Analyzing Post-Launch Anomalies at JPL

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Goal

To reduce the number of safety-critical software anomalies that occur during flight by providing a *quantitative analysis* of previous anomalies as a foundation for process improvement.

Approach

- **Analyzed anomaly data using *Orthogonal Defect Classification (ODC)* method [Chillarege et al., '92]**
  - **Developed at IBM; widely used by industry**
  - **Quantitative approach**
  - **Used here to detect patterns in anomaly data**
- **Evaluated ODC using *Formalized Pilot Study***
  - **R. Glass ['97] detailed rigorous process to get valid results**
  - **35 steps divided into 5 phases**
  - **Used here to evaluate ODC for NASA use**

Adapting ODC to JPL

- **Sample Question: What is the typical signature of a post-launch critical software anomaly?**
- **Metrics:**
  - **Activity = Flight Operations**
  - **Trigger = Data Access/Delivery**
  - **Target = Information Development**
  - **Type = Procedures**
- **Example: Star Scanner anomaly**
  - **Activity = occurred during flight**
  - **Trigger = star scanner telemetry froze**
  - **Target = fix was new description of star calibration**
  - **Type = procedure written**

Web-based Visualization Tool (P. Neubauer, ASU)

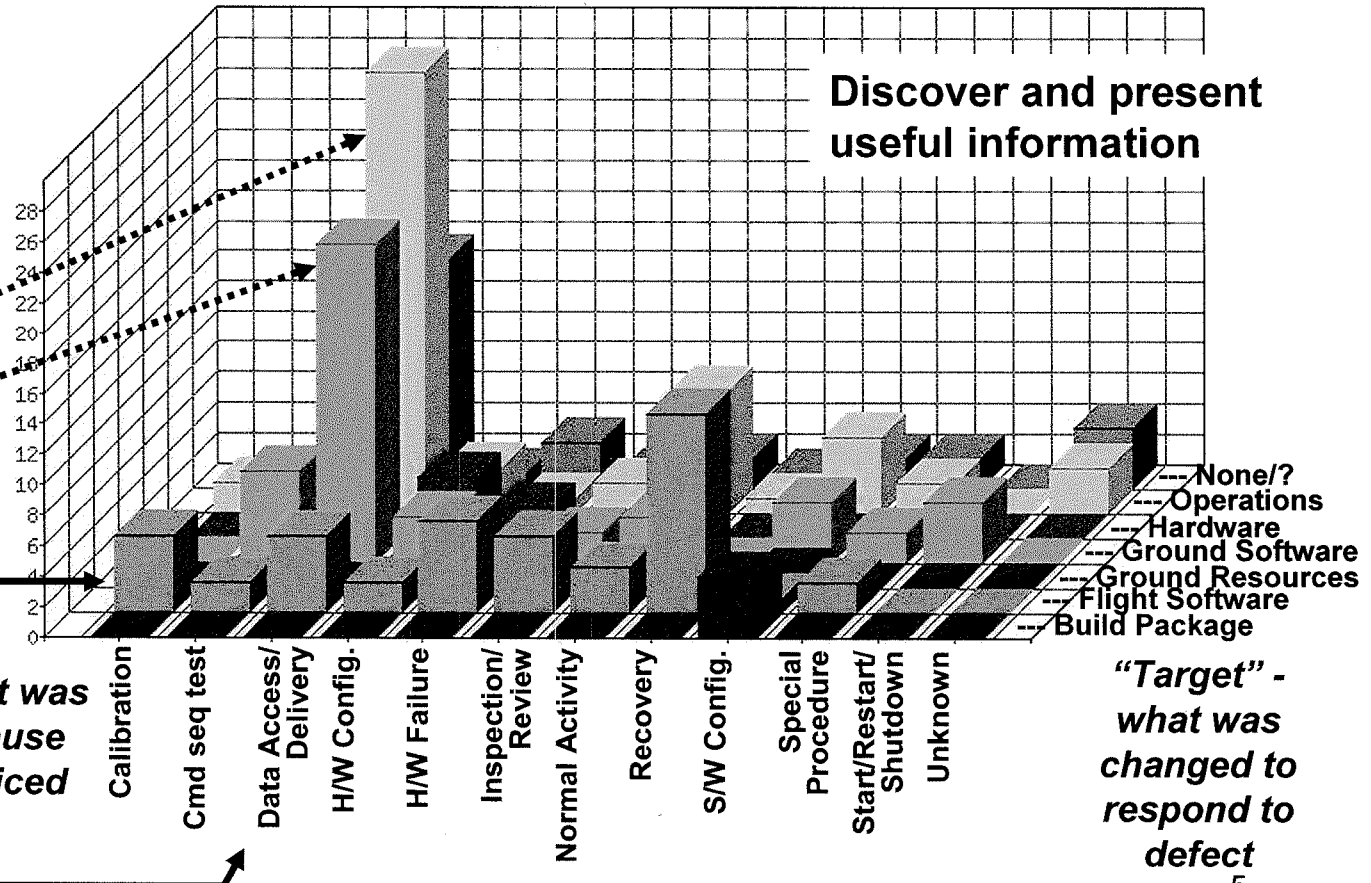
*Objective: Investigate and characterize the common causes of **safety-critical, in-flight software anomalies** on spacecraft. The work uses a defect-analysis technology called Orthogonal Defect Classification, developed at IBM. A rigorous pilot study approach using the Glass criteria is currently underway.*

7 space missions: 189 defects classified; chart shows one of the 6 possible 2-way views into this information

Large number of defects seen during sending commands to / receiving data from spacecraft.

Of these, many were responded to by changing operational procedures or software on the ground.

For other defects, changes to flight software more prevalent



"Trigger" – what was happening to cause defect to be noticed

"Target" - what was changed to respond to defect

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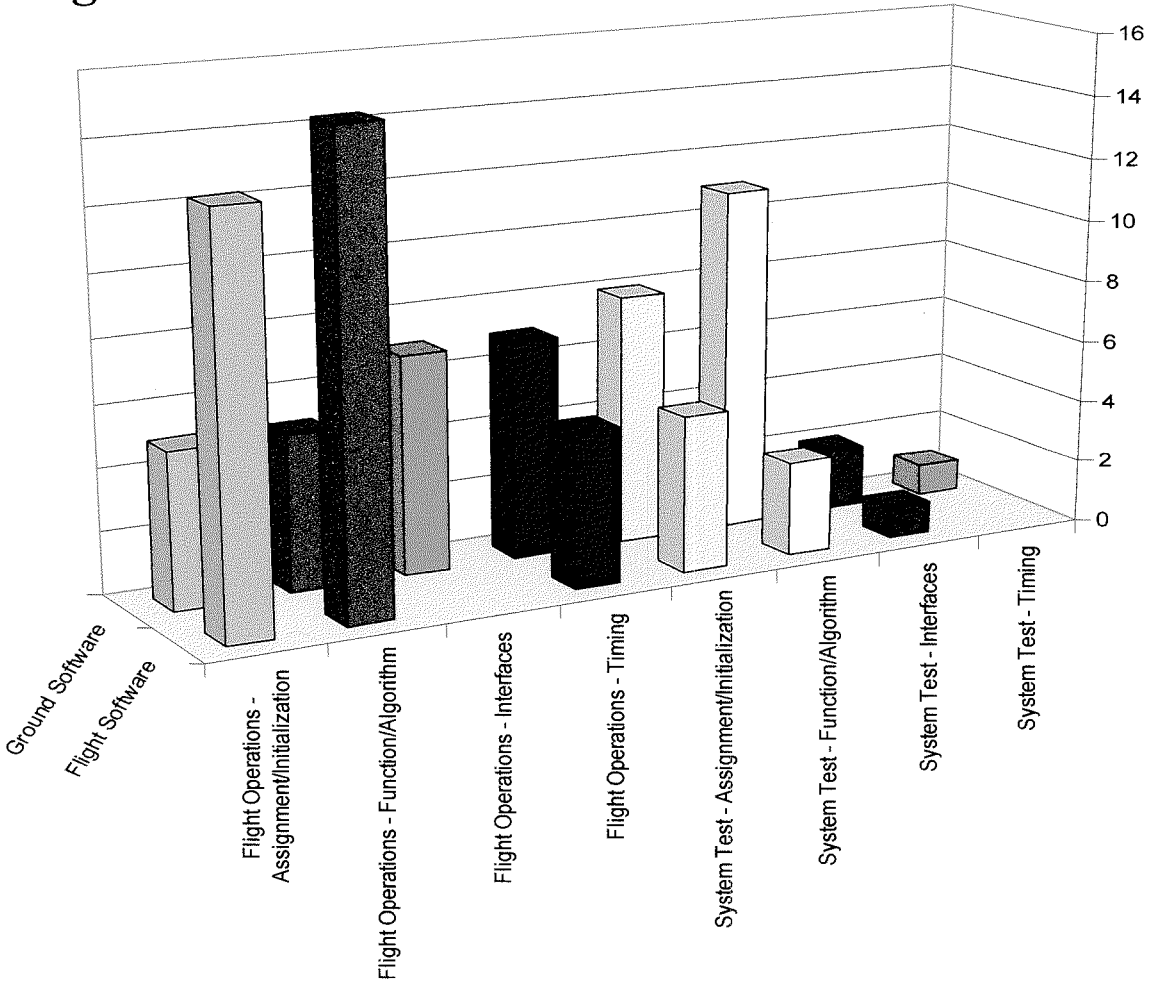
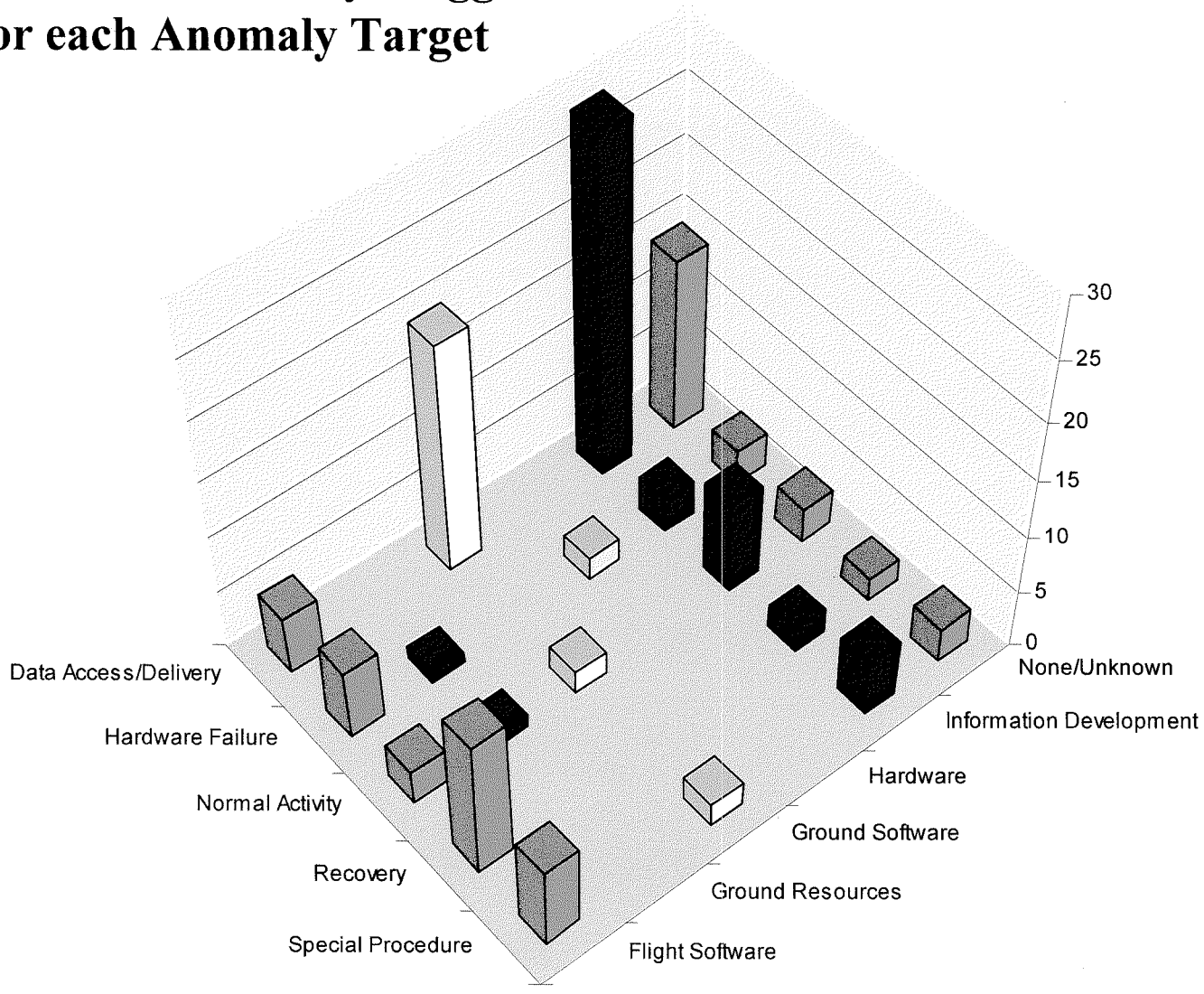
Sample Analyses

Prevalence of Anomaly Types for Ground and Flight Software within Activities



Prevalence of Anomaly Triggers for each Anomaly Target



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Contribution

- User selects preferred representation (e.g., 2-D bar graph) and set of projects to view
- Data mines historical and current databases of anomaly and problem reports to feed-forward into future projects
- Uses metrics information to identify unexpected patterns and focus on problem areas
- Provides rapid quantitative foundation for process improvement
- Equips us with a methodology to continue to learn as projects and processes evolve

For More Information

- **"Evolution of Safety-Critical Requirements Post-Launch," R. Lutz and C. Mikulski, *Proc. Fifth IEEE International Symposium on Requirements Engineering (RE'01)*, Toronto, Canada, Aug. 27-31, 2001.**
- **"Formalized Pilot Study of Safety-Critical Software Anomalies," NASA Office of Safety and Mission Assurance Software Assurance Symposium, Morgantown, W VA, Sept. 4-7, 2001.**
- **"Operational Anomalies as a Cause of Safety-Critical Requirements Evolution,"R. Lutz and C. Mikulski, *The Journal of Systems and Software*, to appear.**
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