Some Challenges in Warranty Data Analysis and Its Use

Jeff Robinson
General Motors R&D Center

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Outline

- Everyday use of warranty data
- Some challenges and issues (partial list)
  - Assessing the number of units at risk
  - Multiple usage measures
  - New data/information sources (e.g. text)
  - Monitoring for emerging issues
  - Recurring problems
  - Are warranty events predictable?
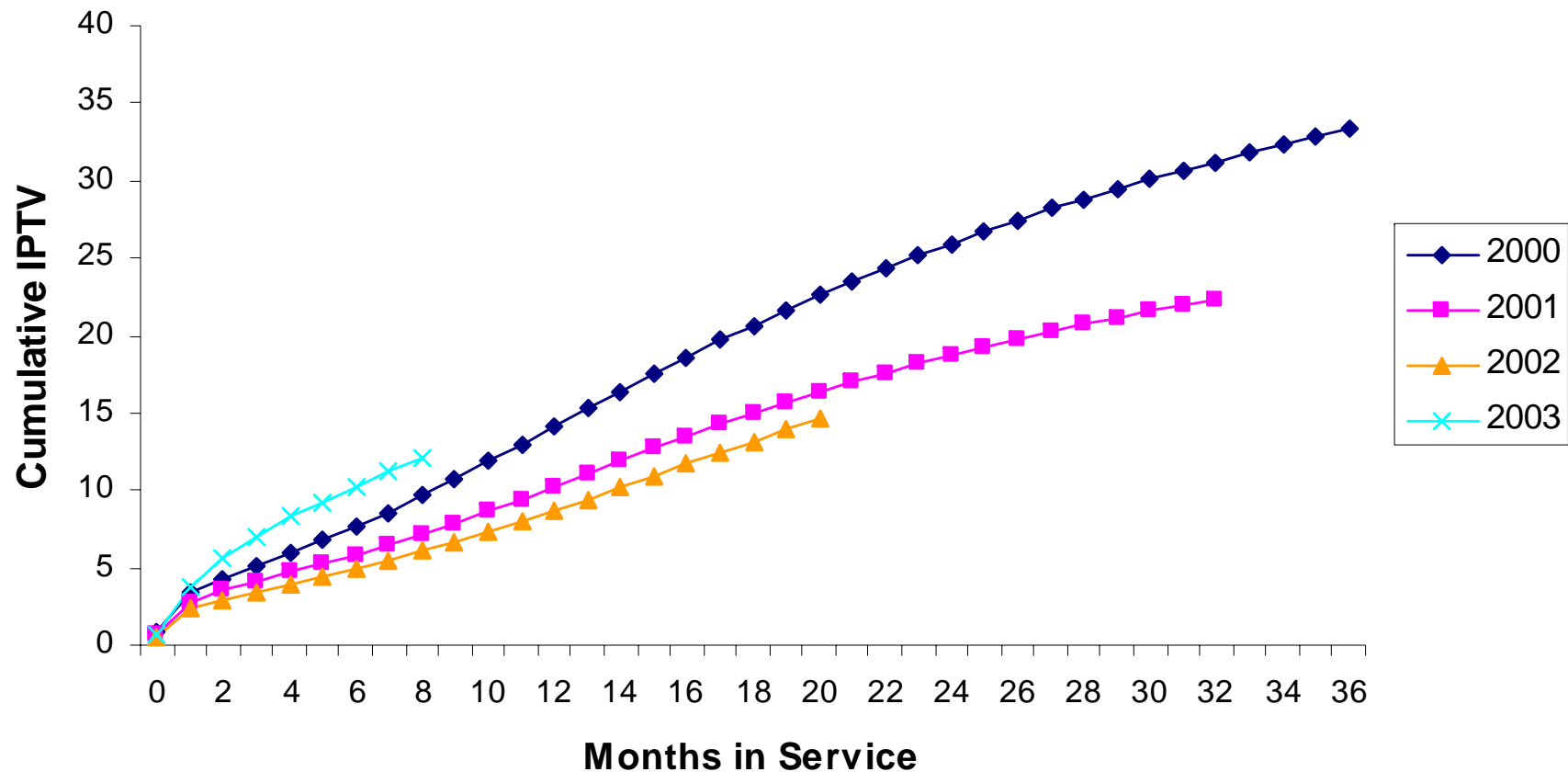- Summary/Comments/Questions

Model Warranty Events as from a Repairable System (Age)
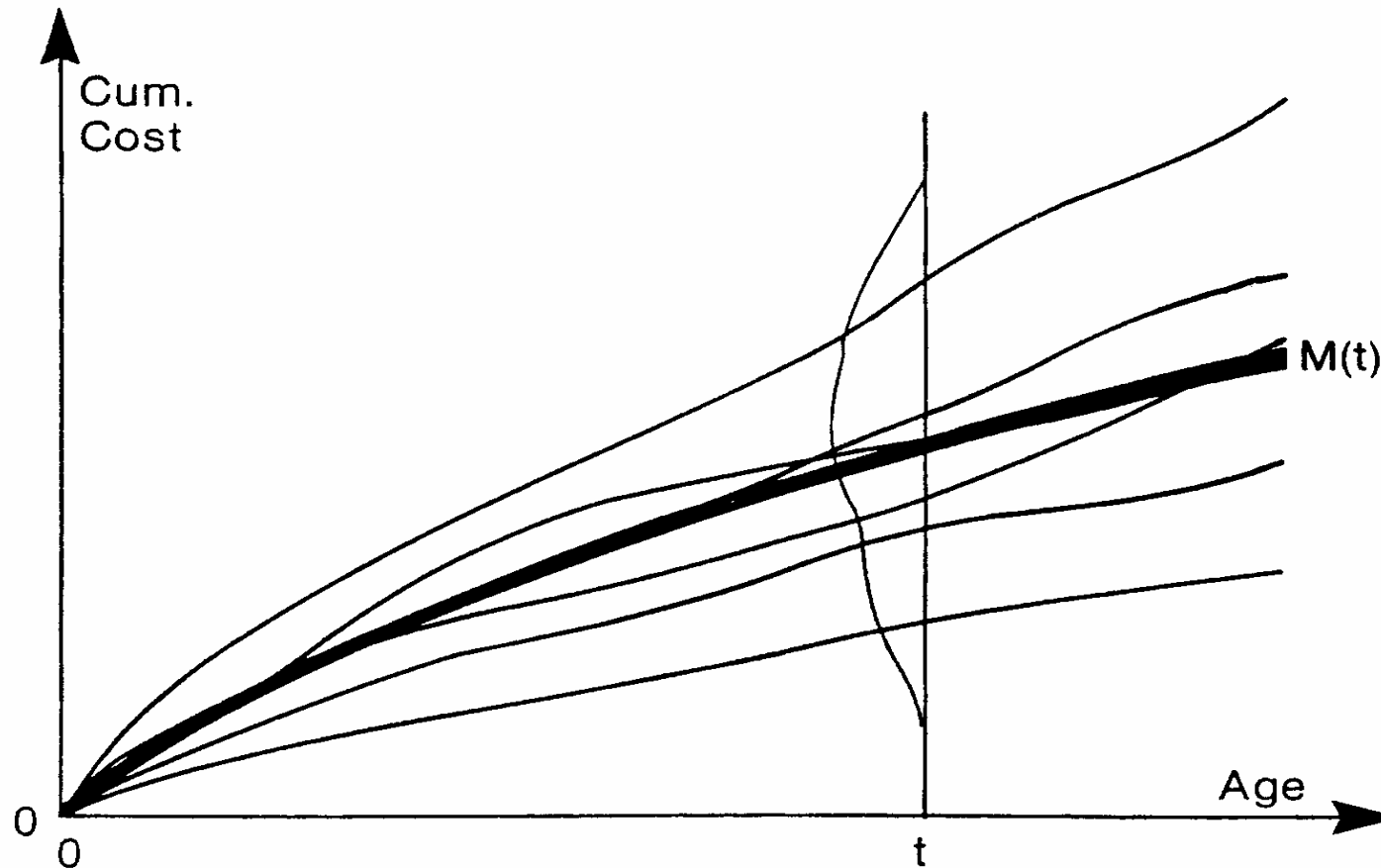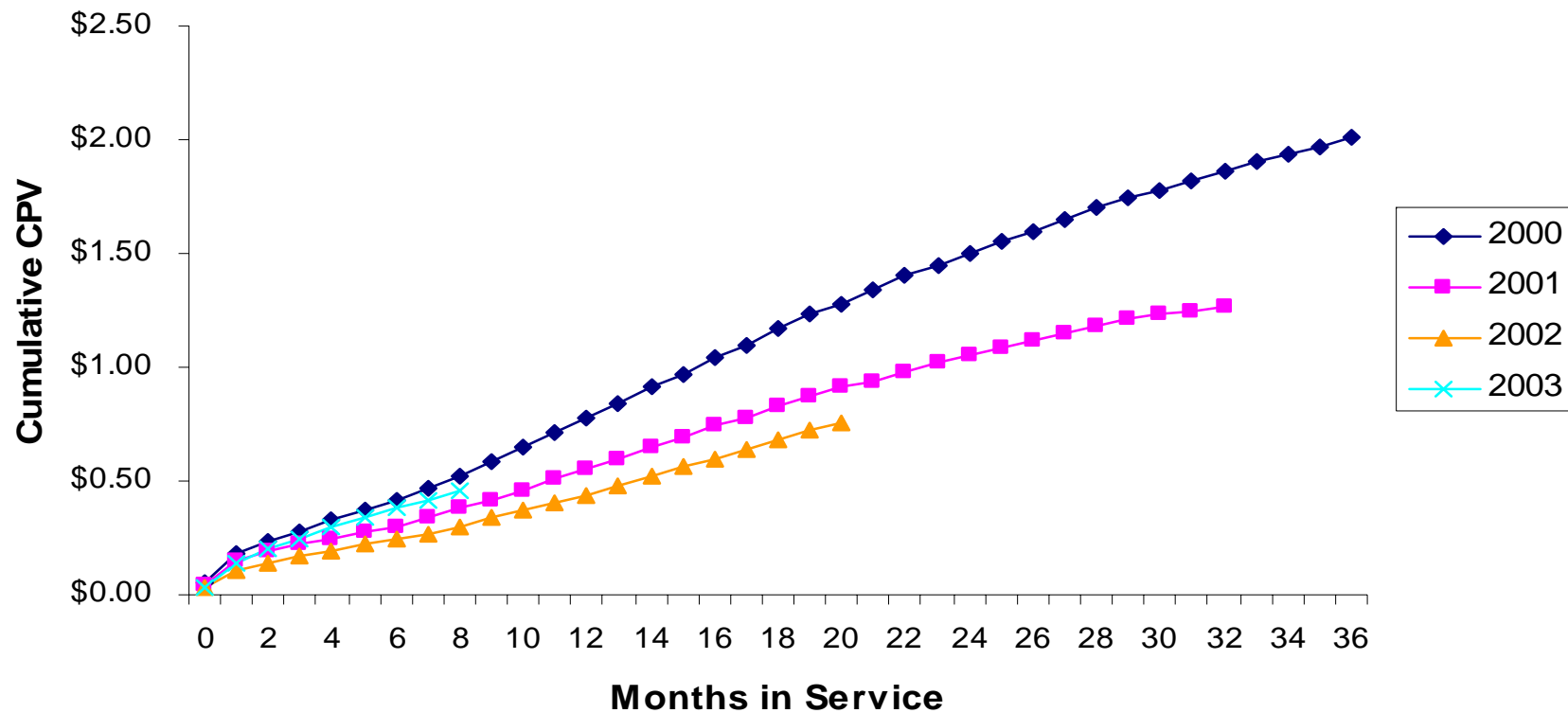

Source: Nelson (2003)

Age-Based Warranty Reporting

Cumulative Incidents per 1000 Vehicles (IPTV) for a Vehicle Subsystem

Age-based Warranty Reporting

Cumulative Cost per Vehicle (CPV) for a Vehicle Subsystem

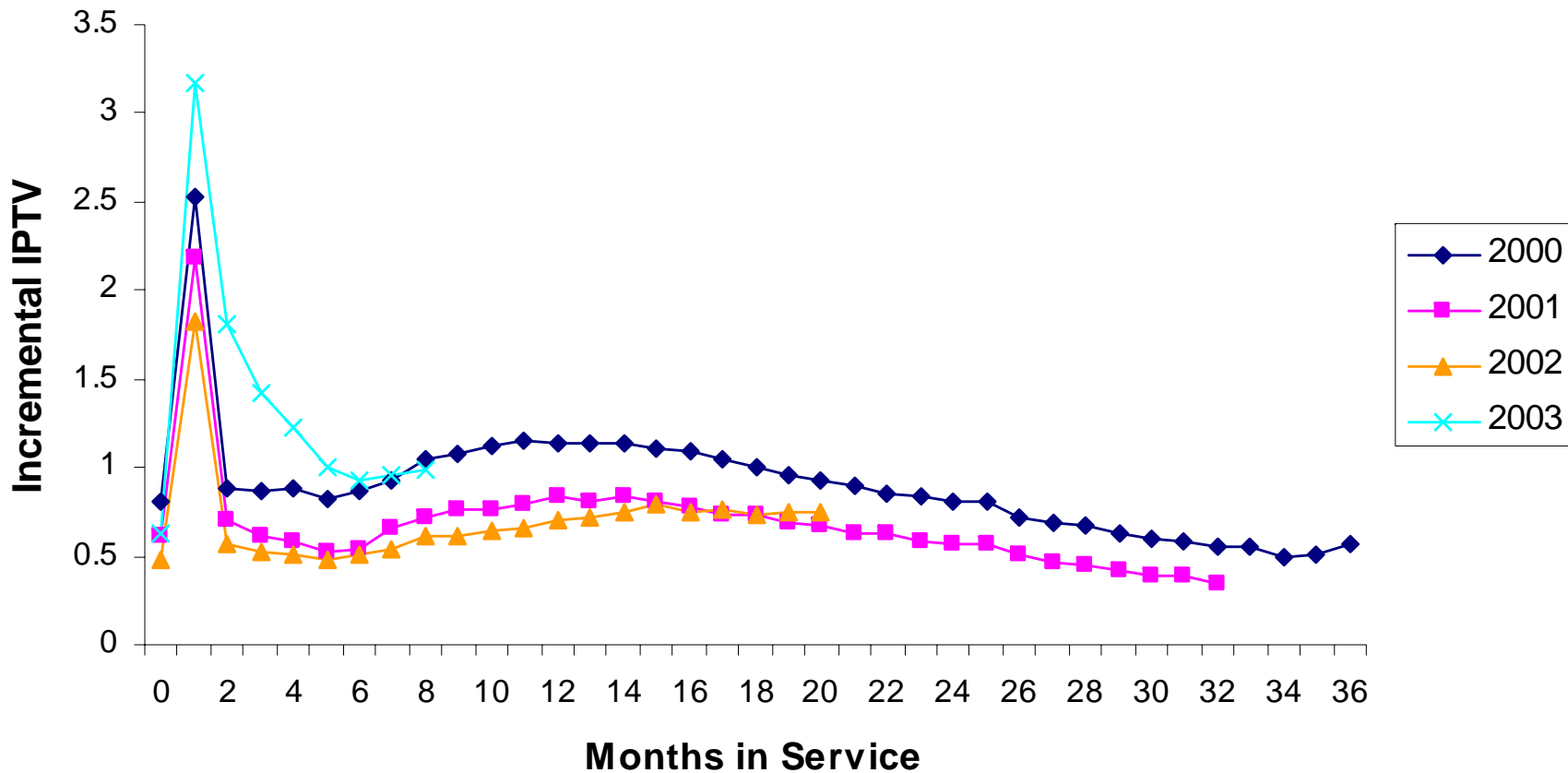# Age-Based Warranty Reporting

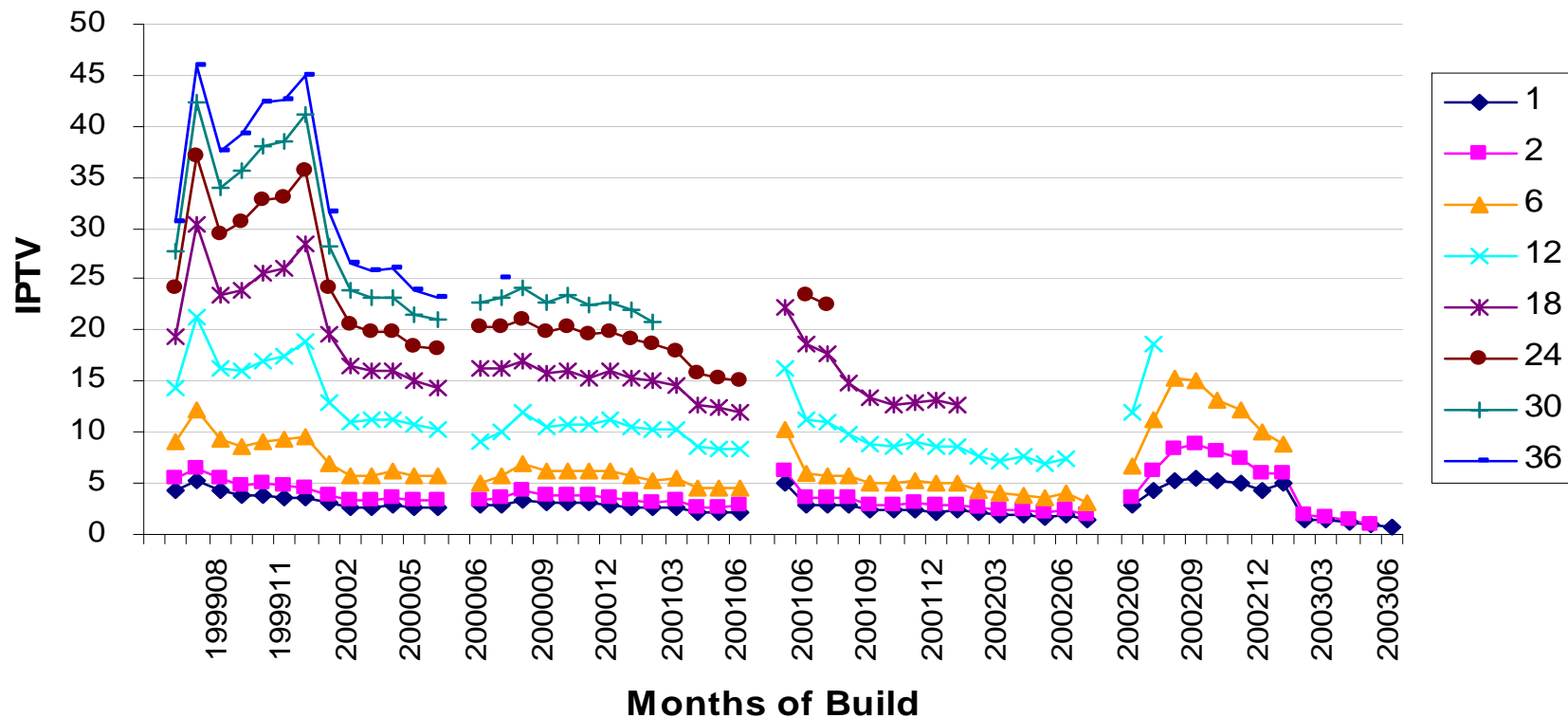## Incremental Incidents per 1000 Vehicles (IPTV) for a Vehicle Subsystem

Age-based Warranty Reporting

Cumulative Incidents per 1000 Vehicles (IPTV) for a Vehicle Subsystem by Build Month at Various Months in Service

Assessing the Number at Risk – Mileage Limits

- ## Warranty coverage is limited by mileage
  - Purely age-based analysis ignores "mile-outs"
  - Mileage only available on warranty claims
- ## Chukova & Robinson (2005) – Adjust for mile-outs
  - Use mileage data from claims
  - Treat as a sample
  - Assume linear mileage accumulation rate
  - → Mileage accumulation rate distribution
  - → Adjusted age-based IPTV or mileage-based IPTV
- ## Other examples – e.g. claim reporting delay

Example: Mileage-Adjusted Cumulative Cost for a Vehicle Subsystem

Age(days)
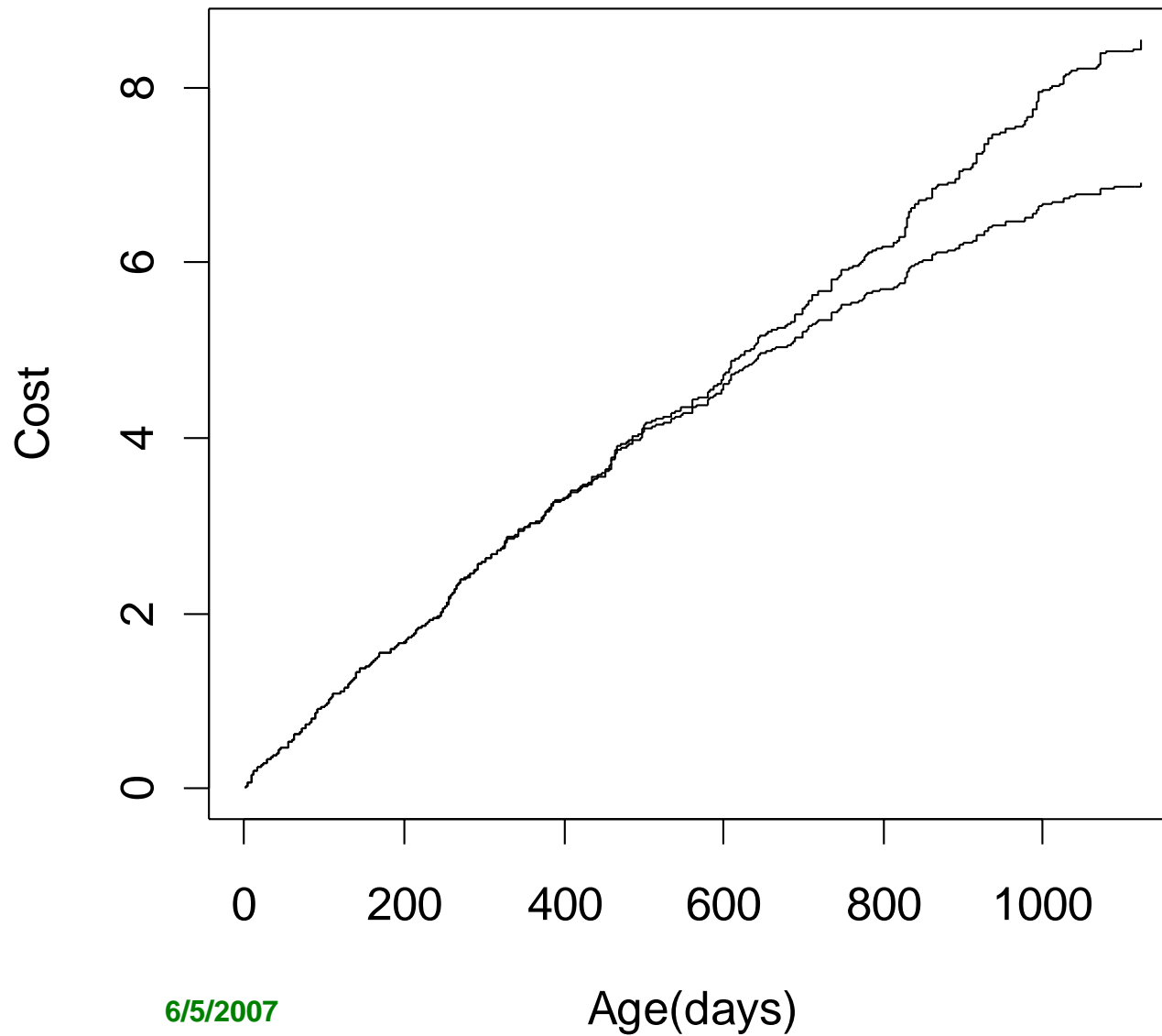
Miles versus Age (from warranty claims)

Mileage at Claim

Scatter plot of Miles at Claim (K) versus Age at Claim (days)
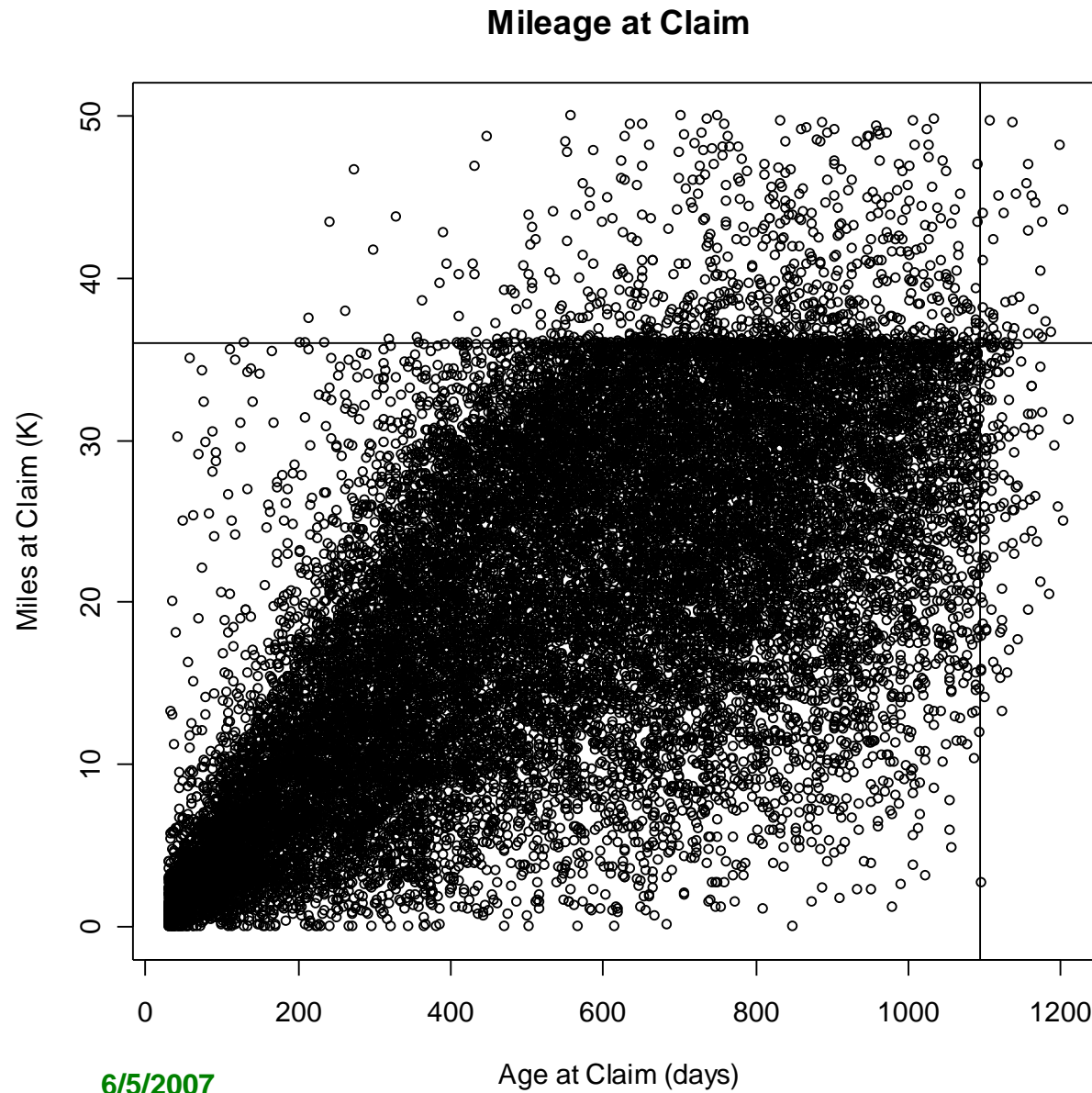
Complete Mileage Traces (monthly)

Sample 1 (250 cars)
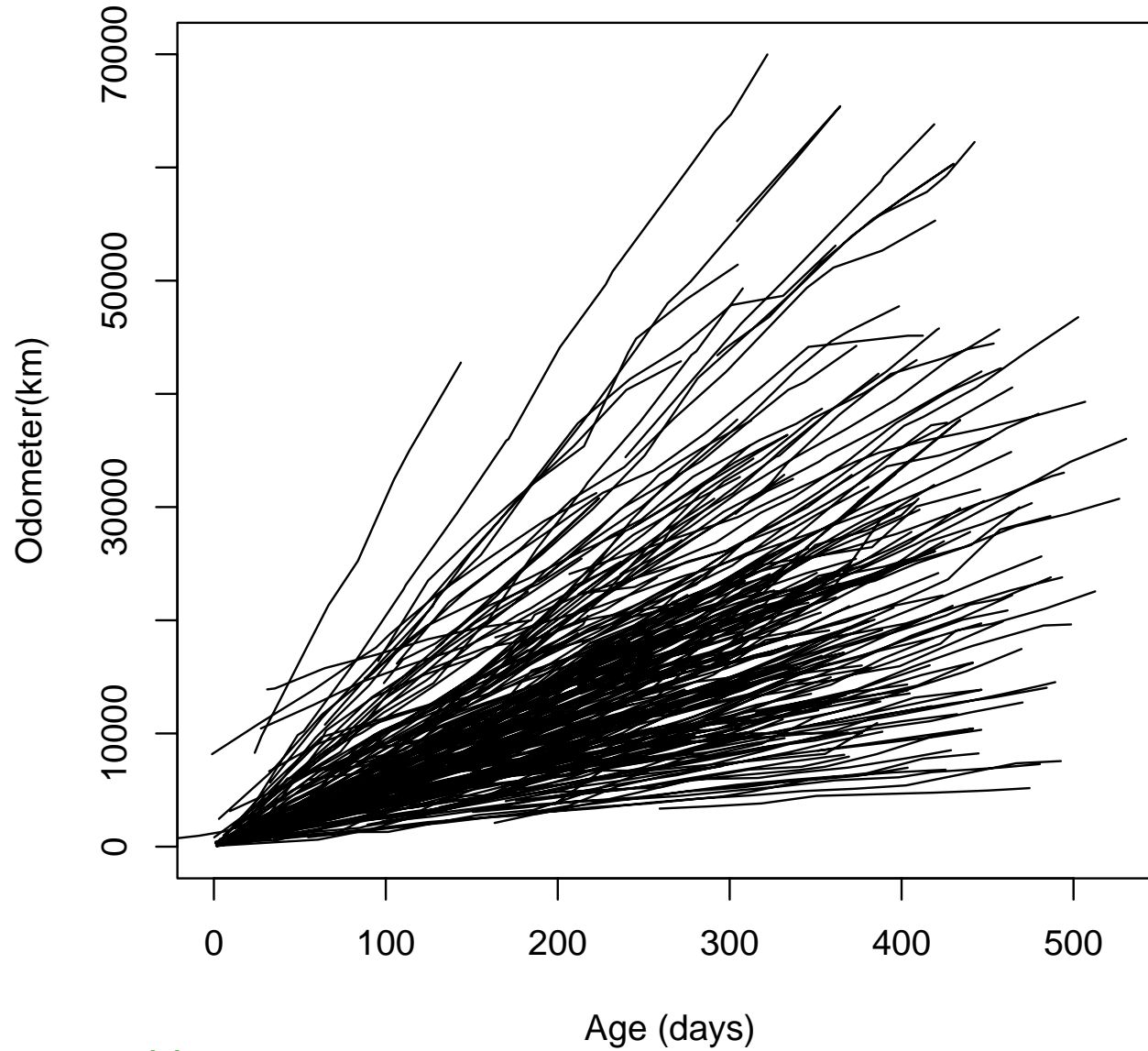
Potential Usage Measures – Almost Limitless

- Cheap memory, fast computing → More data
  - On-board/Off-board
- Other possible usage measures
  - Number of key cycles
  - Engine hours
  - Battery state of charge
  - Tire pressure
  - Anything we have (or will have) a sensor for
- Limited somewhat by privacy issues
- Analysis capability lags the available data (even for the simple age and miles case)

Are Warranty Events Predictable?

- If so, then can we prevent or lessen their impact → Integrated Vehicle Health Management (NASA)
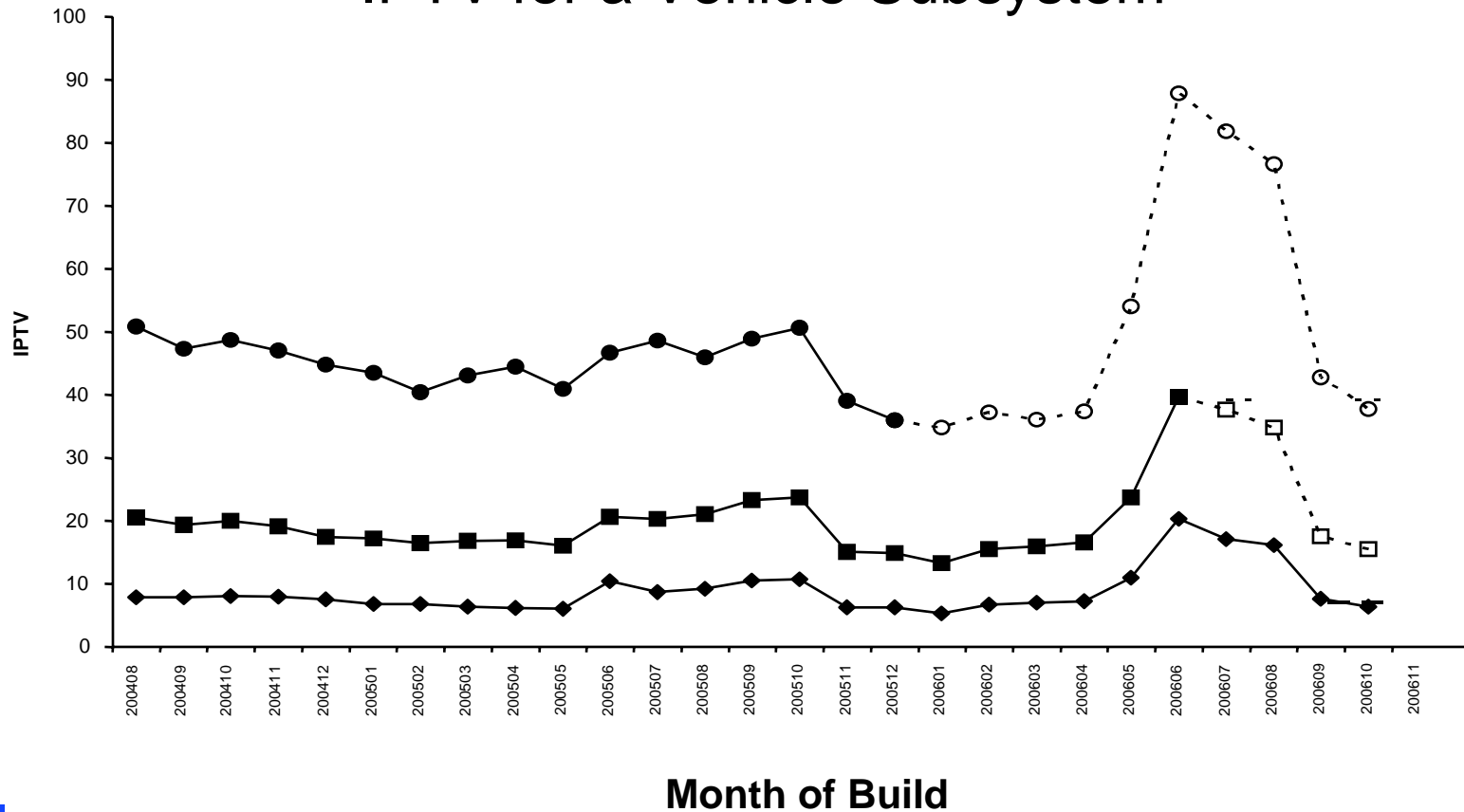- Physics-based modeling
    - Can't do for everything
- Data-based approaches
    - From events only or continuous monitoring
    - Data mining (some success in manufacturing)
    - Statistical methods
- Increasing interest in the topic
    - Upcoming JSM luncheon topic (Necip Doganaksoy, GE)

Tracking Emerging Issues

Warranty - 2, 6 & 12 Months in Service
IPTV for a Vehicle Subsystem

Month of Build

Detecting Emerging Issues

- ## Wu-Meeker (Technometrics 2002)
  - Added decision limits to month-of-build warranty rates
  - Properly accounted for overall false alarm rate
  - Suitable for automated monitoring
  - Superb applied work

- ## Based on limited test use at GM
  - Still lots of alarming
  - Some users have found the results difficult to understand
  - Looking at ways to simplify the reporting

Text as Data?

- We have a lot of text ("verbatims")
- But we can't use free text as "data" for computations
  - to answer quantitative questions, such as "how many" or "how often"
- Information Extraction (IE): Free Text → Features
  - Feature: Any known list of values, e.g.
    - Things customers dislike
    - Customer complaints: symptoms for repair problems
    - Part categories

Why Is IE Very Difficult?

- **The Paraphrase Problem**: *the same thing can be said in many different ways.*
  - synonyms, abbreviations, misspellings, ...
  - A "gas cap" is a "fuel cap"
  - We discovered 25 ways to write "intermittent," including "i"
- **The Disambiguation Problem**: *a word can have different meanings*
  - "gas" has three meanings in standard GM text:
    - fuel, usually, gasoline
    - the gas used for A/C, and
    - the gas used in fuel cells.
- **The Granularity Problem**: *the same problem can be expressed using very specific language or more general language.*
  - "The right front brake caliper piston boot retainer has fractured." or "There is a problem with the right front brakes."

Some Verbatims from Warranty Claims

- *"TRACE AND REPAIR OPEN AT CIRCUIT BREAKER AT RELAYPANEL ORANGE WIRE OPEN AS RELAY PANEL"*

- *"STRG - SUSP CTF-TRAC. CONT-ABS xxxxx RT FRT WSS. CONTACT 24HL+R HUB INTERNAL FAILURE VERIFIED CONCERN.REPLACED BOTH FRT HUBS.CLEAREDCODES,ROAD TE"*

- **Potentially very valuable information if converted to "features"**

Recurring Problems

- Some current monitoring is based on tracking for acute disease. Why not also use methods from epidemiology to study chronic disease?
  - Emphasizes properly counting the number at risk
  - Deals with cohort classes and covariates
  - Might highlight areas that need more investigation

Summary & Comments

- Warranty data will become part of a much larger data structure that will be collected and analyzed in real-time.

- The analysis will include prognosis and it will drive intervention.

- The text information extraction (text) problem will be solved. We can help.
  - by applying statistical methods to the feature problem
  - by accepting features with uncertainty attached

Summary & Comments (cont.)

- Methods from the health fields should be applicable for monitoring warranty.

- We overemphasize inference. But the data miners have something to offer. (But they overemphasize algorithms.)

- Some data is available for academic use.

Backups

The Paraphrase Problem

- Fuel Injection/Injector
  - F/INJN FUEL FEED PIPE
  - F/INJN FUEL FEED HOSE
  - F/INJR FUEL FEED HOSE
  - F/INJR FUEL FEED TUBE

- More hose vs. pipe
  - TRANS FLUID CLR HOSE
  - TRANS FLUID CLR PIPE

- gas cap, fuel cap