The Silent *S* in NICM: NICM Schedule Capabilities

Presenters:
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Jet Propulsion Laboratory
California Institute of Technology

NICM Team

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What is NICM?

- NASA Instrument Cost Model
  - Probabilistic Cost Estimates for Space Flight Instruments
  - Used by all NASA Centers
    - And any organization proposing instruments for NASA Instruments
    - And proposal evaluators
  - Version I Released in 2007
  - Version VII Rev 2 Released 2016

What is NICM?

- NICM also:
  - Estimates schedule
  - Supports JCL
  - Contains an normalized instrument database (for civil servants)
- NICM Terminology:
  - Remote Sensing vs in situ
  - Earth Orbiting vs Planetary
  - Instrument Types

Yes – you can get a copy of NICM

- RSVP for only training at:

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Just kidding, you'll never remember that

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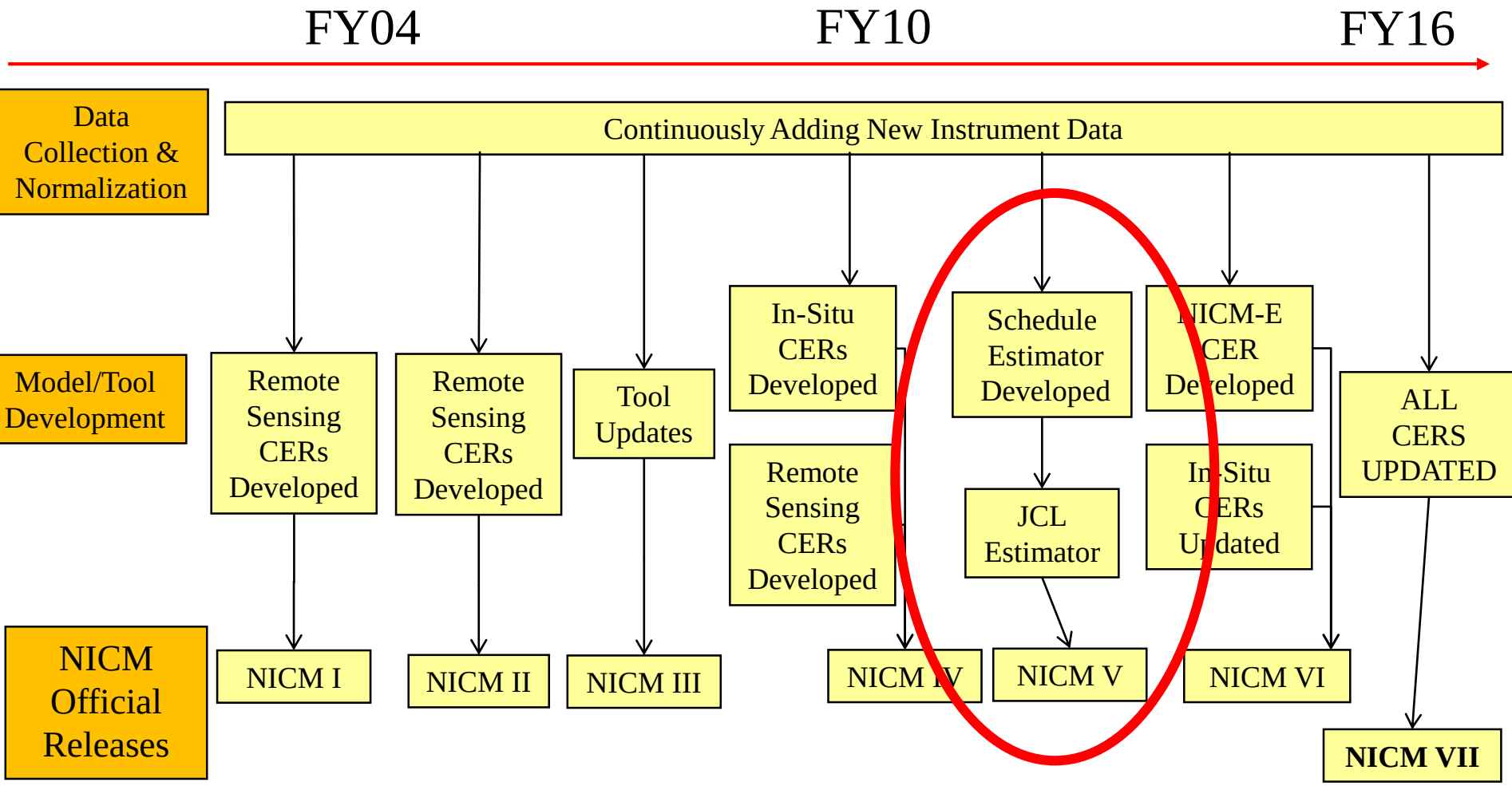
Today's Story: Schedule Estimation



Agenda

- Data Exploration:
  - Histograms, Box Plots
  - Cluster Analysis
  - Principal Components Analysis (PCA)
- Draft SERs for NICM VIII
- Future Work
- Feedback
  - Especially from our new schedule friends!

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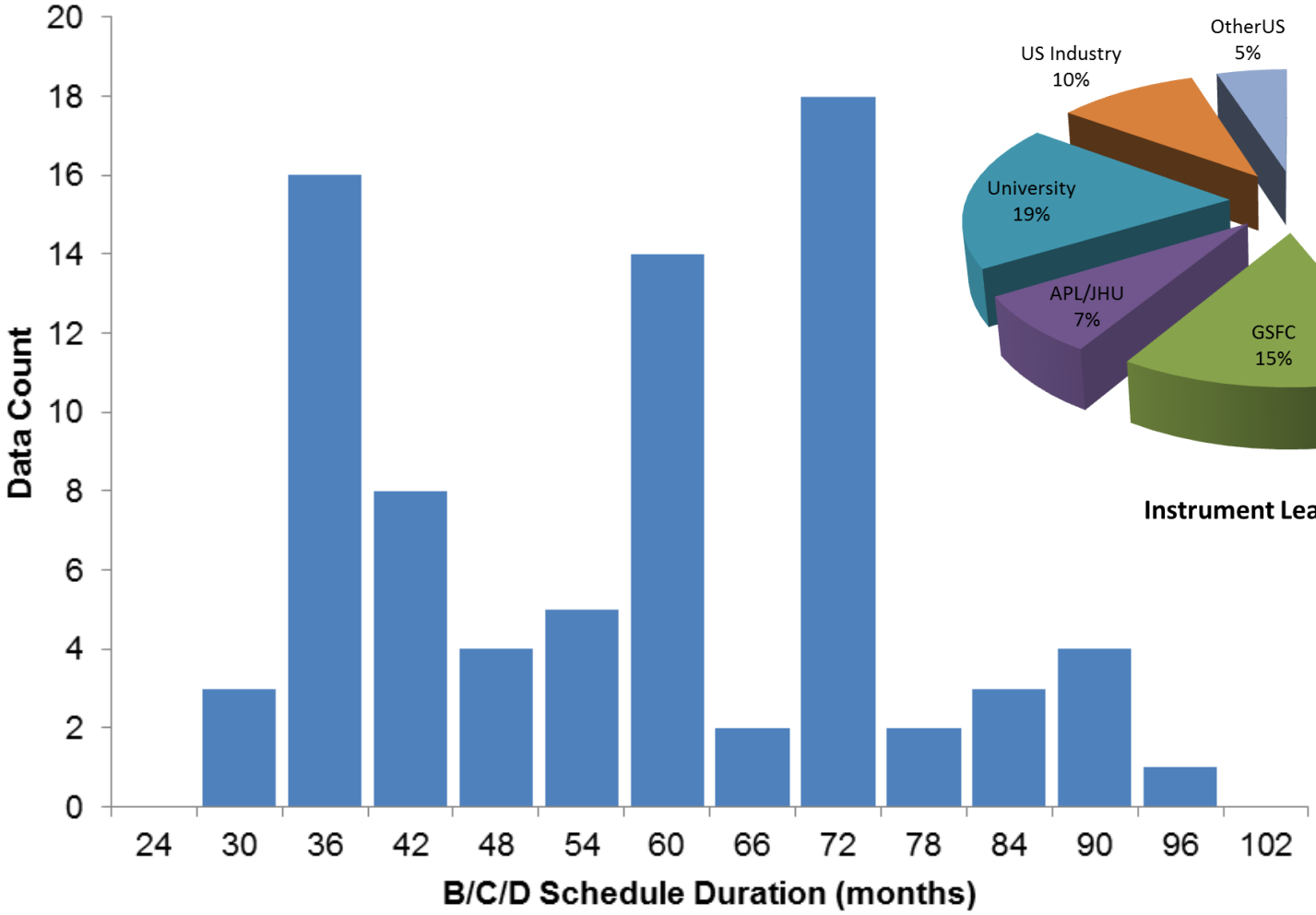
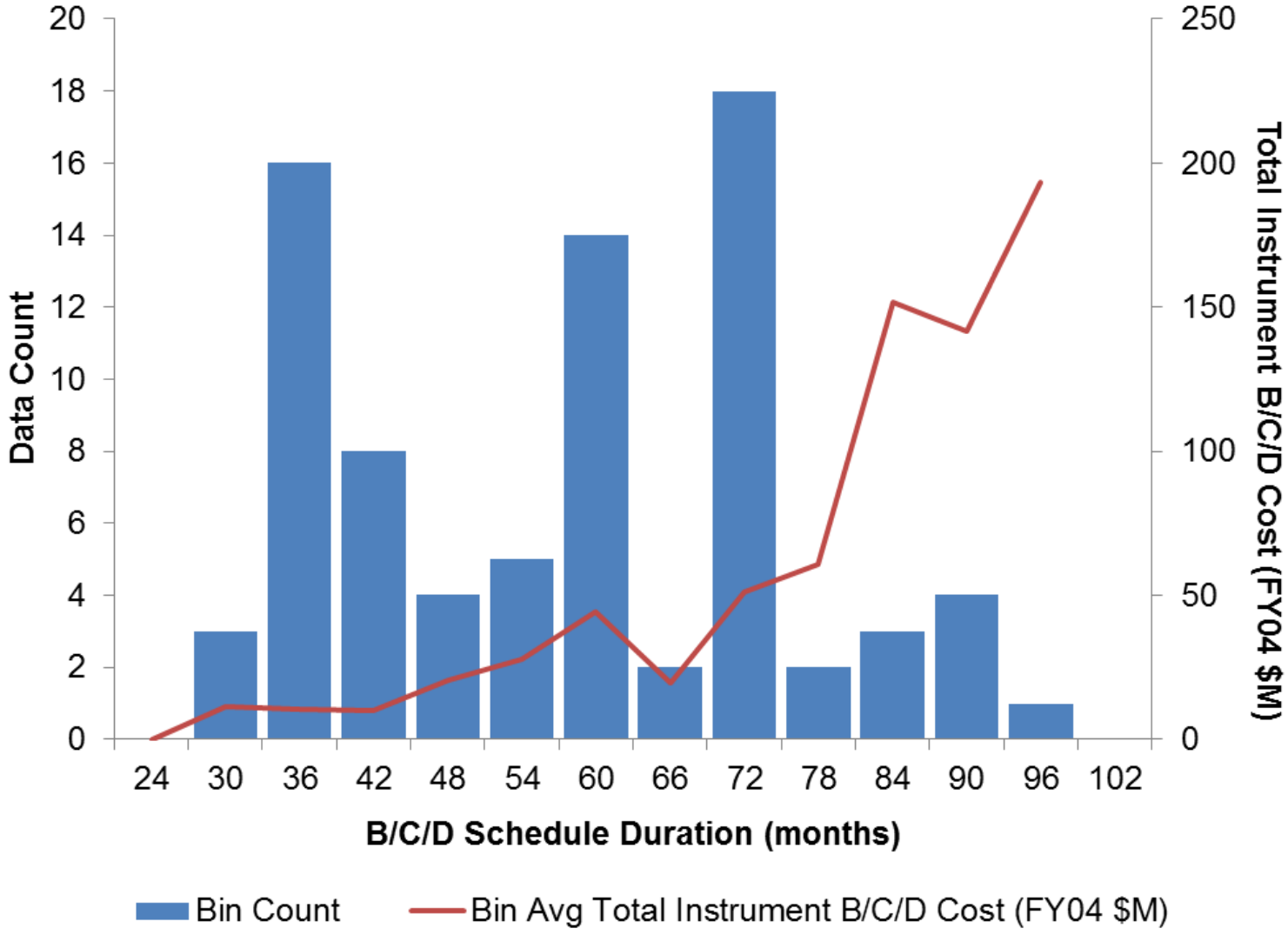
80 Data Points analyzed from across the NASA Community



Instrument Lead Organization

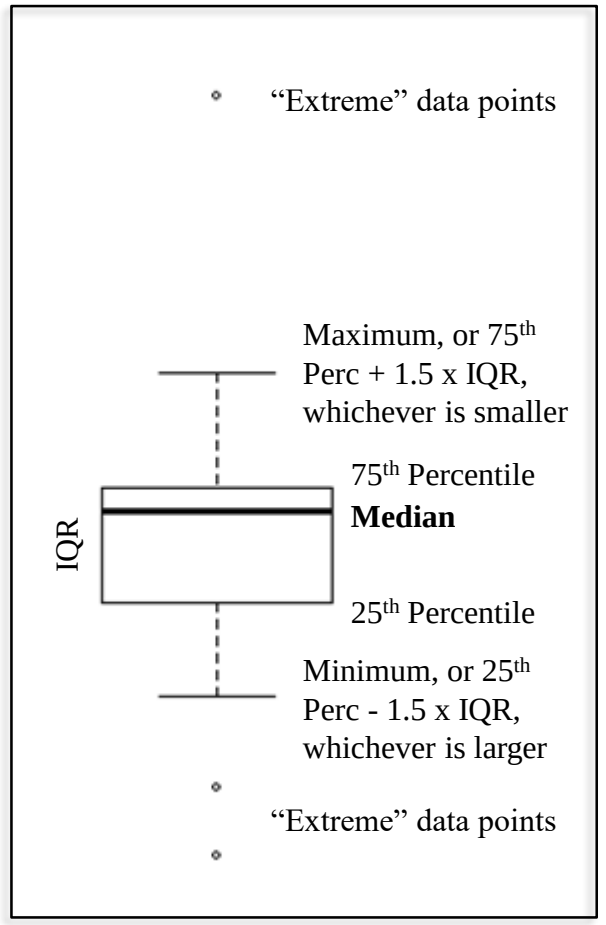
Cost & Schedule are Correlated



Using Box Plots to Find Important Attributes in Data

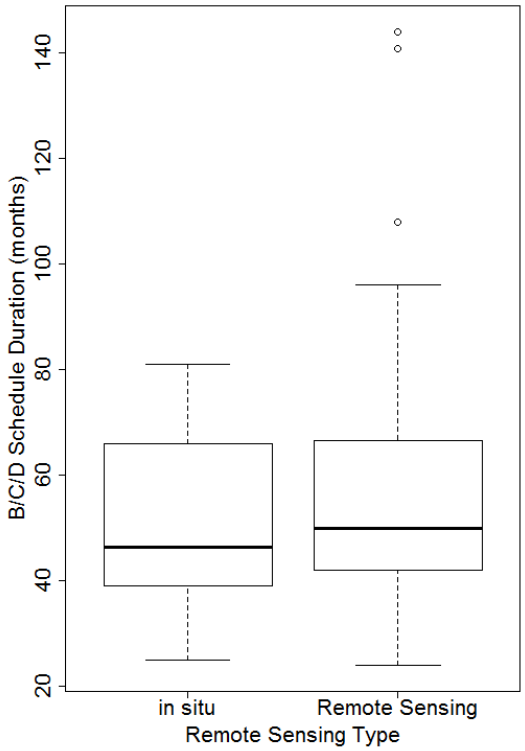
- Great way to find important categorical attributes in the data
  - Box plots give a feel for the distributions in the data without having to make any assumption on the distributional form
  - Informs regression analysis

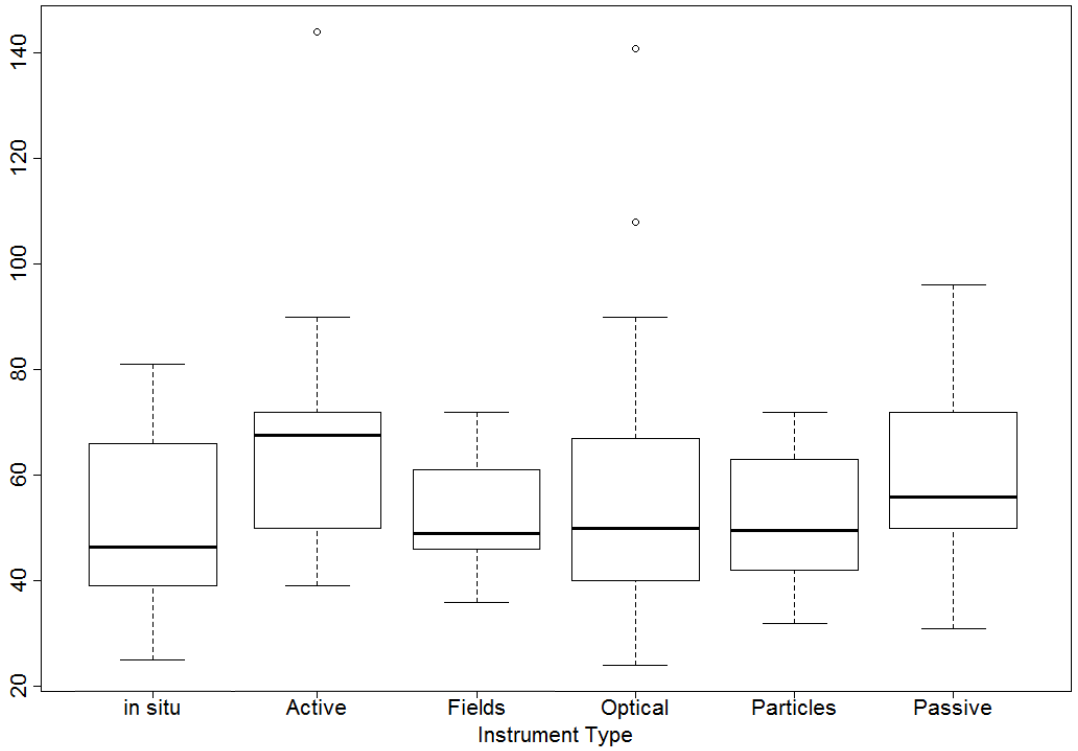
- Box plots are defined according to the picture to the right
  - IQR = Inter-Quartile Range = 75th percentile minus 25th percentile



Schedule Duration by Instrument & Sensing Type

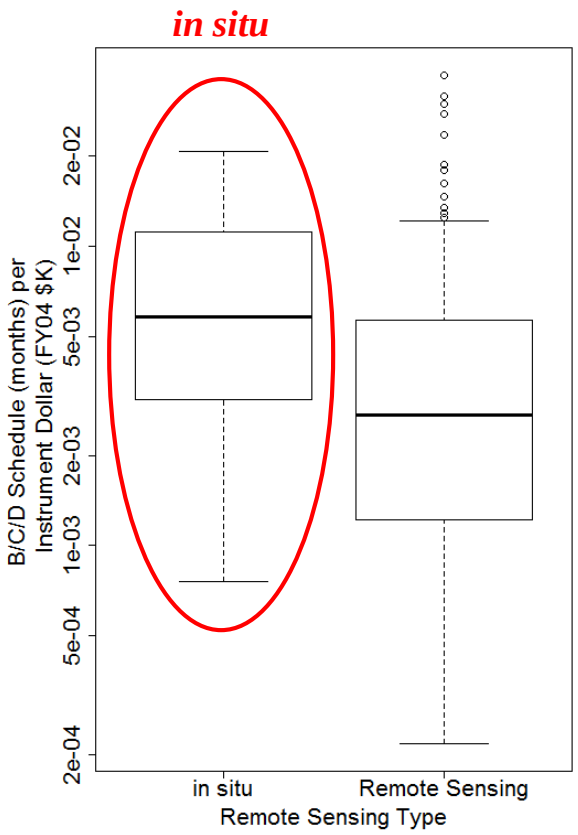
Data by instrument and sensing type do not look much different when looking at *absolute* schedule duration…

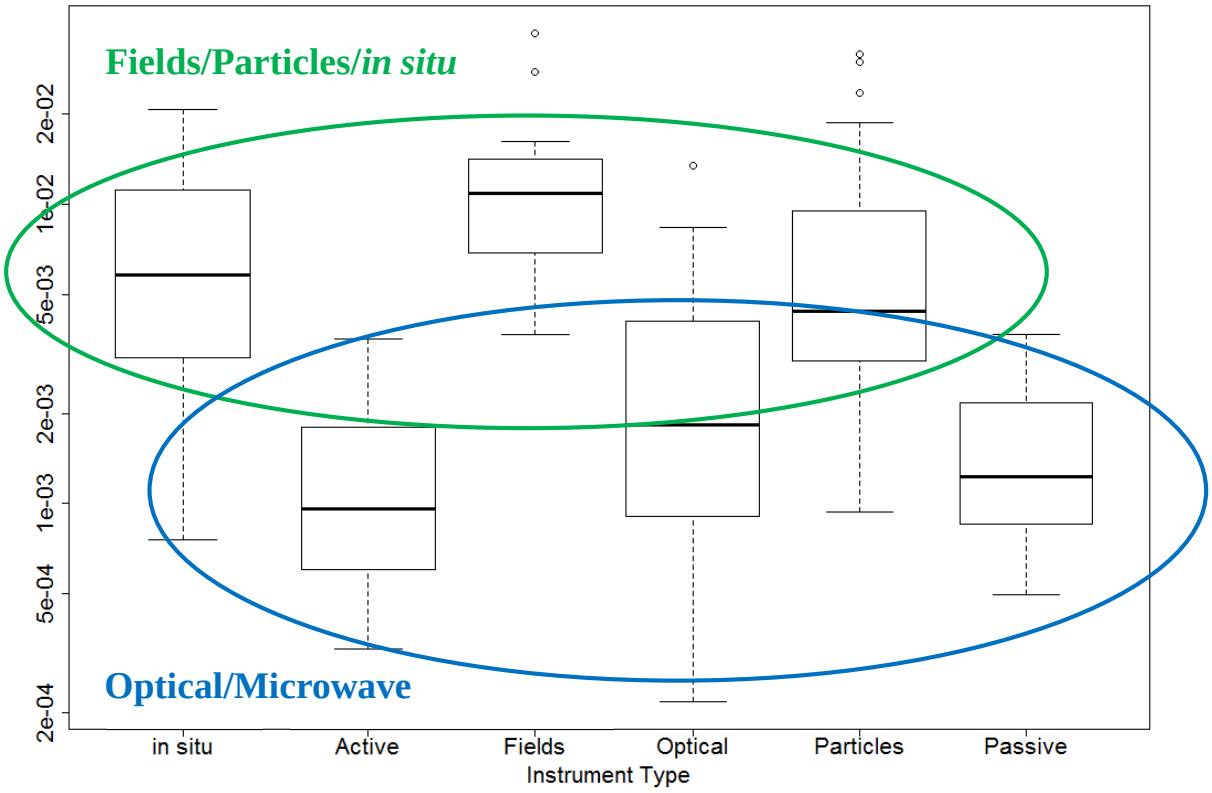




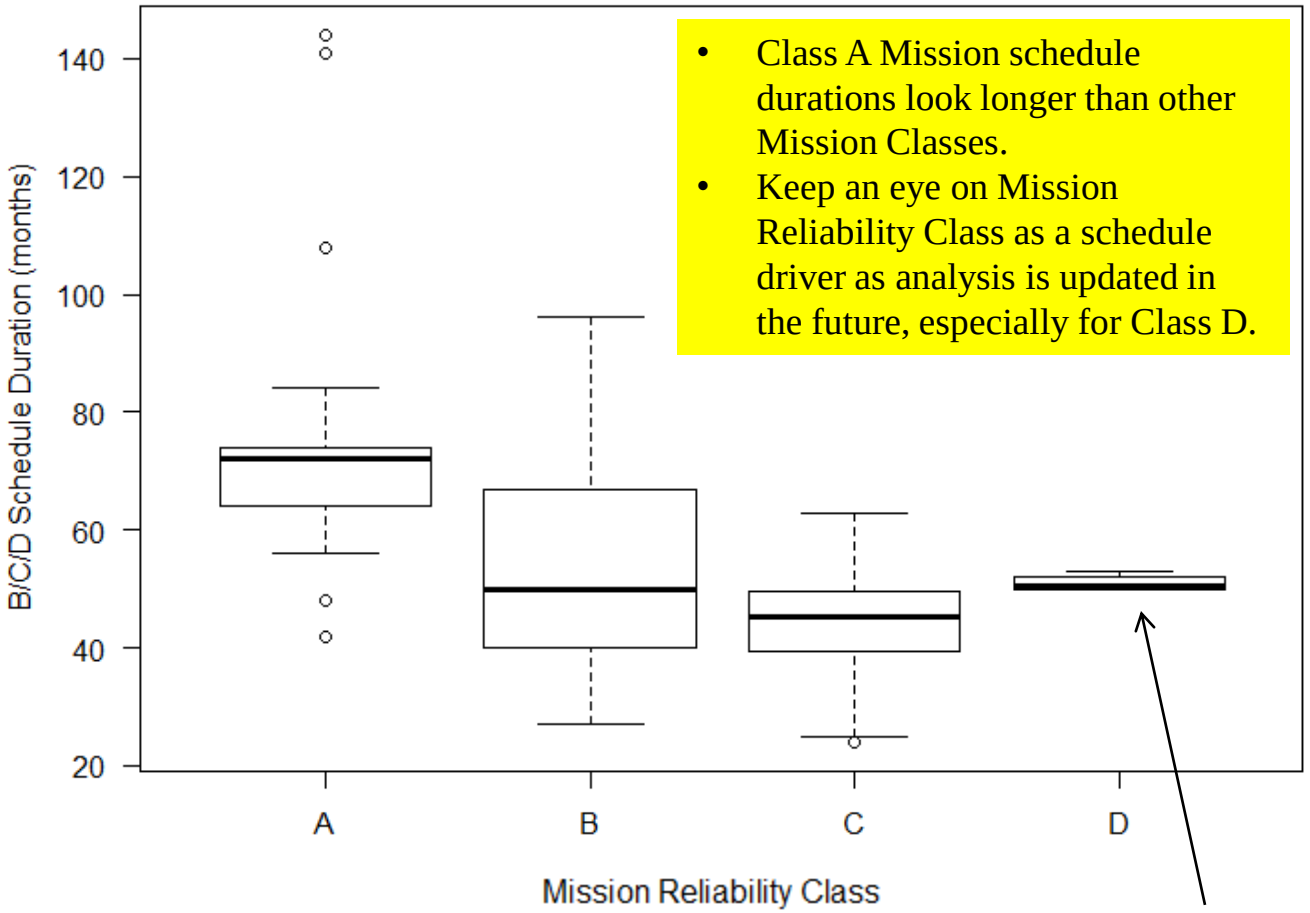
Schedule per Dollar by Instrument & Sensing Type

…but Schedule Duration **per Dollar** shows potential group differentiation for *in situ*, Fields/Particles and Optical/Microwave instruments





Schedule Duration by Mission Reliability Class

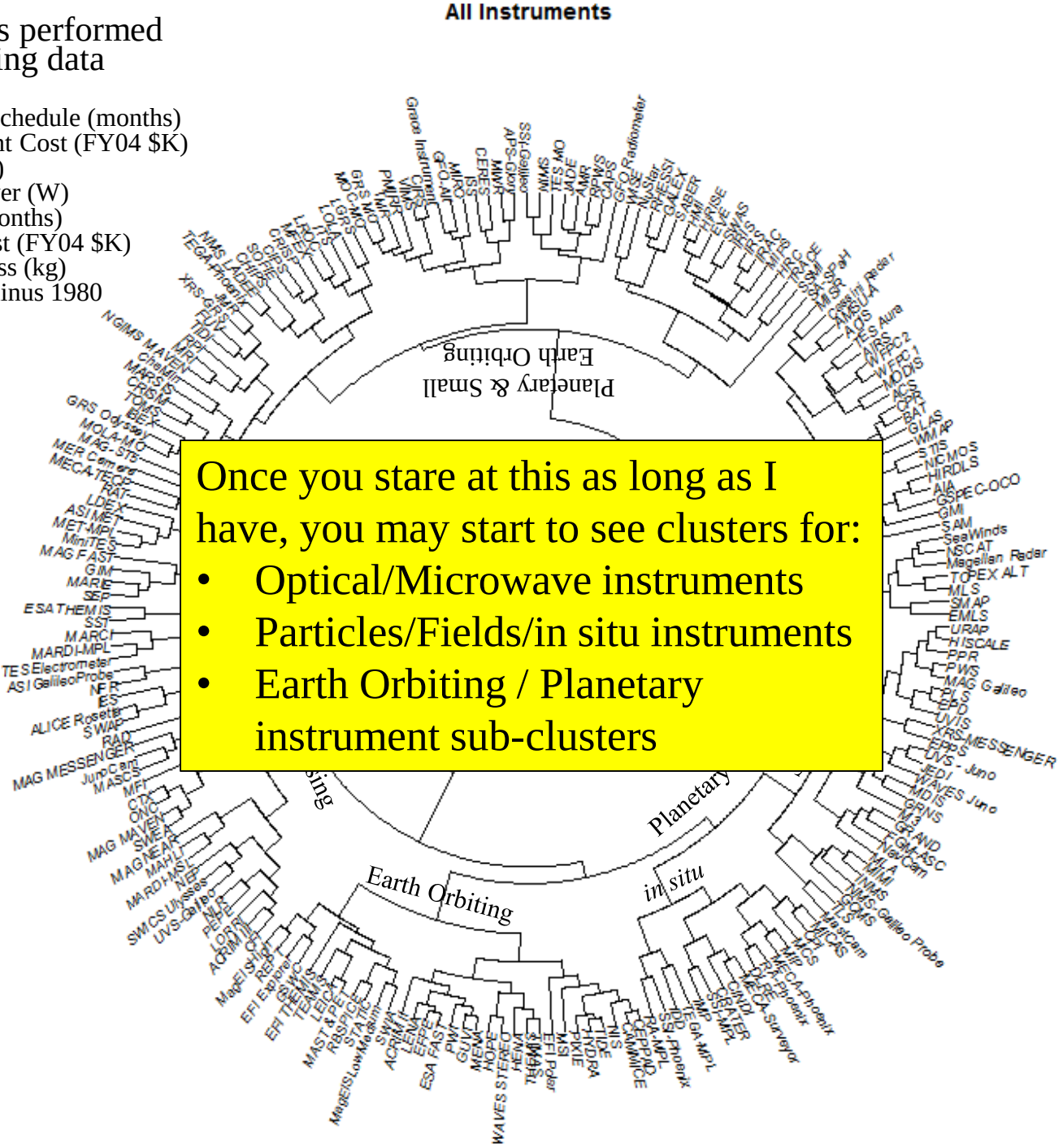


- Class A Mission schedule durations look longer than other Mission Classes.
- Keep an eye on Mission Reliability Class as a schedule driver as analysis is updated in the future, especially for Class D.

When LCROSS data are included (36 month development schedule), there will be a more significant difference between Classes C and D

Cluster Analysis performed used the following data attributes:

- Development Schedule (months)
- Total Instrument Cost (FY04 $K)
- Total Mass (kg)
- Total Max Power (W)
- Design Life (months)
- Electronics Cost (FY04 $K)
- Electronics Mass (kg)
- Launch Year minus 1980

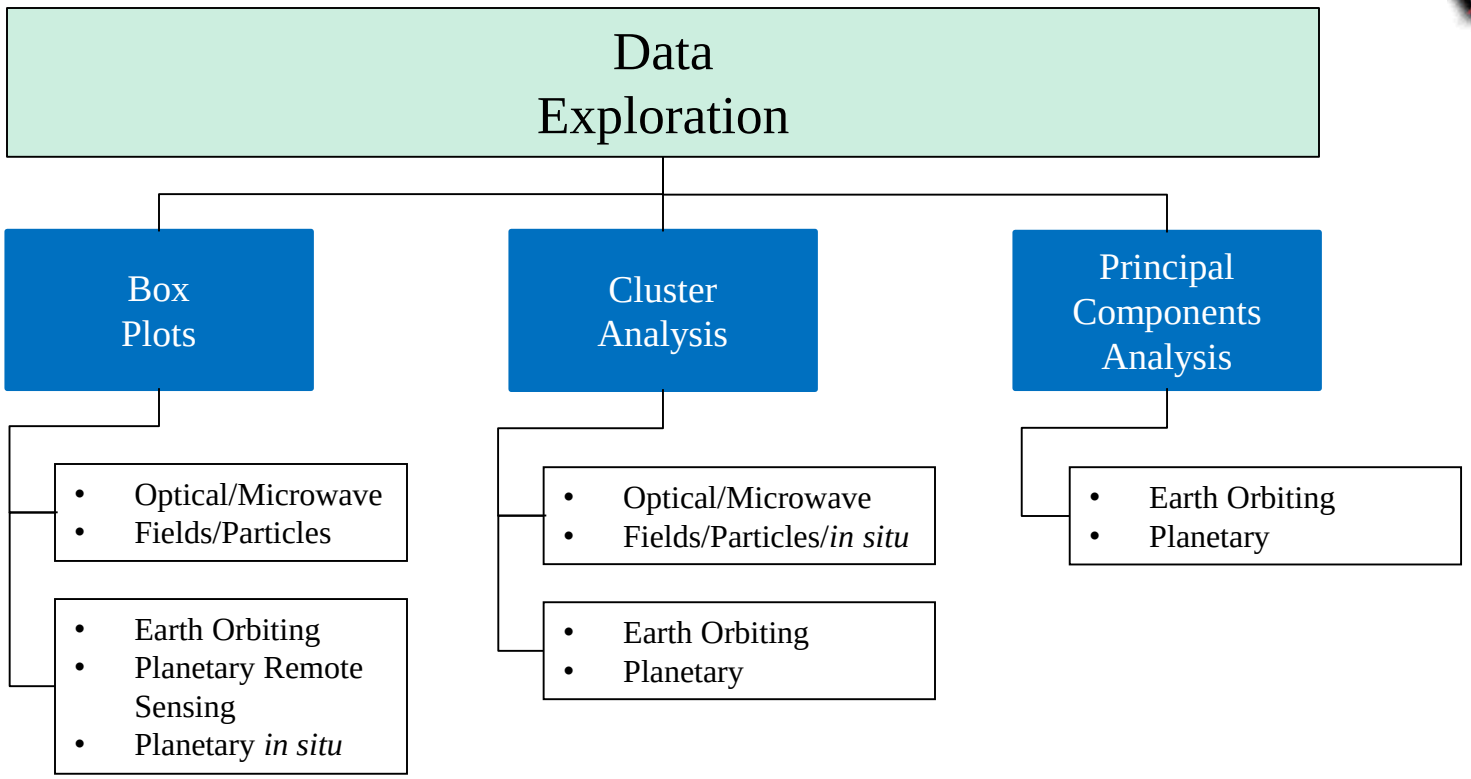


Principal Components Analysis (PCA)

- What if we could somehow look at all variables at once and determine how they are correlated?
  - Specifically, what is correlated with schedule duration?
- What if we could identify combinations of variables that explain the most variation in the data
  - This could help us develop a regression relationship
- What if we saw the data projected onto the primary sources of variation in the data?
  - This is another way to see how our data might be clustering
  - Different than the previous clustering technique because it factors in correlation

These are some of the many benefits of PCA.

Data Exploration Conclusion



Final three groups for building SERs:

1. Earth Orbiting
2. Planetary, Remote Sensing
3. Planetary, in situ

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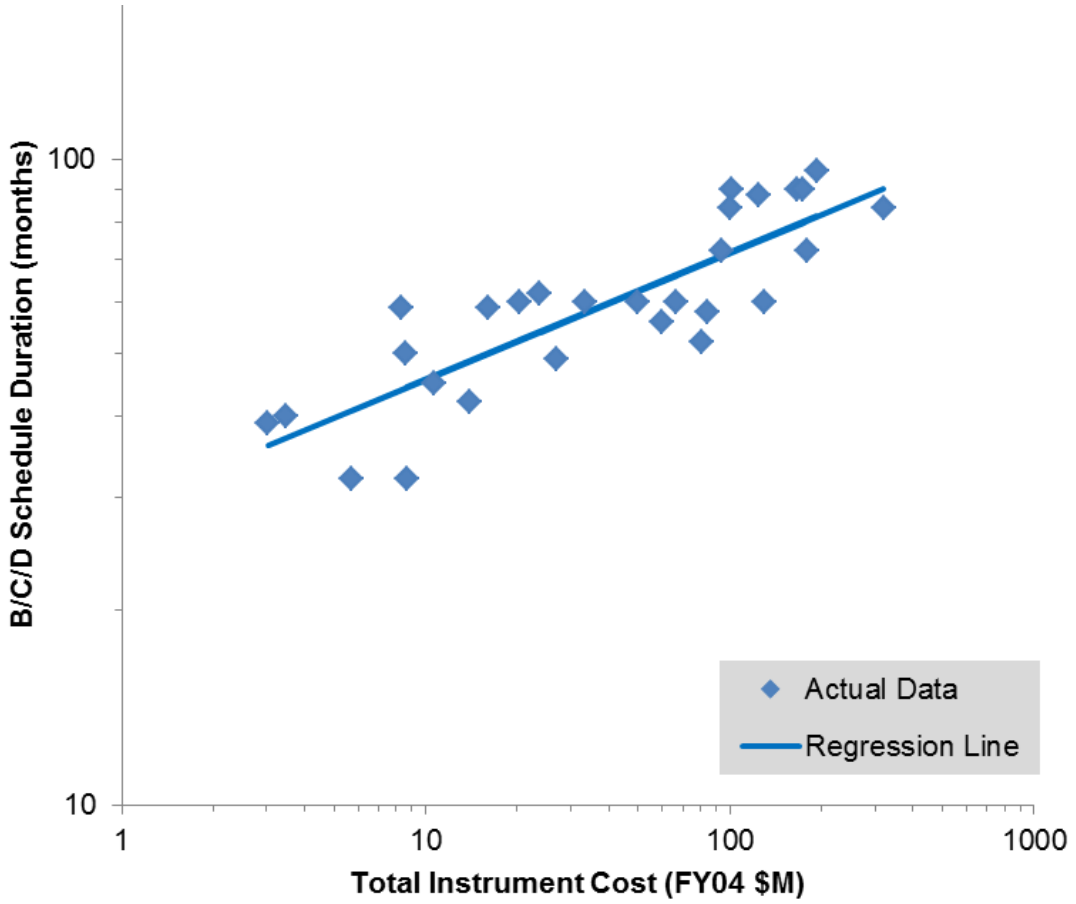
Earth Orbiting SER

$$\text{Schedule(months)} = 29 \times \text{Cost}^{0.20}$$

R^2 = 71%, PE = 18%, N = 28

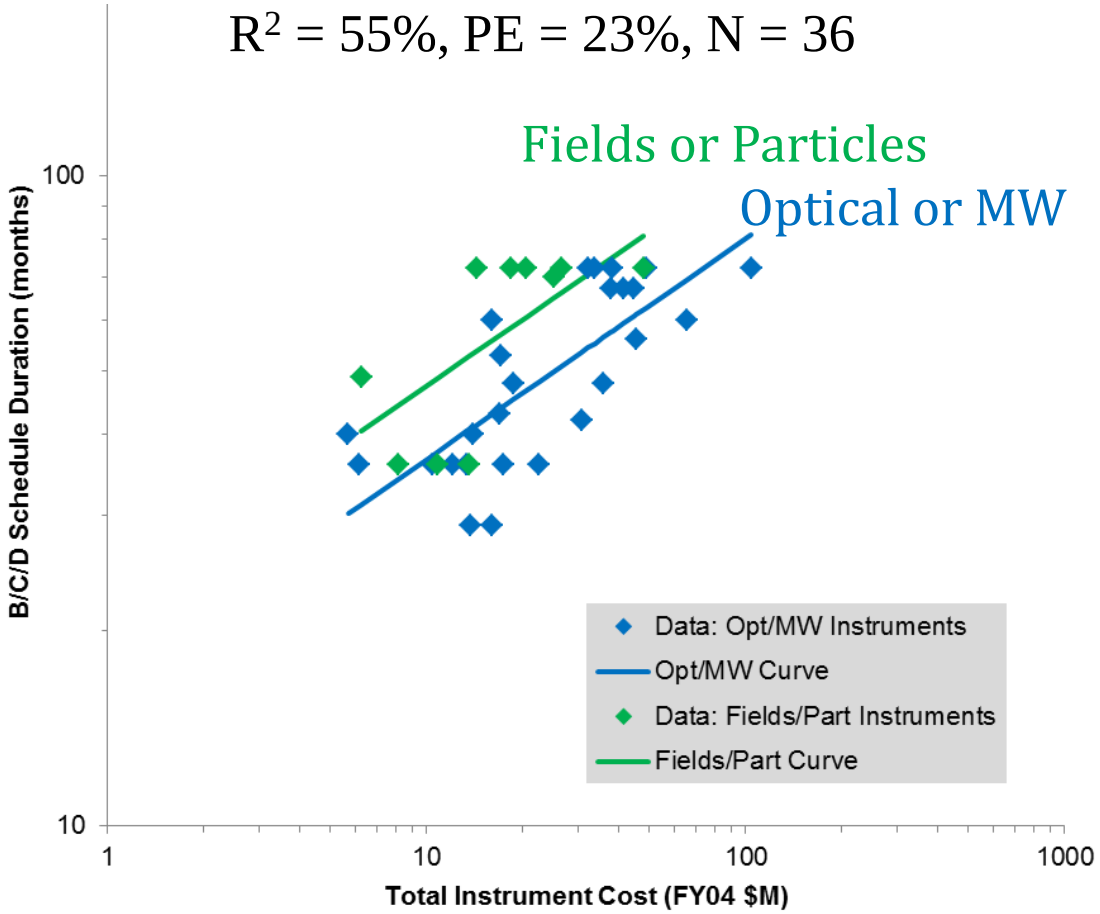


*PE = Prediction Error of SER (1-sigma); N = # of data points used on SER

Planetary, Remote Sensing SER

$$\text{Schedule (months)} = \begin{cases} 17 \times \text{Cost}^{0.34} & \text{if Optical or MW} \\ 22 \times \text{Cost}^{0.34} & \text{if Fields or Particles} \end{cases}$$

R^2 = 55%, PE = 23%, N = 36



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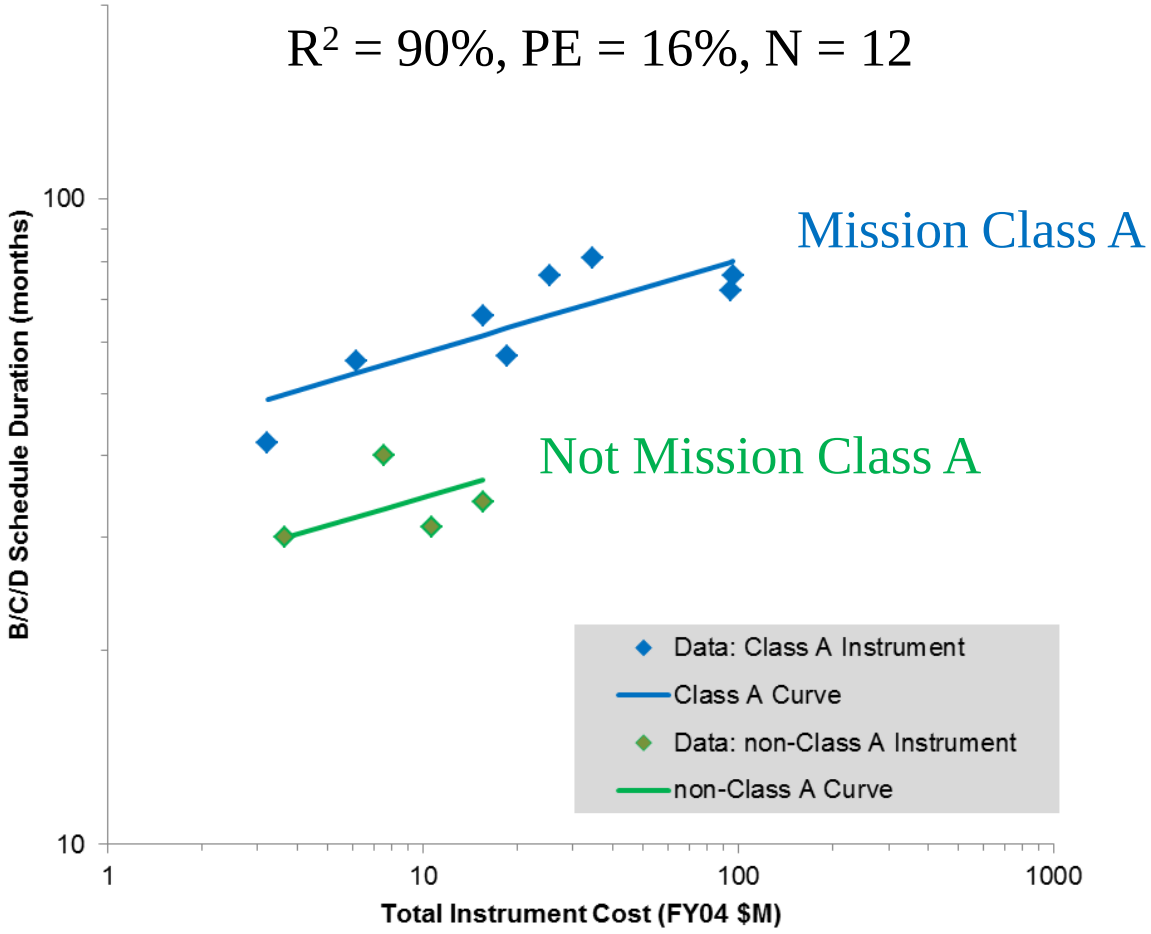
Planetary *in situ* SER

$$\text{Schedule (months)} = \begin{cases} 41 \times \text{Cost}^{0.14} \text{ if Mission Reliability Class A} \\ 25 \times \text{Cost}^{0.14} \text{ otherwise} \end{cases}$$

$R^2 = 90\%$, PE = 16%, N = 12



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Draft SERs for NICM VIII - Summary

Group	Equation	Statistics of Merit*
Earth Orbiting	$\text{Schedule} = 29 \times \text{Cost}^{0.20}$	R^2 = 71% PE = 18% N = 28
Planetary, Remote Sensing	$\text{Schedule} = \begin{cases} 17 \times \text{Cost}^{0.34} \text{ if Optical or MW} \\ 22 \times \text{Cost}^{0.34} \text{ if Fields or Particles} \end{cases}$	R^2 = 55% PE = 23% N = 36
Planetary, *in situ*	$\text{Schedule} = \begin{cases} 41 \times \text{Cost}^{0.14} \text{ if Mission Reliability Class A} \\ 25 \times \text{Cost}^{0.14} \text{ otherwise} \end{cases}$	R^2 = 90% PE = 16% N = 12

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Concluding Remarks & Future Work

- We have shown in this presentation:
  - Candidate SERs for NICM VIII
  - The analysis results that steered us to them
- From here we would like to:
  - Hear what you have to say!
  - Incorporate NASA cost/schedule community feedback into our modeling
- Other work we plan on doing:
  - Update analysis with NICM VIII dataset
    - Keep an eye on Mission Class and Design Life as potential parameters for SERs
    - Look more closely at *in situ* – Probe Mounted data
  - Incorporate updated SERs into the NICM VIII Tool

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Questions?