeat complaints
  - High replacement activity of autopilot mode control panel (MCP)
  - Extensive maintenance down time
  - Poor logistics support
- Analysis
  - Detailed review of the aircraft maintenance data since delivery
    - Revealed chronic aircraft caused by installing specific serial number MCPs (Rogue Units) that exhibited repeated infant mortality
    - Though they have failed, Rogue Units always bench check good
- Corrective Action
  - OEM Engineering assessed the Rogue Units, modified the bench test procedure to identify and resolve the aberrant failure modes

Result 7: 148% Improvement in MTBUR

Autopilot Mode Control Panel



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Analysis Technique Examples

- Perform surveillance of individual end items for repetitive system complaints
  - Determine final repair actions – “lessons learned”
- Assess end item group maintenance data
  - Common system / hardware problems
  - Maintenance program shortcomings
  - Age-related issues
- Review individual component performance
  - Rogue Units
  - Life limits
  - Batch problems
  - OEM part number differences
  - Shop repair problems
  - Depth of repair when sent to shop (overhaul vs. repair)

SIM Data Requirements

- Assign end item a specific tracking number
- Mainframe data collection program
  - Group common end item maintenance events
  - Create unique end item system identifiers
    - I.E.: Electrical power generation = 24
- Collect end item maintenance history
  - Enter all maintenance complaints and corrective actions in appropriate end item system data sets
    - End item serial number
    - Date of complaint, corrective action
    - Narrative of complaint, corrective action
  - Enter component replacements
    - Part Number
    - Serial Number (if applicable)
    - Installation position in end item (left, right, 1, 2, etc.)
    - Reason for removal (scheduled, unscheduled, “other”)

Benefits of Focusing on the “+”

- Quick quantum leaps in end item system reliability and Operational Readiness
- Identification and resolution of failure root causes, not just mitigation of failures
- Reduction of unscheduled maintenance
- Improvement of scheduled preventive maintenance, predicated on real-life field data
- Improved logistics effectiveness and reduction of spare inventory

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