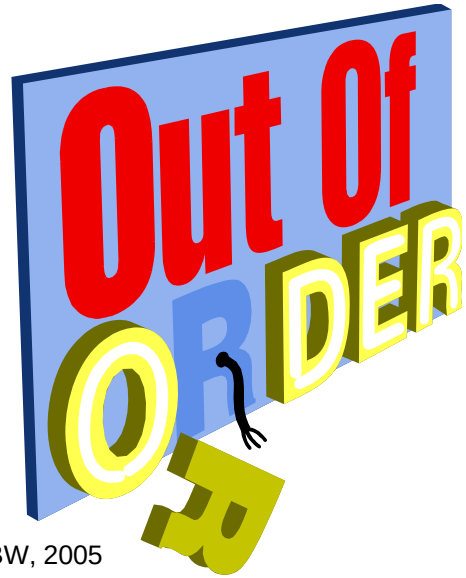
NCBA 27th Annual Symposium
Pinehurst, NC
December 5 - 7, 2005

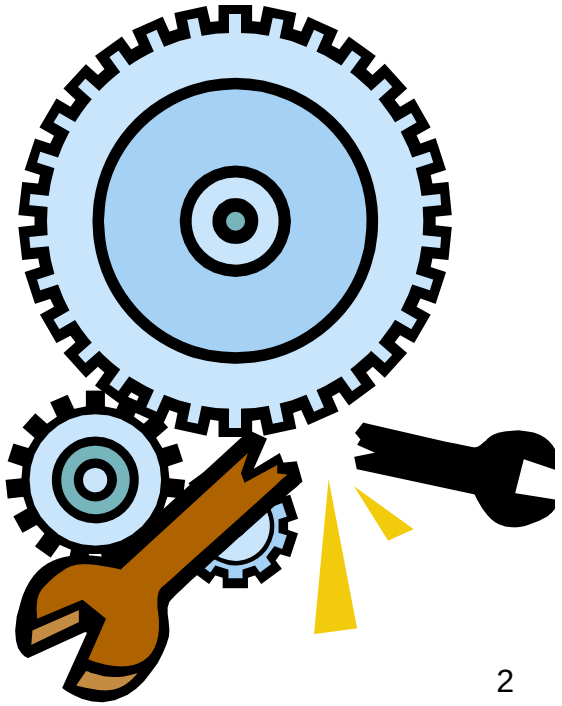
Failure Rate as a Potential Equipment Management Outcome Metric



Richard W. Eliason
Binseng Wang
Steve Vanderzee*
ARAMARK Healthcare Management Services/
Clinical Technology Services
***Now with UHS**

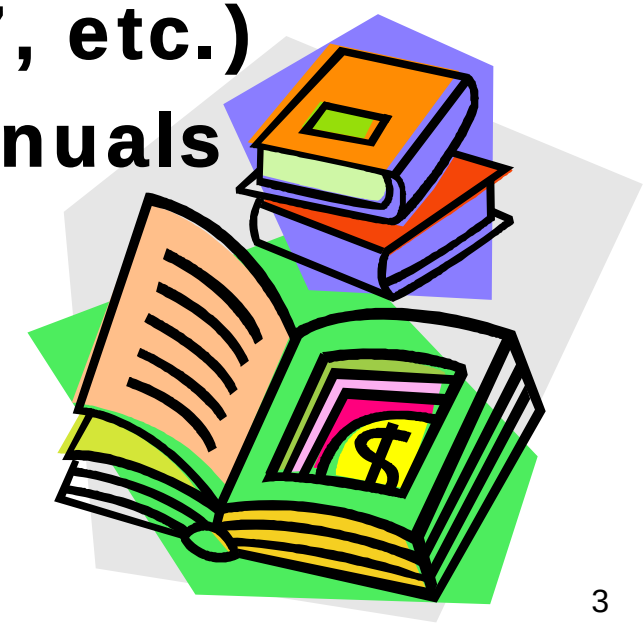
Table of Contents

- Introduction
- Failure Rate
  - Definition & candidate for performance metrics
  - Data analysis
    - Old data
    - ServiceMaster
    - Premier CTS
    - Solucient Action O-I
- Discussion
- Conclusion



Review of Performance Metrics

- **Main references:**
  - **T. Cohen (BIT, 1995, 97, 98)**
  - **D. Autio & R. Morris (*Biomed Eng. Handbook*, 1995; *Clinical Engineering*, 2003)**
  - **A. Mahachek (JCE, 1987, etc.)**
  - **Solucient Action O-I Manuals**



Other Performance Metrics

- Customer satisfaction survey
- Mean response time
- Mean time to repair - MTTR (turn-around time)
- Mean-time-between failures - MTBF
- Mean time between repairs – MTBR
- Hourly labor cost
- Service cost per device, beds, FTE, sq feet, etc.
- Productivity
- Down (or up) time
- Corrective versus preventive work o
- Repeated repairs
- % failed PMs
- etc., etc., etc.

Criteria for Good Metric (Indicator)

Adapted from Cohen et al., 1995

- **Well defined (accurate & consistent)**
- **Objective**
- **Measurable**
- **Based on current knowledge & experience**
- **Valid, i.e., direct relationship to structure, process, or outcome**

Conclusion of Literature Review

- "Most valid" metric (Cohen et al., 1995):
  - Total maintenance costs / acquisition costs (%)
- Other widely adopted global* metrics:
  - Customer satisfaction survey
  - PM completion rate

However, none of them reflect outcome

*Applicable to entire hospital, CE Dept. or inventory.

Outcome metrics

- Consistent with healthcare and clinical research: outcome or evidence-based, i.e., good process does not guarantee outcome
- Outcome metrics
  - Uptime
  - Failure rate

Uptime

- **Definition: Uptime = 1- downtime (both measured as % of total planned operational time) -> thus measure AVAILABILITY for users**
- **Downtime is correlated to MTBR = MTBF – MTTR**
- **However, uptime has some limitations**
  - **Only justifiable for a small fraction of the inventory, typically stationary, heavily-used and one-of-a-kind equipment (CT, MRI, etc.) -> labor intensive**
  - **Meaningless for those with back-ups or alternatives**
  - **Is affected by factors outside of CE control: abuse, age, parts availability, vendor response, etc.)**
  - **Difficult to roll up to the entire inventory (%uptime has very different meaning for MRI versus Nuclear Medicine)**

Table of Contents

- Introduction
- Failure Rate
  - Definition & candidate for performance metrics
  - Data analysis
    - Old data
    - ServiceMaster
    - Premier CTS
    - Solucient Action O-I
- Discussion
- Conclusion

Failure Rate

- **Definition: # failures / # devices, as measured by *repair* work orders and *inventory* items**
- **Otherwise, it fits the other criteria:**
  - **Well defined (accurate & consistent)**
  - **Objective**
  - **Measurable**
  - **Based on current knowledge & experience**
  - **Valid, i.e., direct relationship to structure, process, or outcome**

"Validity" of failure rate

- **Probable Root Causes of Failure Rate**
  - **Normal wear and tear outside of CE control -> baseline**
  - **Poorly designed or made -> OEM**
  - **Not properly maintained -> PM & repairs**
  - **Too old -> replacement planning**
  - **Being abused -> user training**
  - **Environmental problems (voltage, temp, etc.) -> facility management issues**
- **As most of these causes can and should be addressed by the CE Dept, Failure Rate is a direct measure of the outcome of our efforts (i.e., valid per Cohen et al.).**

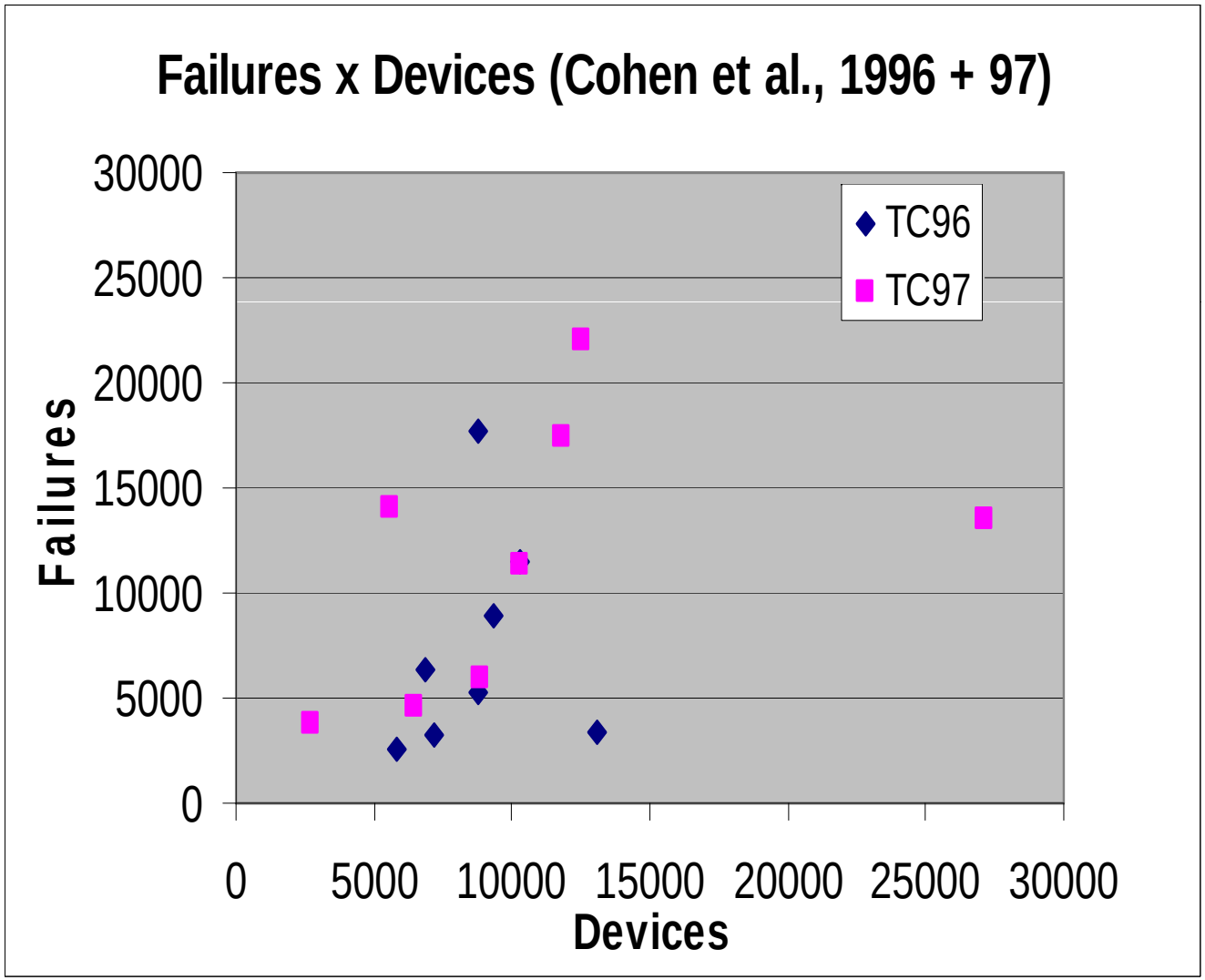
Is failure rate a really good metric?

- "In god we trust, all others bring data" (W.E. Deming)
- Four sets of data
  - Cohen et al.
  - ServiceMaster
  - Premier CTS
  - Solucient Action O-I

Old data (Cohen et al., 1996 + 97)

- #Hospitals = 8 each year, with 3 in both surveys, totaling 13
- Date range: 1996 - 1997
- Imaging equipment included: 4 in 1996 and 7 in 1997
- Findings: low correlation coefficient (.39) => questionable validity as a good metric
- Cause: apparently because "everyone counts devices and requests differently" (lack of consistency)

Cohen et al.'s data

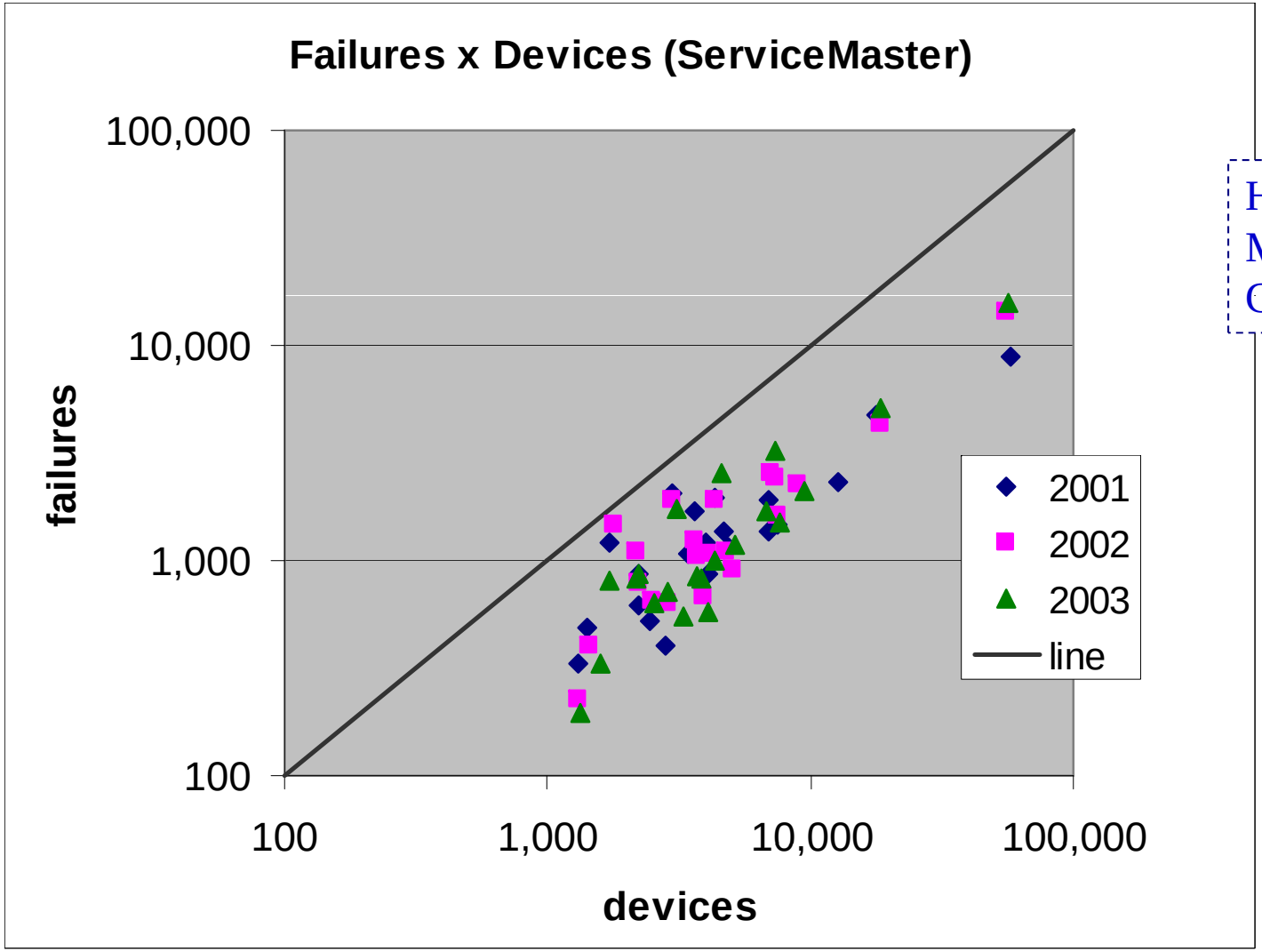


Hospitals = 13
(3 w/2y data)
Mean = 1.06
Correl coef. = .39

New Data #1: ServiceMaster

- #Hospitals = 24
- Date range: 2001 - 2003
- Filtering criteria: all inventoried equipment, included system components and accessories

ARAMARK (former ServiceMaster)

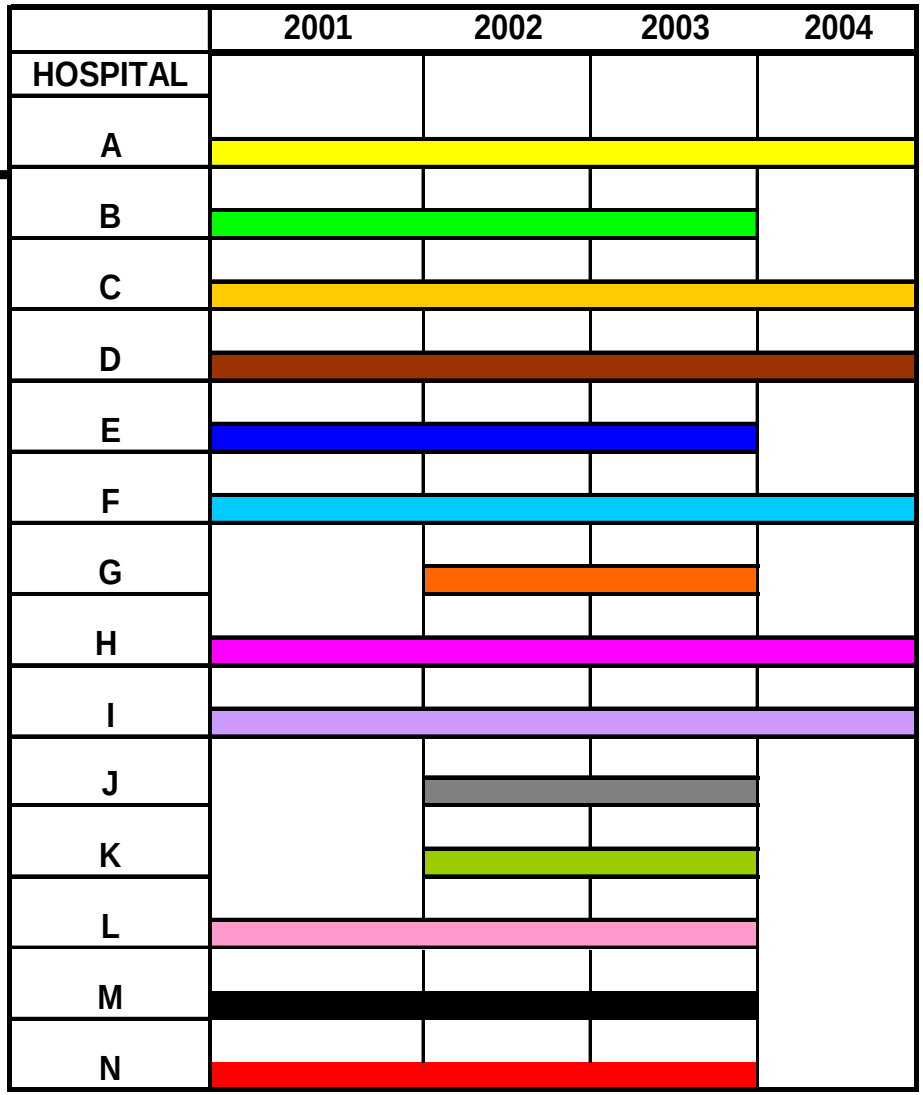


Hospitals = 24
Mean = 0.28
Correl coef. = .95

Notice log x log scales!

New Data #2: Premier CTS

- #Hospitals = 14
- Date range: 2001 – 2004, with distribution shown at right



Inventory Filtering Criteria (1)

- **Inclusions:**
  - **Date = Calendar Year (2001 – 2004)**
  - **Equipment Type = Biomed/Imaging/Lab**
  - **Equipment Status = Active**

Inventory Filtering Criteria (2)

- **Exclusions:**
  - **"Department ID's" (i.e., non-asset/device related service. Could be projects, rounds, consultation, etc. done in a specific department)**
  - **Imaging components/sub-systems**
  - **Physiological monitor modules**
  - **Wall mounted suction regulators/flow meters**
  - **Manual/aneroid sphygmomanometers**

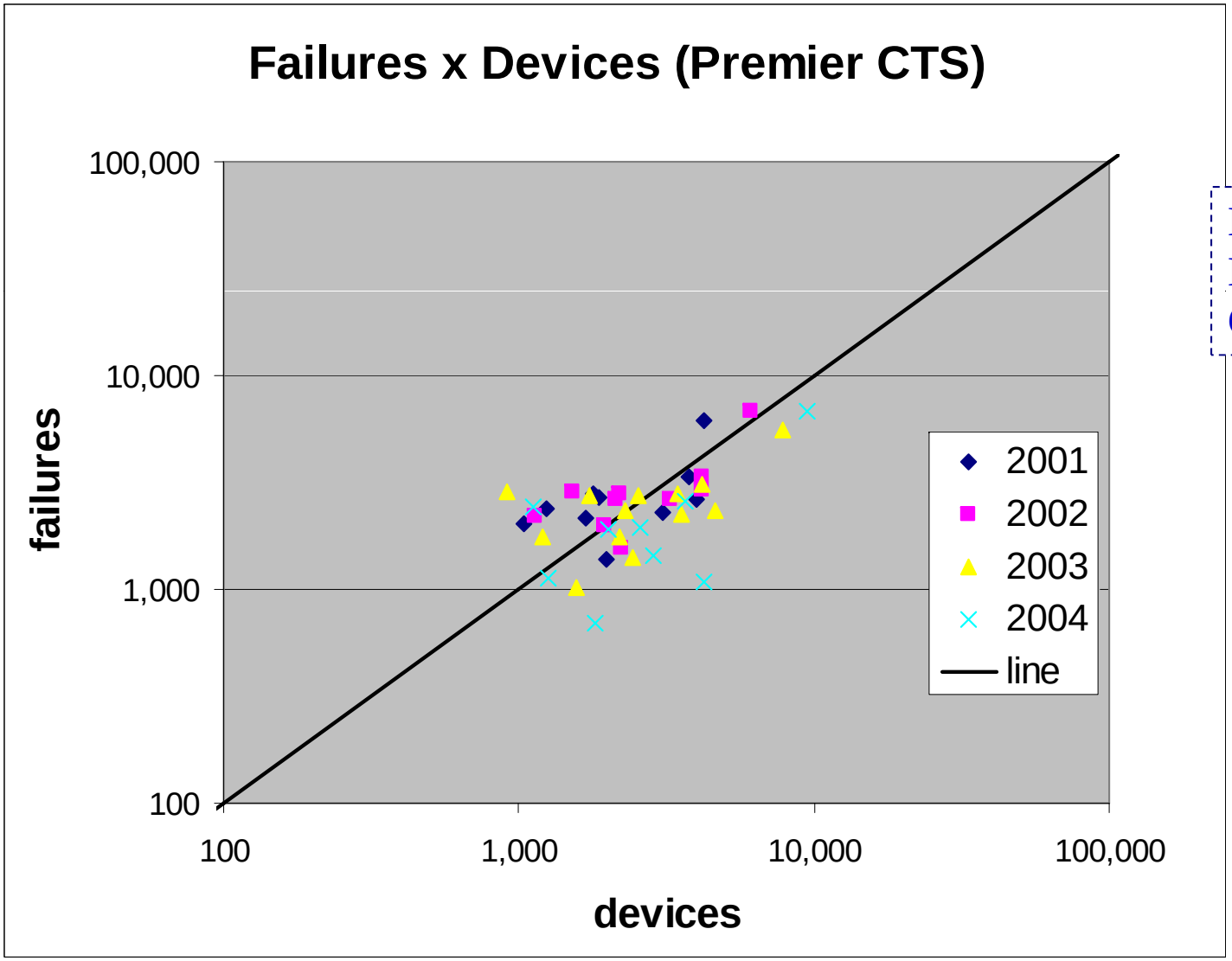
Work Request Filtering Criteria (1)

- **Inclusions:**
  - **RE – Emergency Repair**
  - **RR – Routine Repair**
  - **VS – Supervision of Vendor/Vendor Repair**
  - **Work Request Completion by Calendar year (2001 – 2004)**
  - **Equipment Type = Biomed/Imaging/Lab**

Work Request Filtering Criteria (2)

- **Exclusions: (non – "Wrench time")**
  - **PM – Planned Maintenance**
  - **UE – Use Error**
  - **CND – Could not Duplicate**
  - **II - Incoming Inspection**
  - **Others, etc.**

ARAMARK (former Premier CTS)



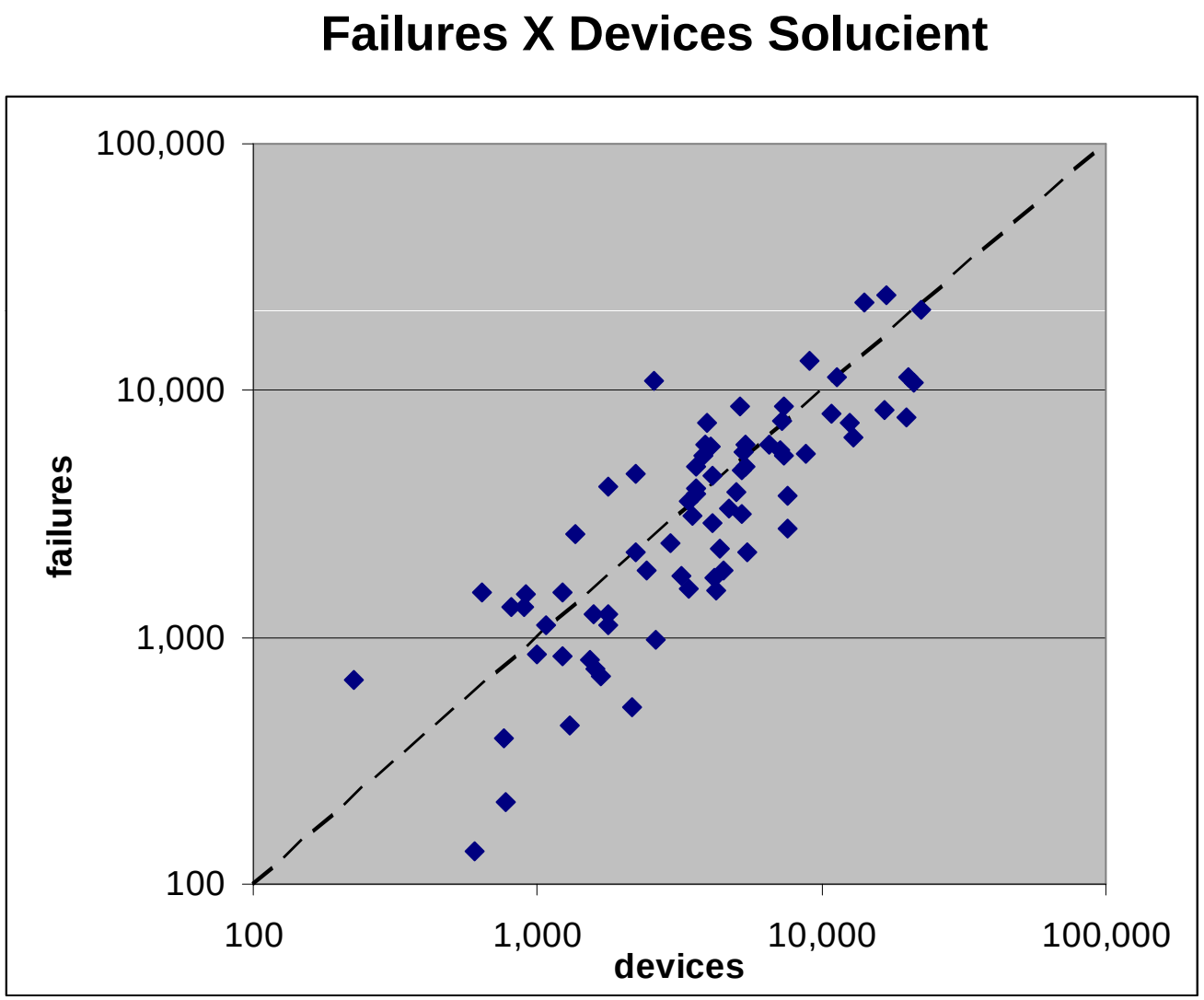
Hospitals = 14
Mean = 1.07
Correl coef. = .74

New Data #3: Solucient Action O-I

- #Hospitals =74
- Date range: 2004
- Filtering criteria: CE data submitted by *Solucient Action O-I subscribers

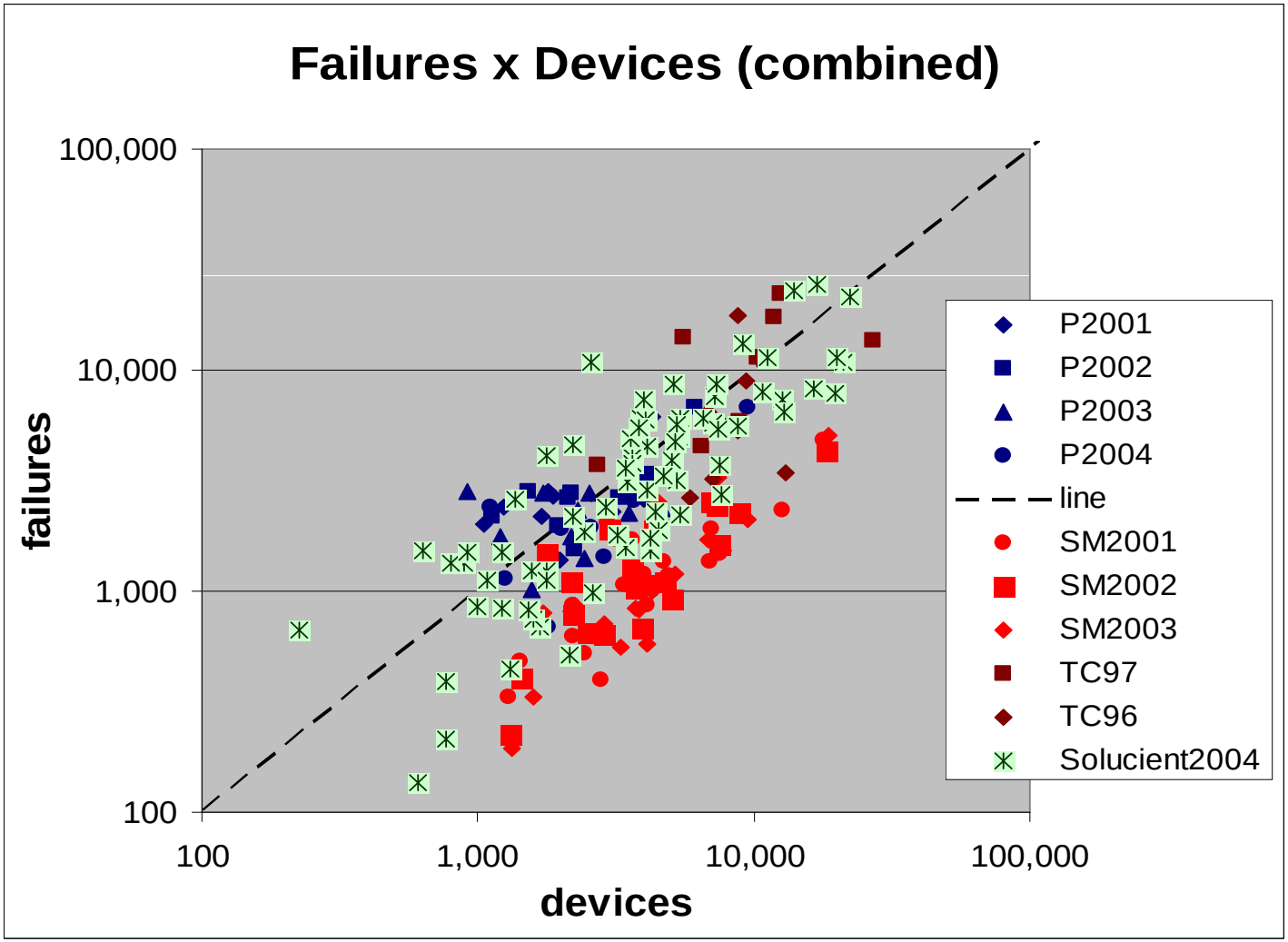
* A benchmarking data service for providing the operational intelligence required to identify, exam, and improve organizational performance

Solucient Action O-I



Hospitals = 74
Mean = 0.99
Correl coef. = .78

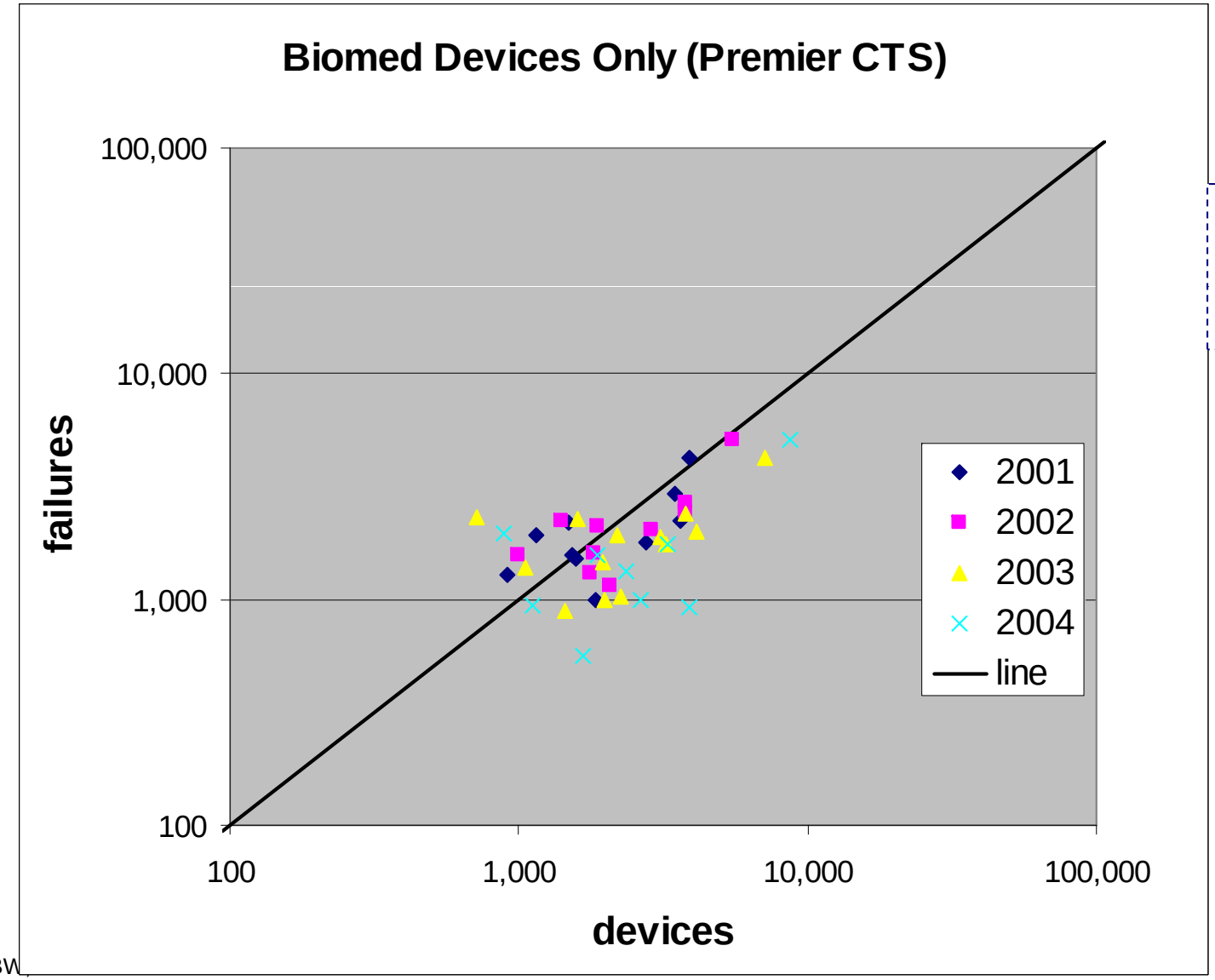
Combined Data



Further Investigation (Premier CTS only)

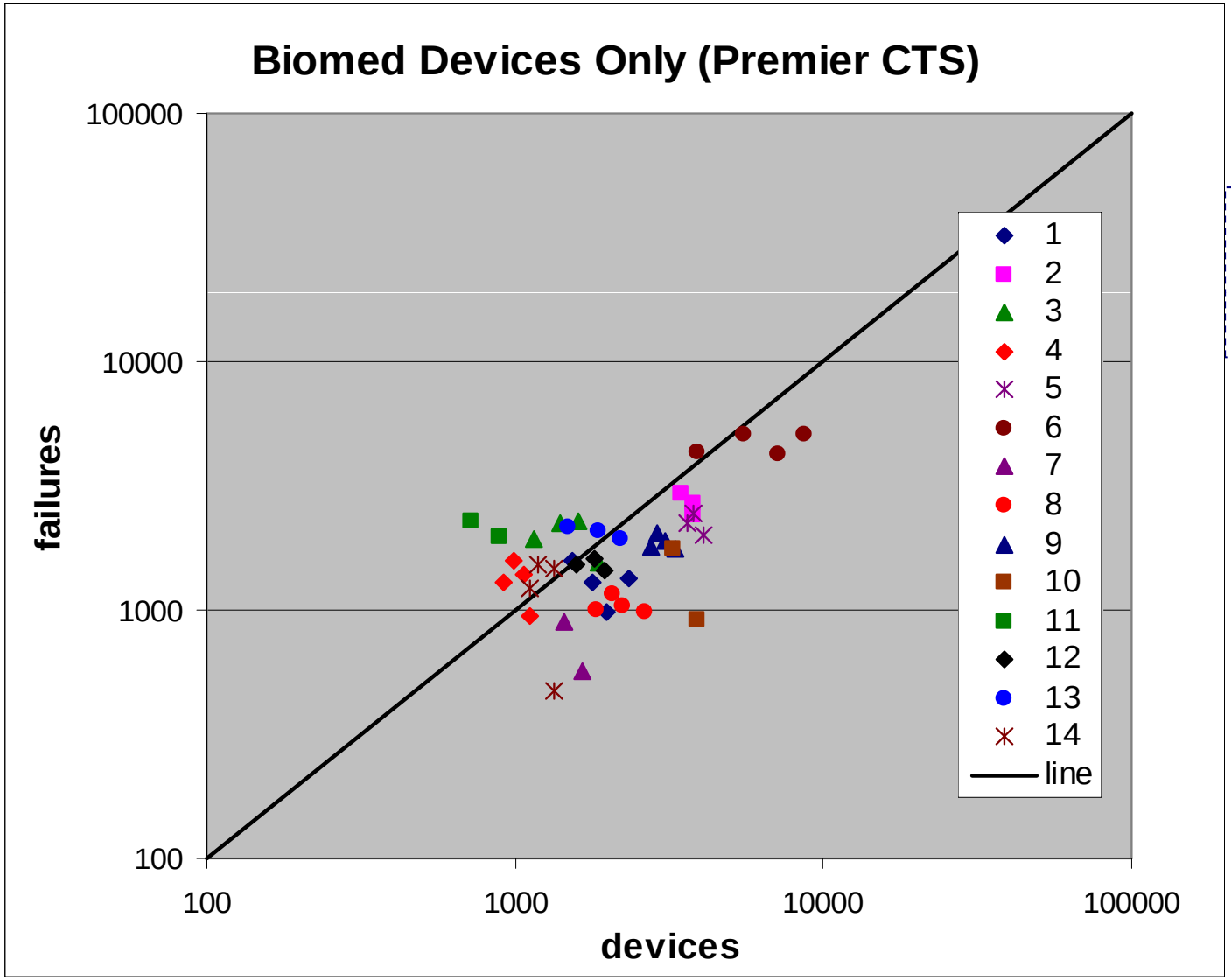
- **Divide the inventory and work requests into modalities:**
  - **Biomedical equipment**
  - **Imaging equipment**
  - **Laboratory equipment**

Biomedical Data (grouping by year)



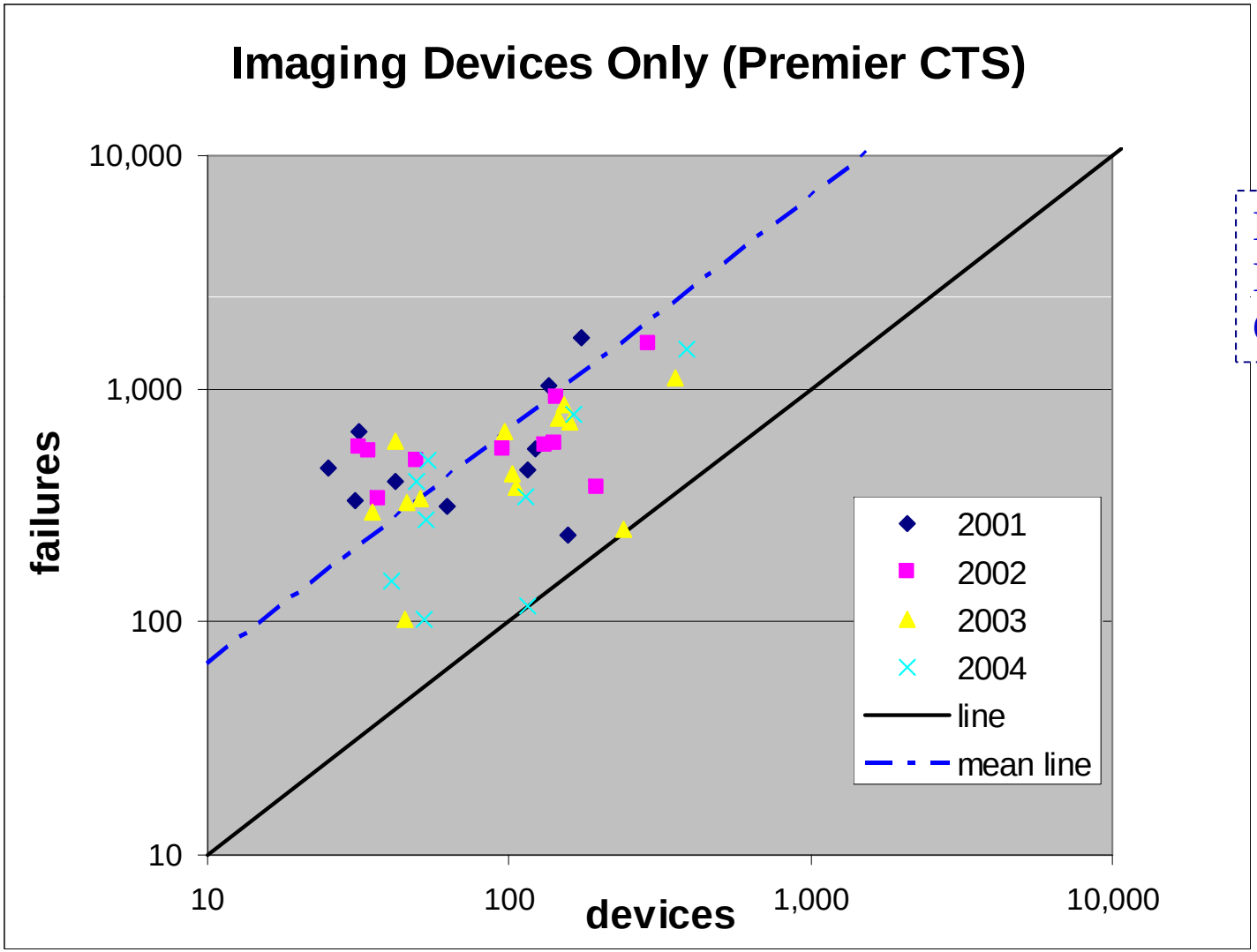
Hospitals = 14
Mean = .92
Correl coef. = .76

Biomedical Data (grouping by hospital)



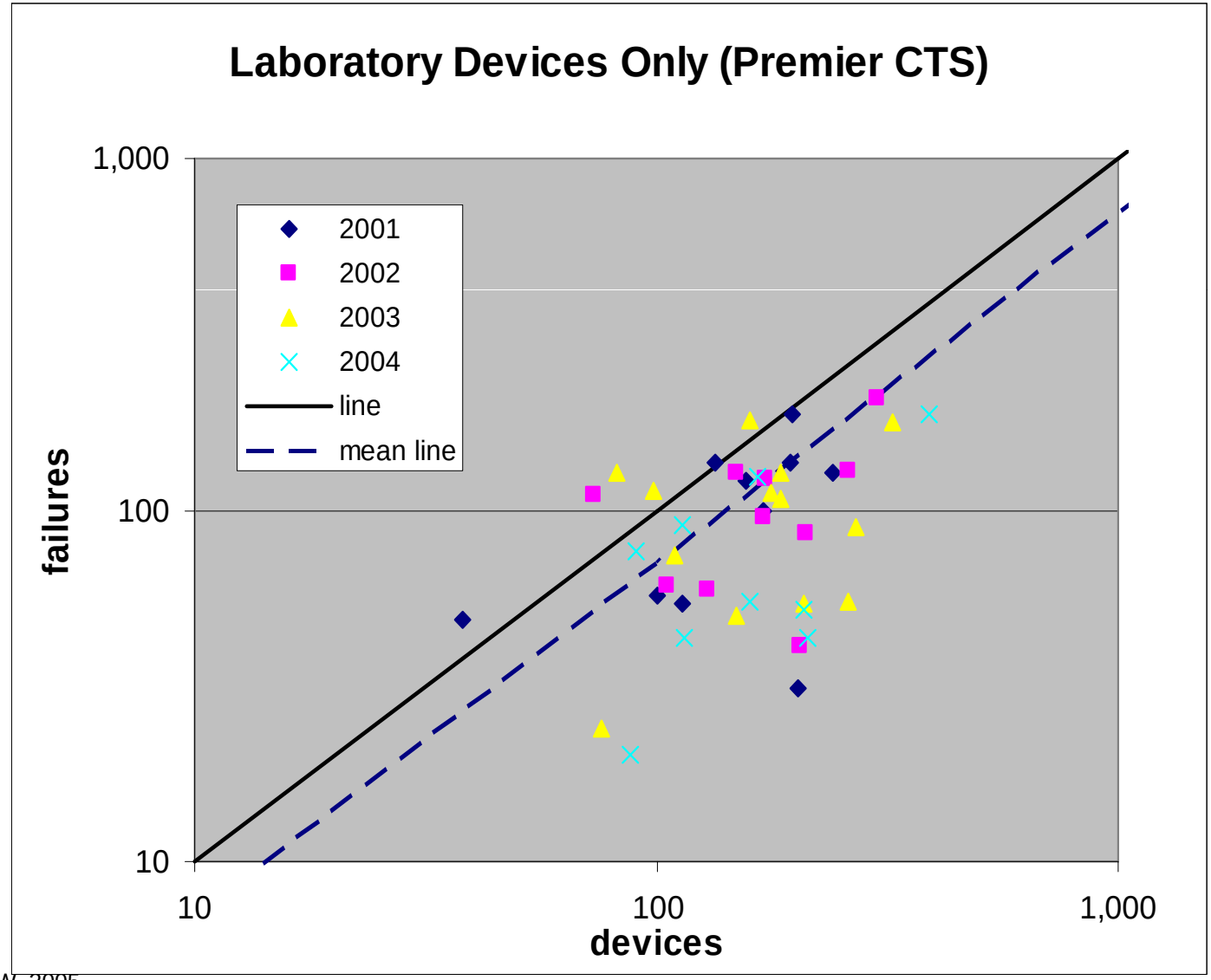
Hospitals = 14
Mean = .92
Correl coef. = .76

Imaging Data



Hospitals = 14
Mean = 6.67
Correl coef. = .68

Laboratory Data



Hospitals = 14
Mean = .70
Correl coef. = .42

Table of Contents

- Introduction
- Failure Rate
  - Definition & candidate for performance metrics
  - Data analysis
    - Old data
    - ServiceMaster
    - Premier CTS
    - Solucient Action O-I
- **Discussion**
- **Conclusions**

Discussion (1)

- All four sets of data suggest the number of failures is **linearly** correlated with the number of **Biomed** devices, i.e., constant failure rate.
- However, the value of failure rate depends how the inventory is counted.
- The correlation is weaker for **Imaging** equipment and unclear for **Lab** devices.*

Discussion (2)

- **Even in the same hospitals, the failure rate varies for Biomed and Imaging devices (and perhaps Lab equipment).**
- **Some possible explanations for the difference are:**
  - **Difference between complex systems and single devices (e.g., one RF room with multiple components versus an infusion pump)**
  - **Difference in users: multiple versus dedicated, training, motivation (e.g., several nurses versus one lab tech)**
  - **Intrinsic differences in technologies used (e.g., high energy and heavy, moving parts in imaging systems versus low power and small, stationary parts in Biomed devices)**

Discussion (3)

- **Inventory methodology strongly affects failure rate -> consistency is critical for benchmarking across organizations**
- **If there has been little change in methodologies, individual hospitals (or hospital groups) can use historical data (trends) for decisions on service strategies.**

Further Discussion (4)

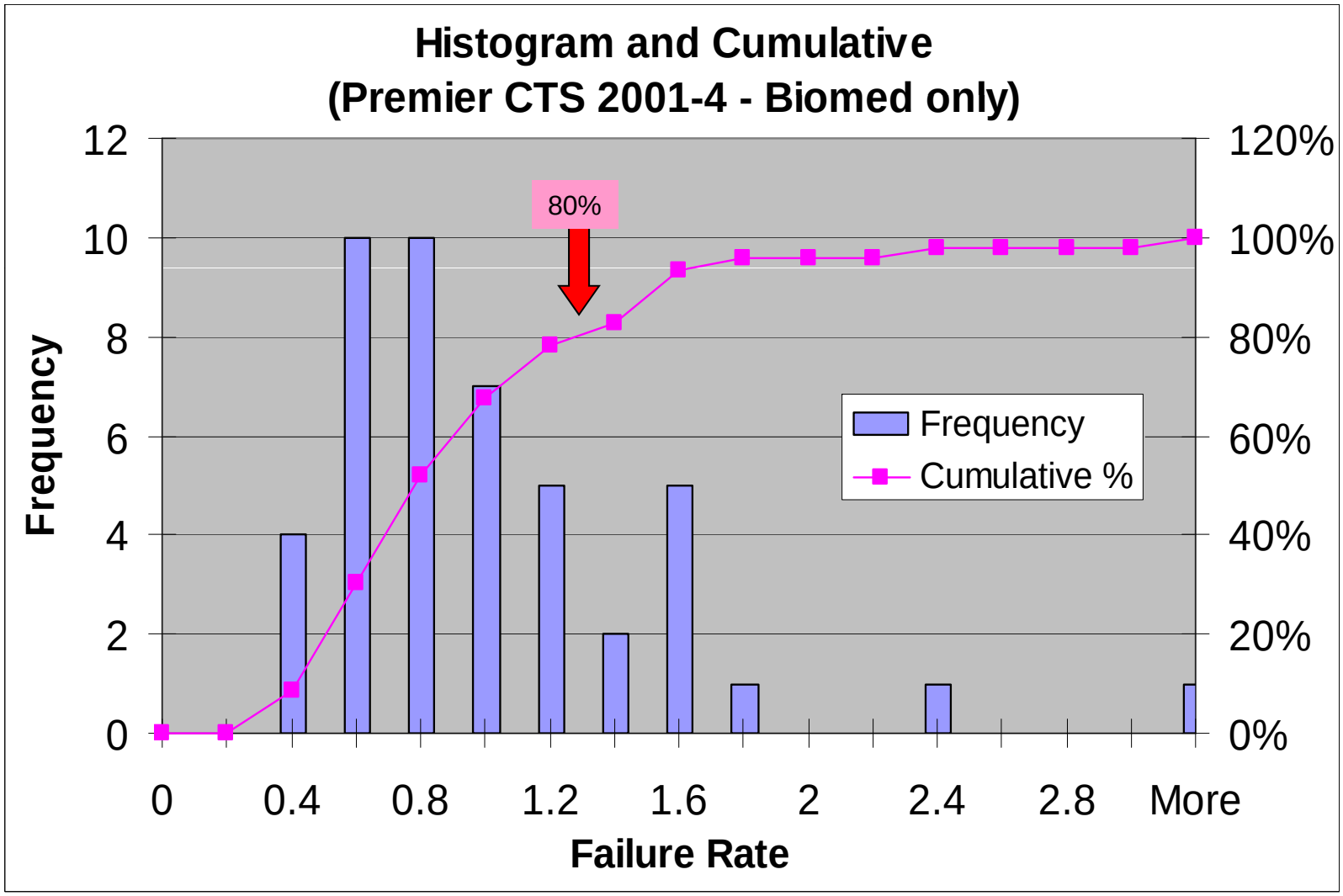
Potential Applications of Failure Rate:

- Performance evaluation of MEMP (PM, SPI, repairs, user training, etc.)
- Equipment replacement planning
- Equipment pre-purchase comparison
- Service planning/costing
  - Staffing
  - Parts planning
- At least, it provides a "rule of thumb" for closer scrutiny

An Example of Failure Rate Application

- After measuring the average failure rate for a group of equipment in a hospital, one can create a "rule of thumb" for analyzing individual pieces (or groups) of equipment that have failure rate > 80% of cumulative%:
  - Poorly designed or made -> don't buy
  - Not properly maintained -> improve service
  - Too old -> replace ASAP
  - Being abused -> user training
  - Environmental problems (voltage, temp, etc.) -> improve facility management

ARAMARK (former Premier CTS)



No Metric is Perfect! (especially alone)

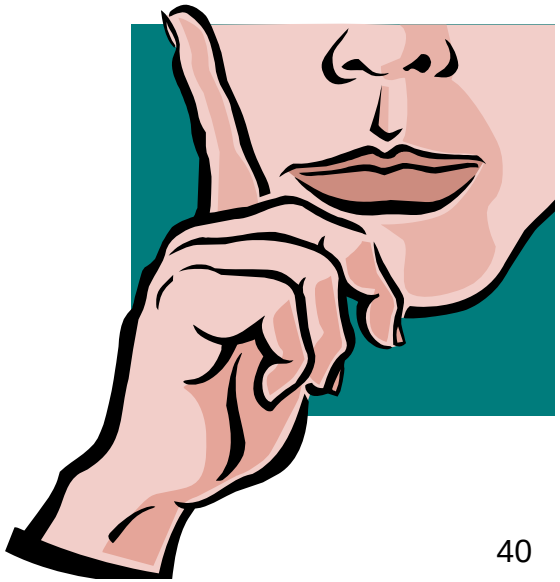
- Total maintenance costs/ acquisition costs (%): low cost is important but cheap may not be good
- Customer satisfaction survey: perception is critical but subjective and transitory
- PM completion rate: important but only consider a small fraction of the CE duties
- Uptime : is only justifiable for few devices due to measurement challenges
- Failure rate: may vary significantly due to different criteria for work orders and inventory

However…

- **When used together, these performance metrics provide a good measure of the "value" of CE services**
  - **Financial: total maintenance costs / acquisition costs (%)**
  - **Satisfaction: customer satisfaction survey**
  - **Operational: PM Completion Rate**
  - **Outcome: uptime for critical devices**
  - **Outcome: failure rate**

Table of Contents

- Introduction
- Failure Rate / Outcome Metric
  - Preliminary Findings
    - Discussion
    - Conclusion
  - Further Examination
    - Biomed Devices
    - Imaging Devices
    - Laboratory Devices
- Discussion
- **Conclusion**



Conclusion (1)

- Failure Rate seems to be (at least for Biomed equipment) a good, valid metric from the "uncontrolled, look-back" data available. But need more "controlled" studies to validate it unequivocally.
- Needs consistency
  - Internal consistency can track performance and help plan equipment replacement
  - External consistency can help benchmarking
- Needs refinement
  - By equipment group / modality, brand / model, usage pattern, etc.

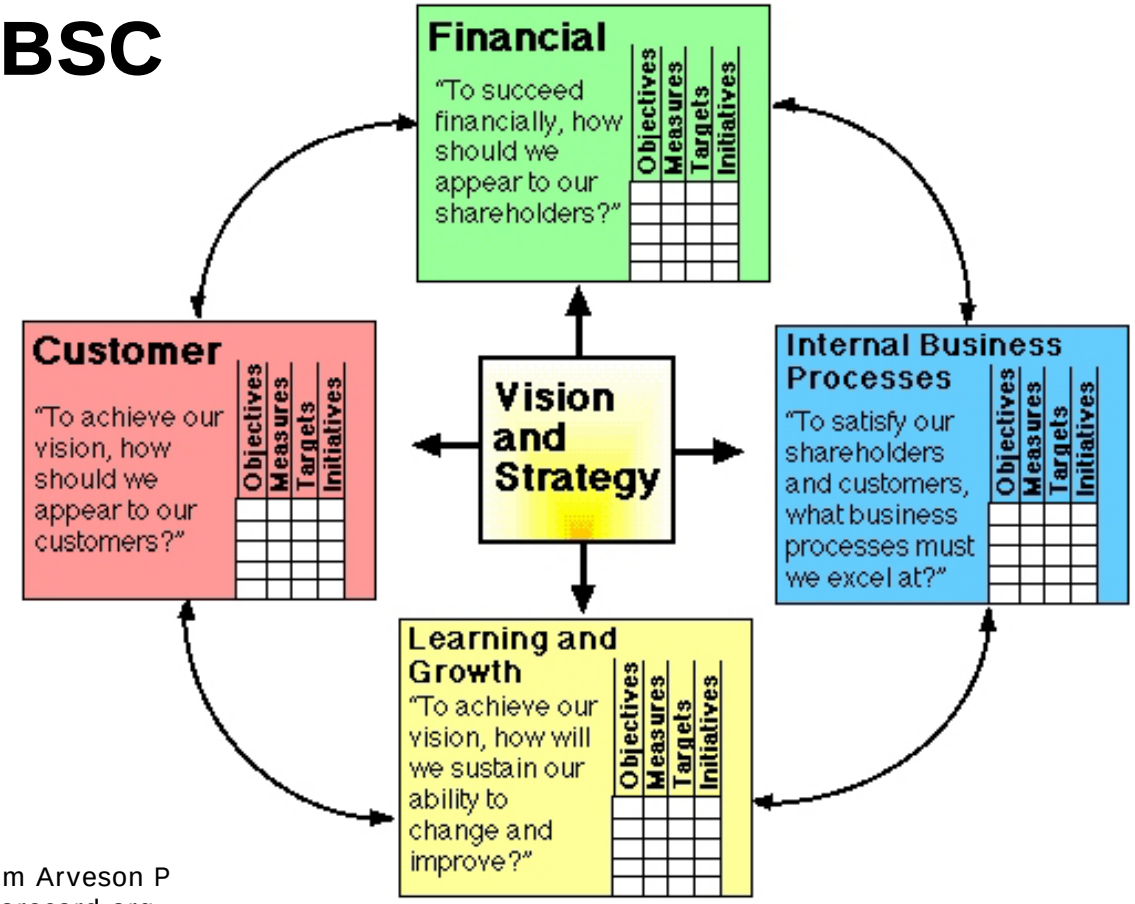
Conclusion (2)

So please help us help you!

- **Review your own data and verify failure rate is worthwhile**
- **Let us reach a consensus to achieve wider consistency**
- **Let us compare data to validate the metrics before attempting benchmarking**

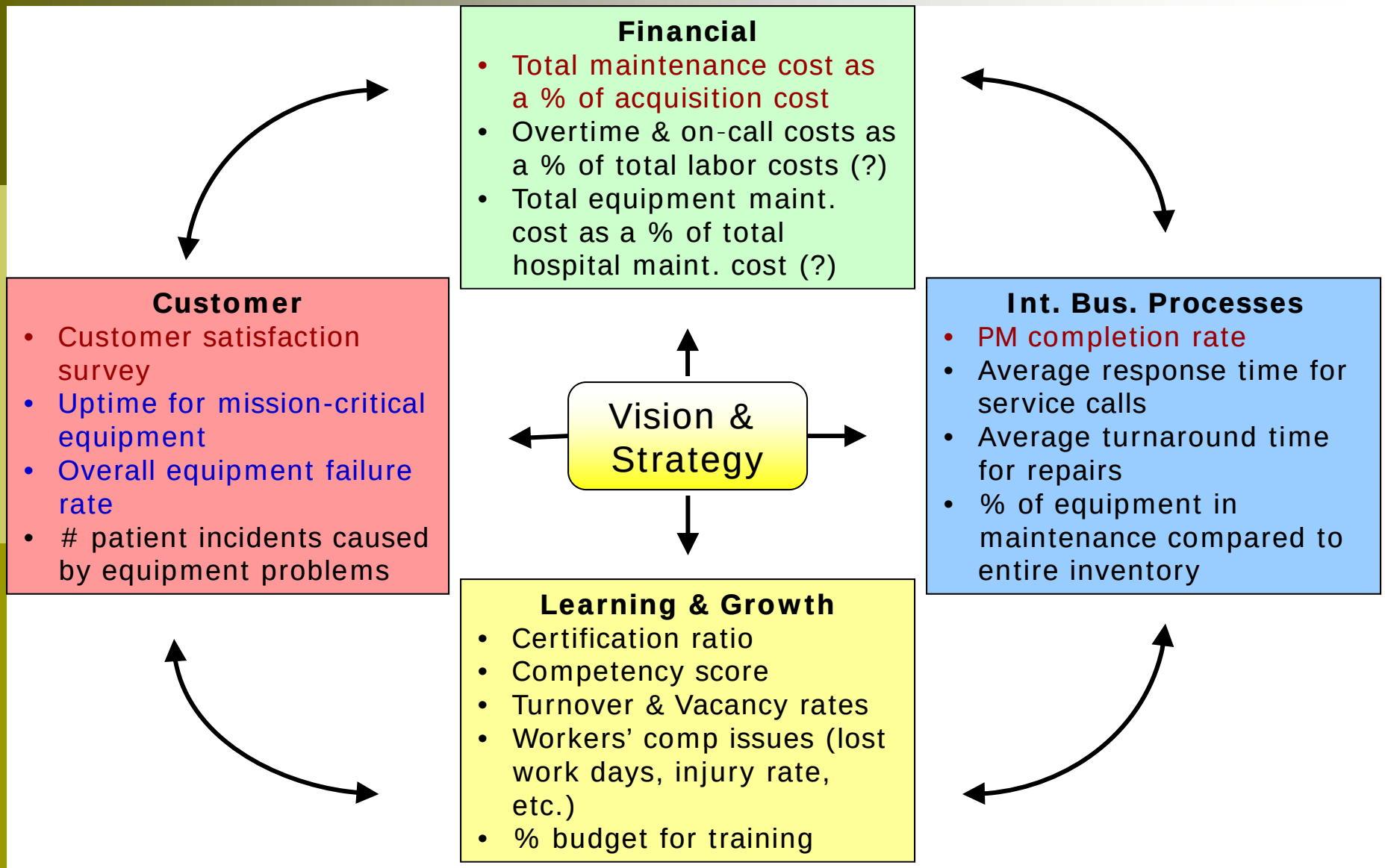
Eventual Goal

- **Develop a "balanced scorecard" (BSC) for assessment of CE services.**
- **The original BSC**



Kaplan and Norton, adapted from Arveson P (1998), http://www.balancedscorecard.org

A proposal for CE BSC



Thank You!

- If you have questions, comments, suggestions, etc., please contact us
- Richard Eliason
  - e-mail: eliason-richard@aramark.com
  - telephone: 704-948-5719
- Binseng Wang
  - e-mail: binseng@alum.mit.edu
  - telephone: 704-948-5729
- But will not talk unless you have data (performance metrics data)!