How Many Developers?

Staffing Strategies for Maintenance of Critical Software Systems at the Jet Propulsion Laboratory

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Mission Critical Software

- How do you get to another planet?
  - You're going need a couple million lines of code.
    - That code is going to have bugs
    - Bugs can be mission ending
  - You're going to have to fix bugs
    - You are going to need software developers
    - The laws of physics don't wait for you to respond
  - How do I staff for this?
    - Not enough, I can't fix things
    - Too many, I'm losing resources elsewhere

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JPL Navigation Software

- About 800,000 lines of code
- We know our process
  - Productivity
  - Number of bug discoveries per day
  - Defect density
  - Distribution of time required to fix a bug.
- Staffing based on intuition
  - Staffing justification "*If we don't have this many people, things will be bad*"

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Staffing Based On Size—A Simple, Wrong Idea

- It would be nice to have a simple rule of thumb
  - I've got N lines of code
  - A developer can maintain M lines of code
  - To maintain my code I need N/M developers
- It has an element of plausibility
  - Larger systems have more bugs
  - A developer can only know a portion of a large system
- The problem is I cannot get a value for M
  - How do I determine M ?
  - How do I defend my value?
- This model ignores
  - Maintenance response to the number of issues received
  - Maintenance depends upon the time needed to respond to an issue.

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Staffing for Maintenance as Risk Mitigation

- Mission failures (like most failures) are generally the result of many small failures.
  - We address issues to enhance the odds of success—removing the small failures.
  - Schedules may be driven by physics.
  - Not being able to address a new issue allows the many small failures to accumulate
    - Ability to address issue depends upon staff available
- Staffing needs to be adequate to ensure timely resolution of issues
    - Paying for staff is risk mitigation
      - Staffing is a running taxi meter
    - What is the smallest staff that mitigates the risk?

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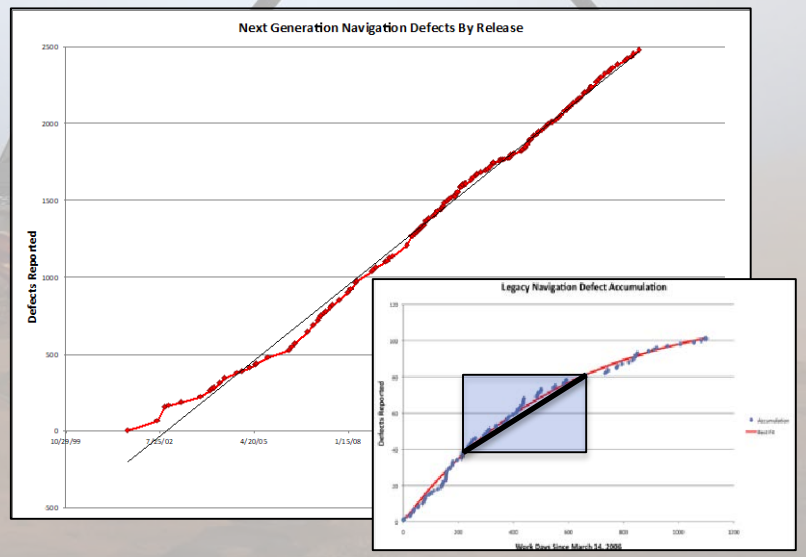
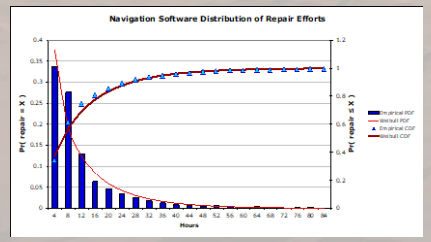
Just Keeping Up

- Issues arrive at some mean rate for a long time

  r issues/day (0.49)
- Mean effort

  E days/issue (1.28)





- k developers resolve issues at a rate

  k/E issues/day

To just keep up $k > rE$ (1.78)

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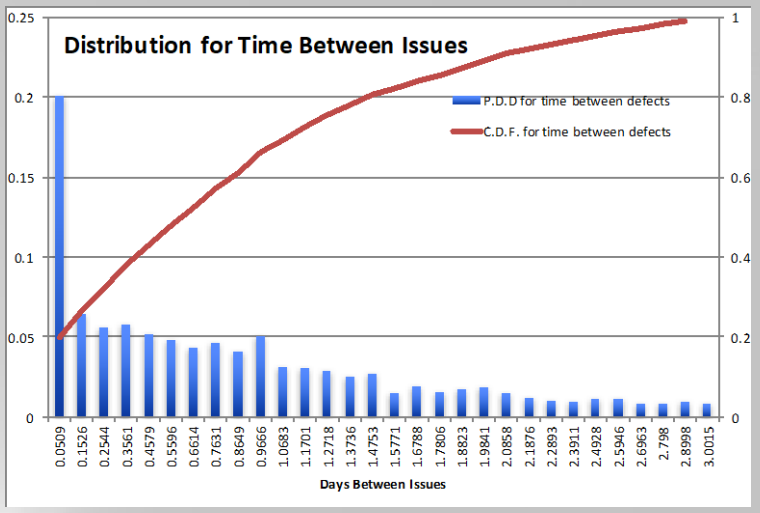
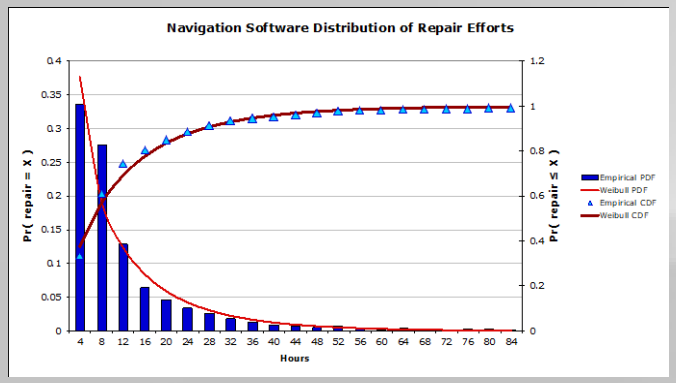
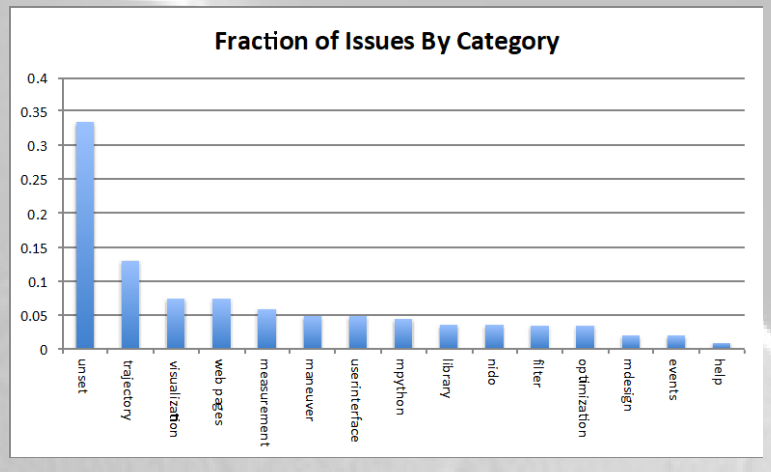
Simulation

- Issue creation distribution
- Effort Resolution
- Areas of expertise
- Learning Model







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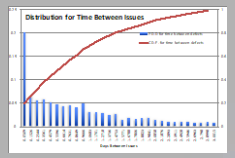
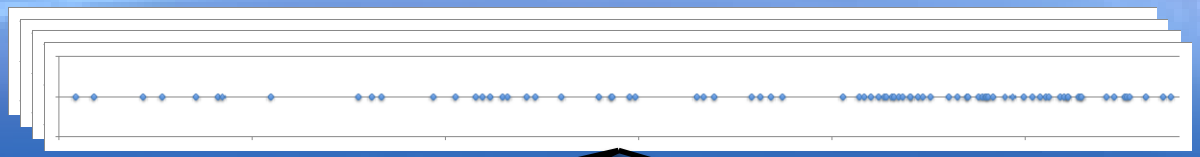
Simulation (2)

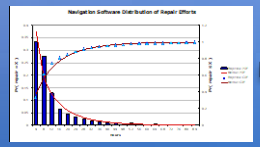


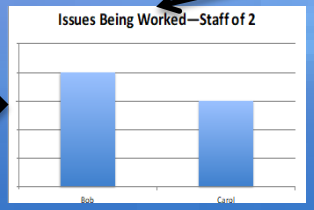
Distribution for times between issues

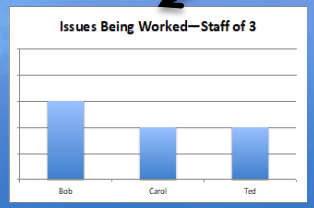
Issue History Generator

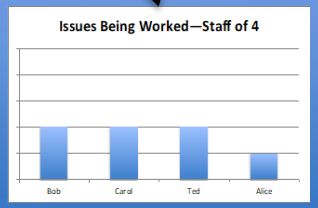


Distribution for Effort to resolve









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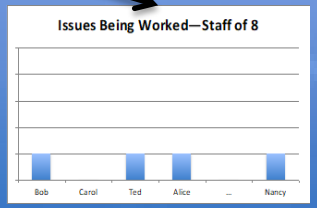
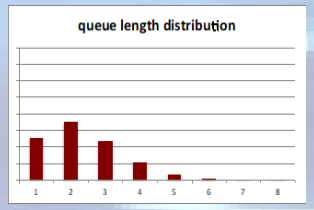
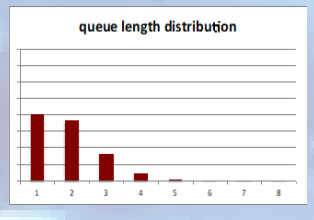
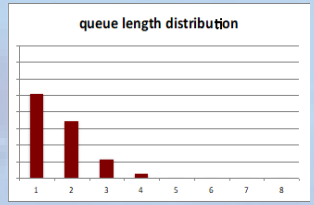


Distributions for Queue sizes, Open times







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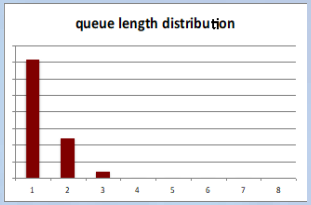

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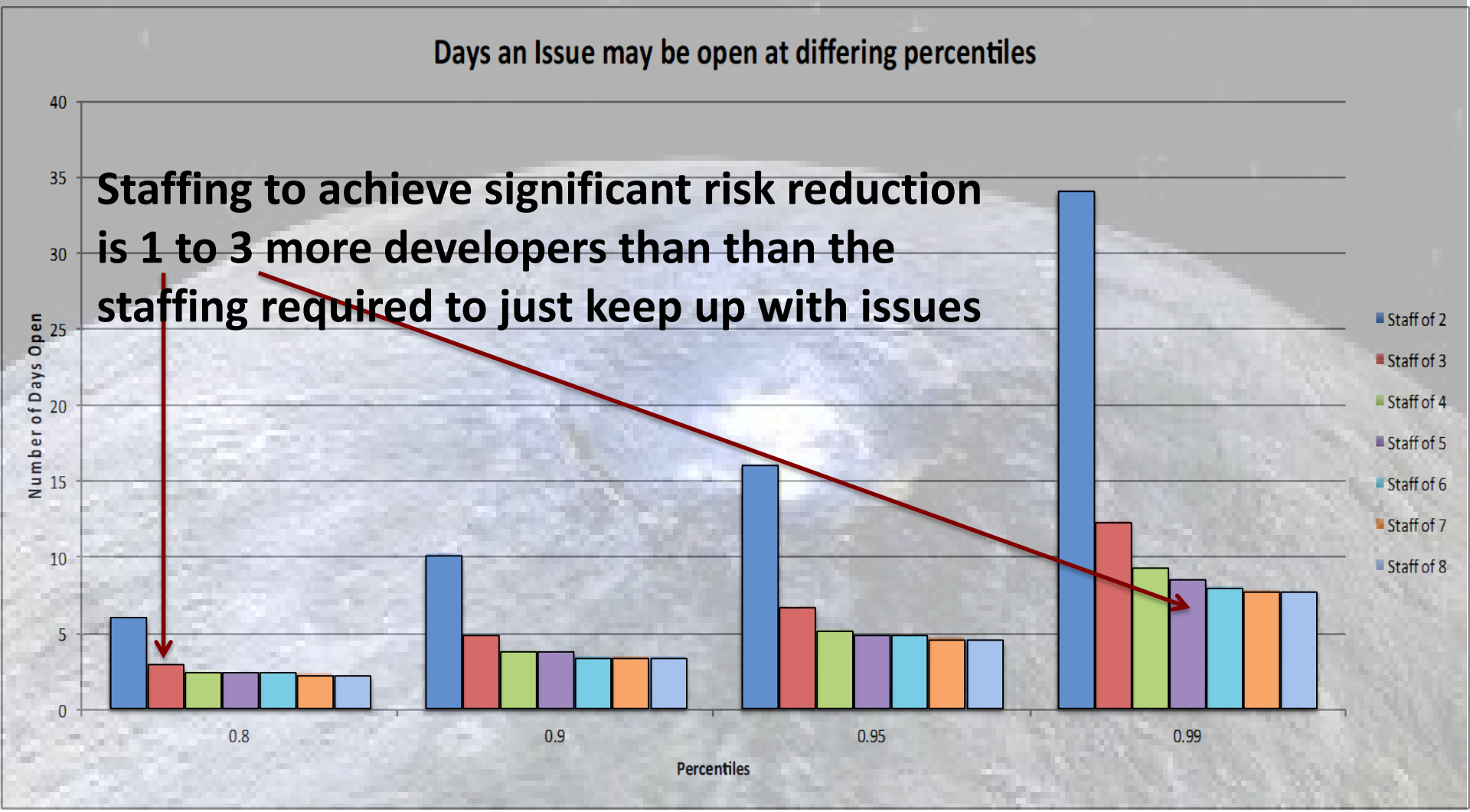
Results



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Results (2)

- **Given Probability(issue open after t days, staff size k)**
  - **We can determine staffing that successfully resolves issues y % of the time in t days or fewer**
  - **Balance this against the cost of maintaining a staff of a given size.**
- **Staffing discussions focus on institutional risk**
- **Staff does not have to be idle**
  - **New features**
  - **User support**

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Next Steps

- How should resources be allocated?
  - We have same maintenance issues
  - Different approach to addressing funding with sponsors
- Advocate for Metrics
  - Models enabled by over a decade of disciplined data collection

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Conclusions

- **Maintenance needs to be viewed as a risk mitigation question. Staffing is a function of**
  - **Issue discovery**
  - **Issue response**
  - **Risk comfort**
- **Costs are large**
- **Probabilities are small, but almost certainly larger than you think.**
- **Staffing sizes to lower your risk are are more than the amount it takes to stay even, but not a lot.**

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