Lessons Learned, Tips and Tricks for Programmatic Analysis

by
Barney Roberts, Reed Integration
broberts@reedintegration.com

Image credit: NASA/Keegan Barber

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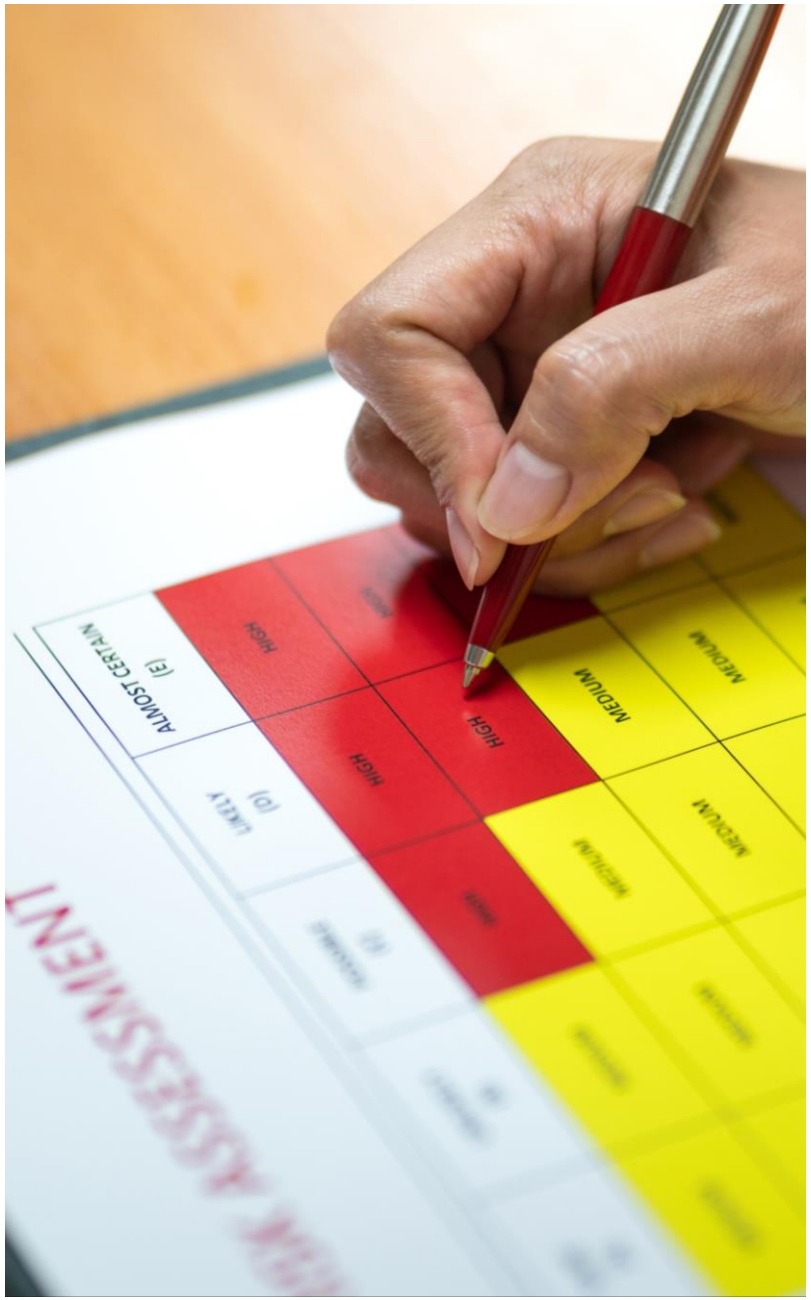
Introduction

This presentation is a composite of ***lessons-learned*** and ***tricks and tips*** collected over 30 years of performing program and project risk assessments.

- **Trending:** Erosion of the deterministic completion date, band-aid charts.
- Recommended approach for dealing with special issues.
- **Tips for programs with multiple projects:** Constrain human resources, facility availability and availability of ground support equipment.
- Tips on how to find and how to illustrate probabilistic critical paths.
- Best use of cost and schedule scatterplots.
- Tips on modeling planetary missions.



I hope these are helpful to you. I know that some of you already know some of these and maybe a few know all of them. However, the NCSS is a great place to show and archive them.

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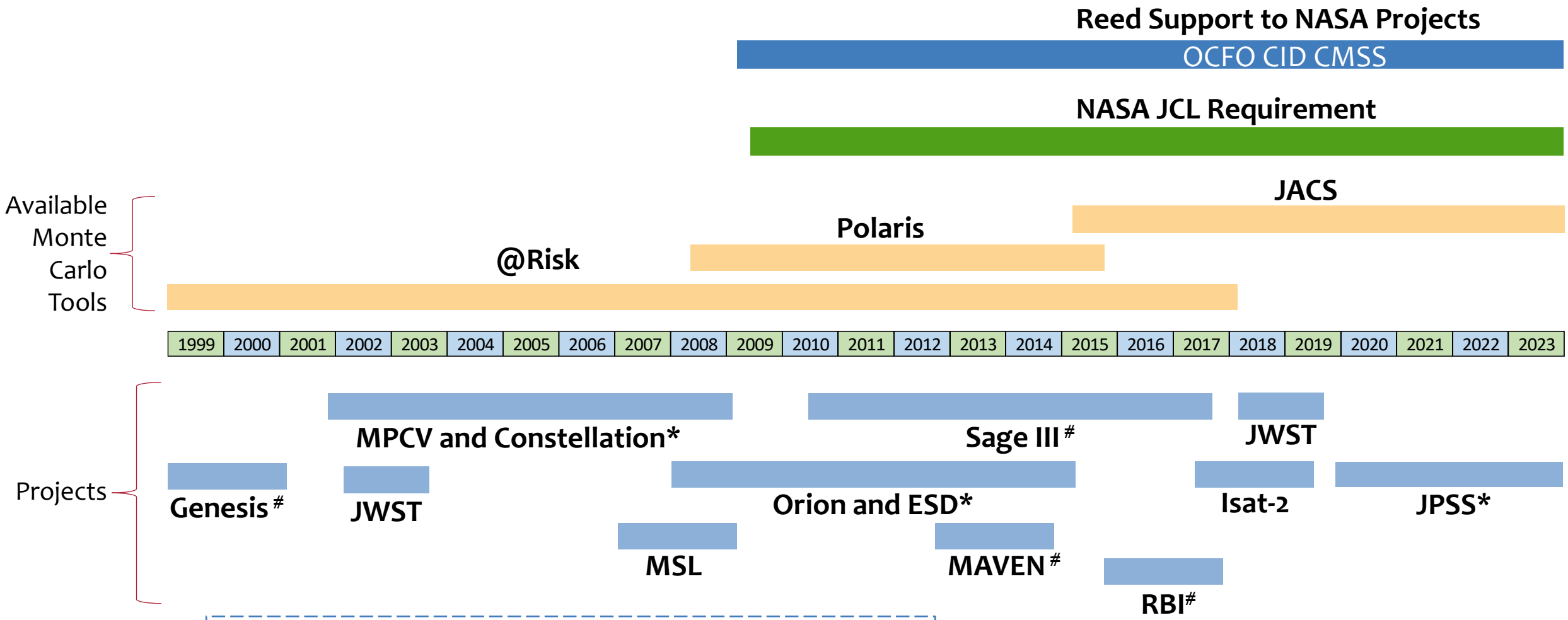
Time-line of Experience



*Multi-project Programs
#Direct support to project, all others are independent reviews

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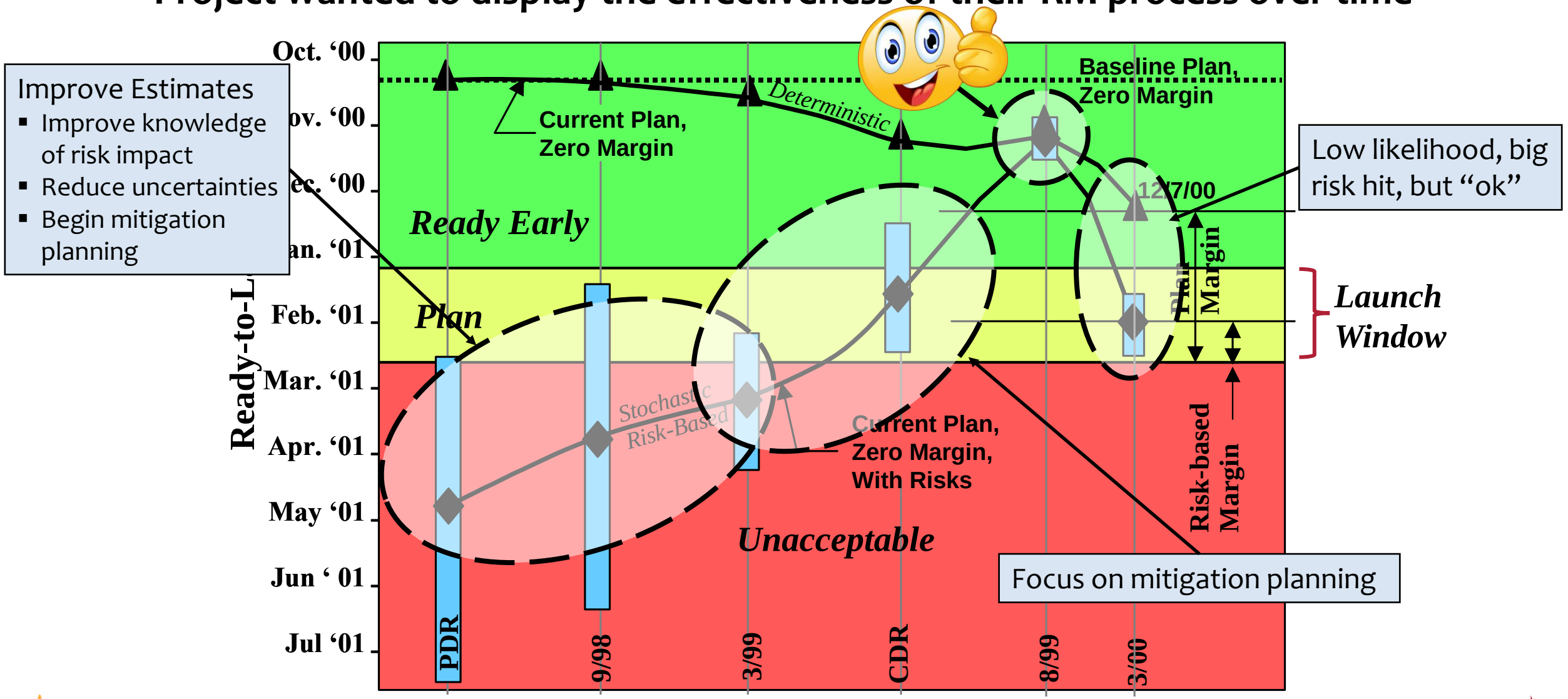
Topics
Trending and BandAids
How to Deal with Special Issues
Multi-project Programs
Probabilistic Critical Paths
Using Scatterplots
Planetary Missions

Schedule Risk Analysis Trending for Genesis

Project wanted to display the effectiveness of their RM process over time



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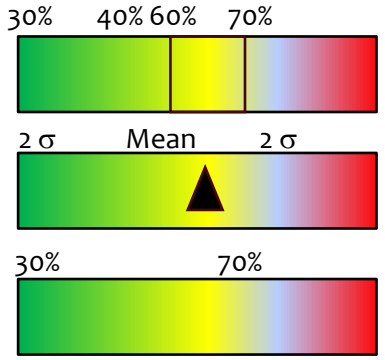
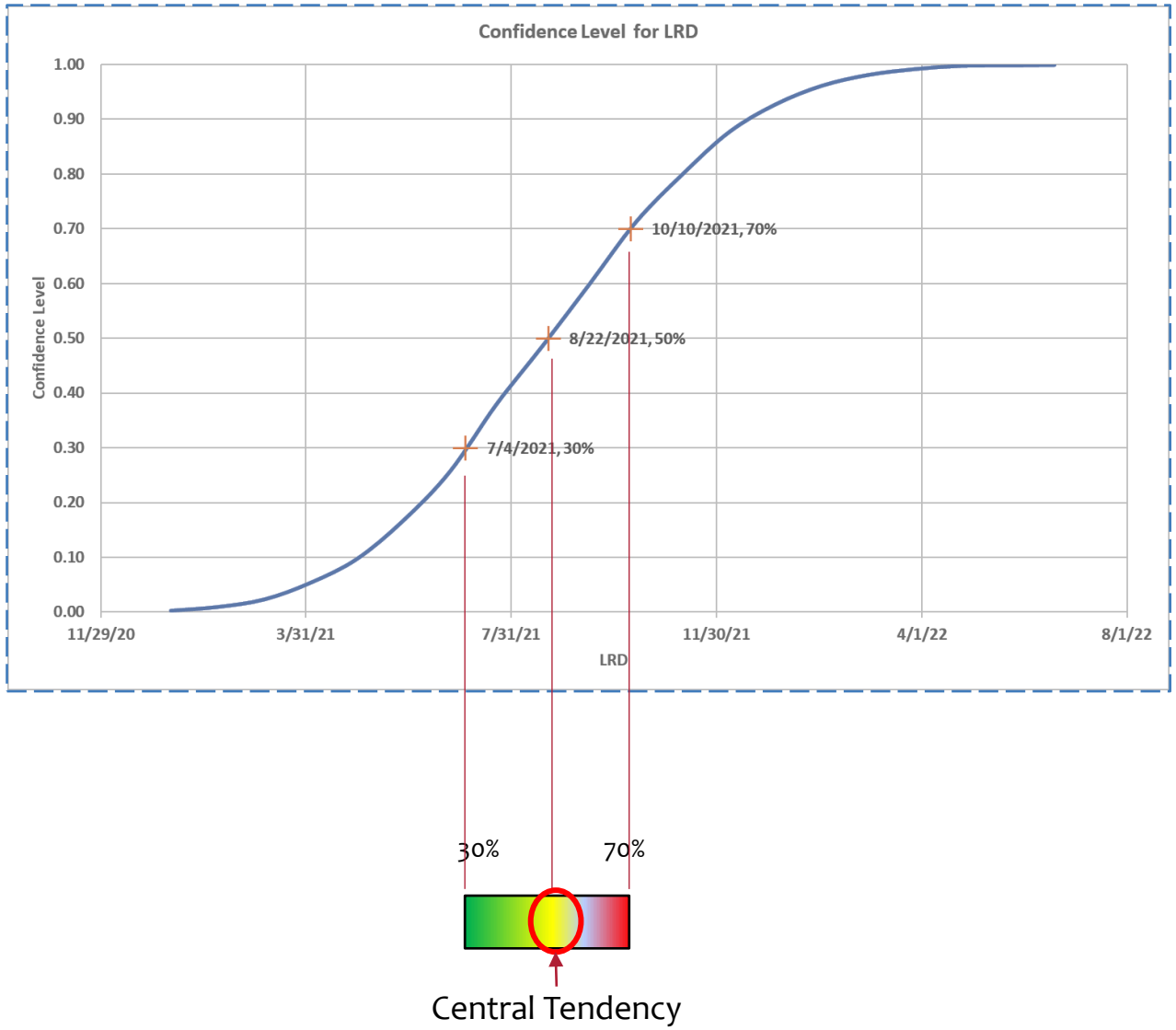
BandAid Charts, What are they?

- So called because of the resemblance to a BandAid.
- ***A few examples:***



- ***Two examples follow:***
  1. Trend tracking, PDR, CDR to SIR.
  2. Augmentation of slack erosion tables.



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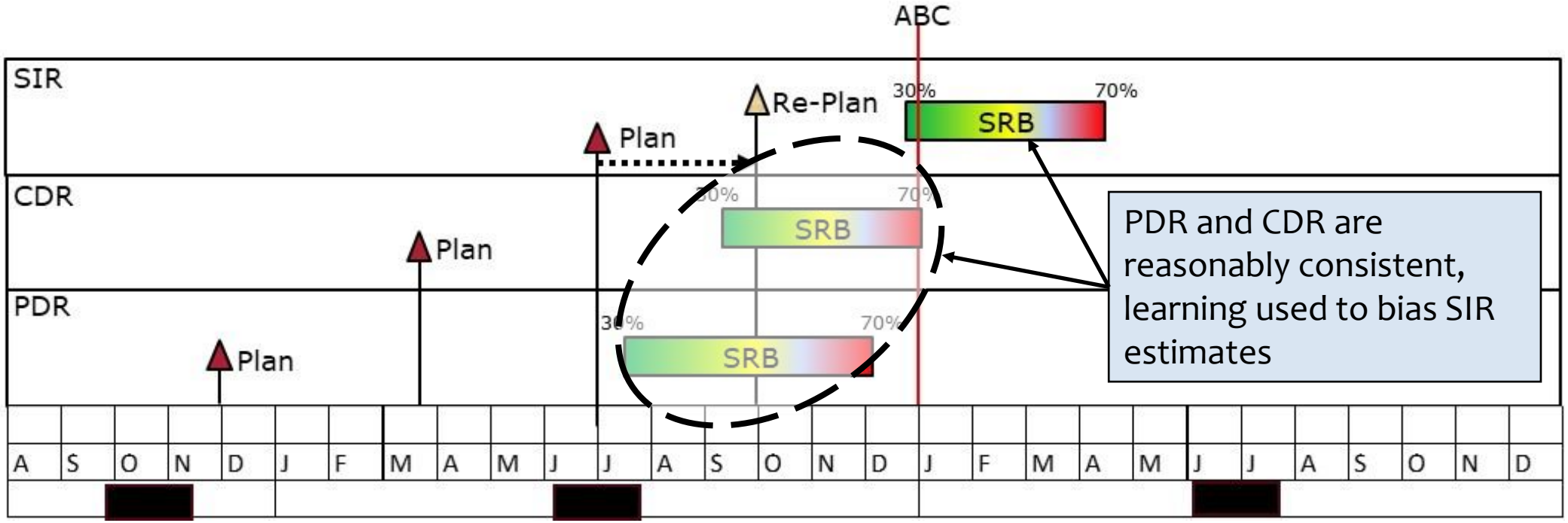
Trending: Evolution of LRD Over Time

- **Objective:** Observe trends to improve risk estimates
- Slipping ~ 4-5 months/year
- Tends to confirm risk assessment results
- Supports that some inefficiencies should continue throughout.



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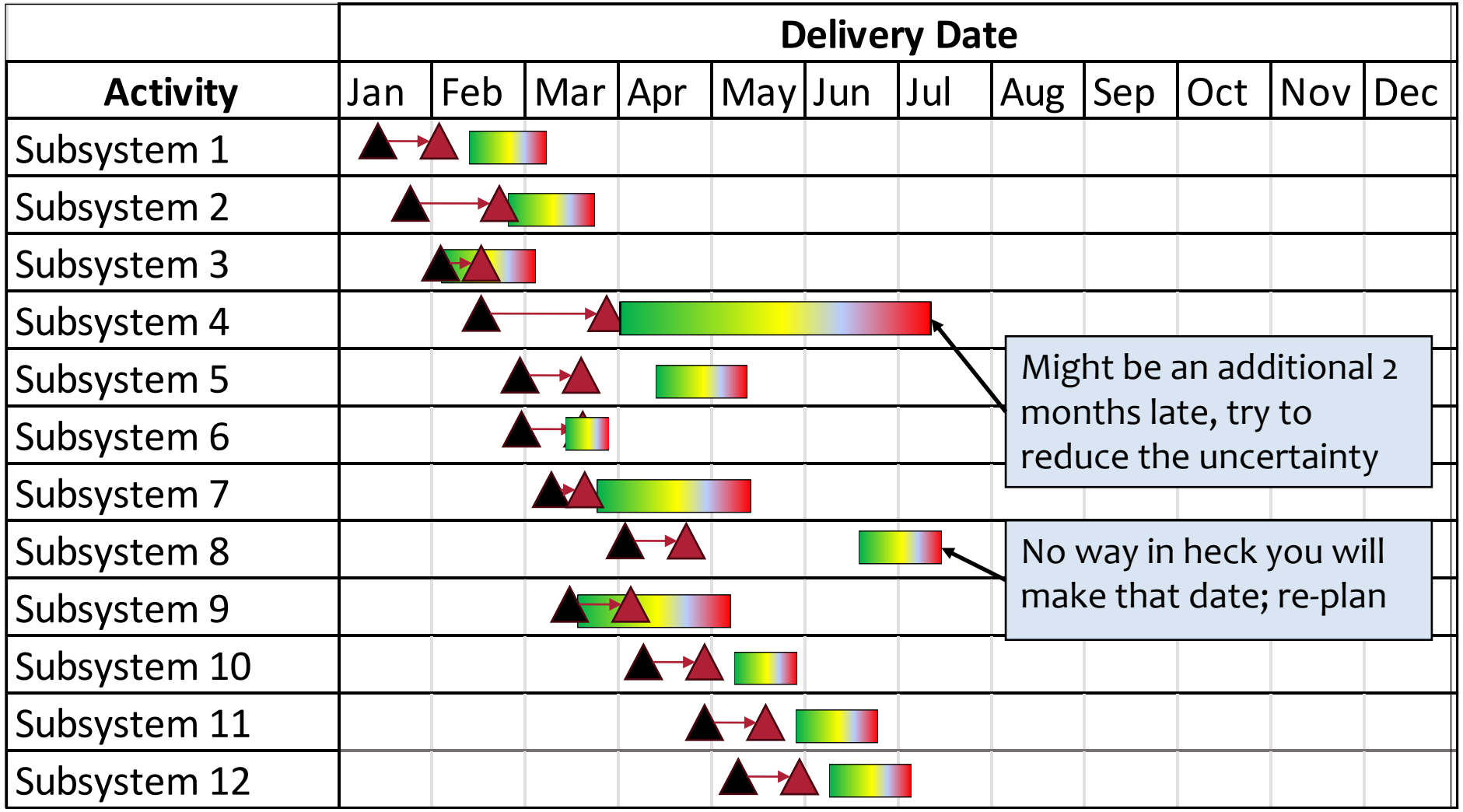
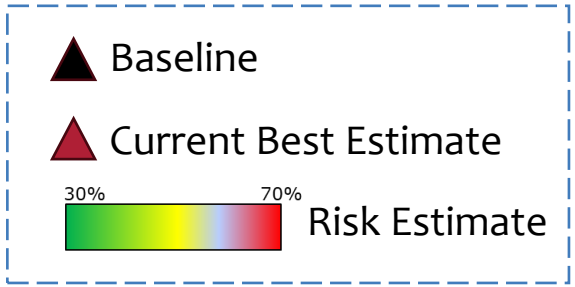
Slack Erosion Tables with BandAids



- Slack erosion tables are a common reporting format
- Risk assessment information added as BandAids
- Display trouble spots, assign actions



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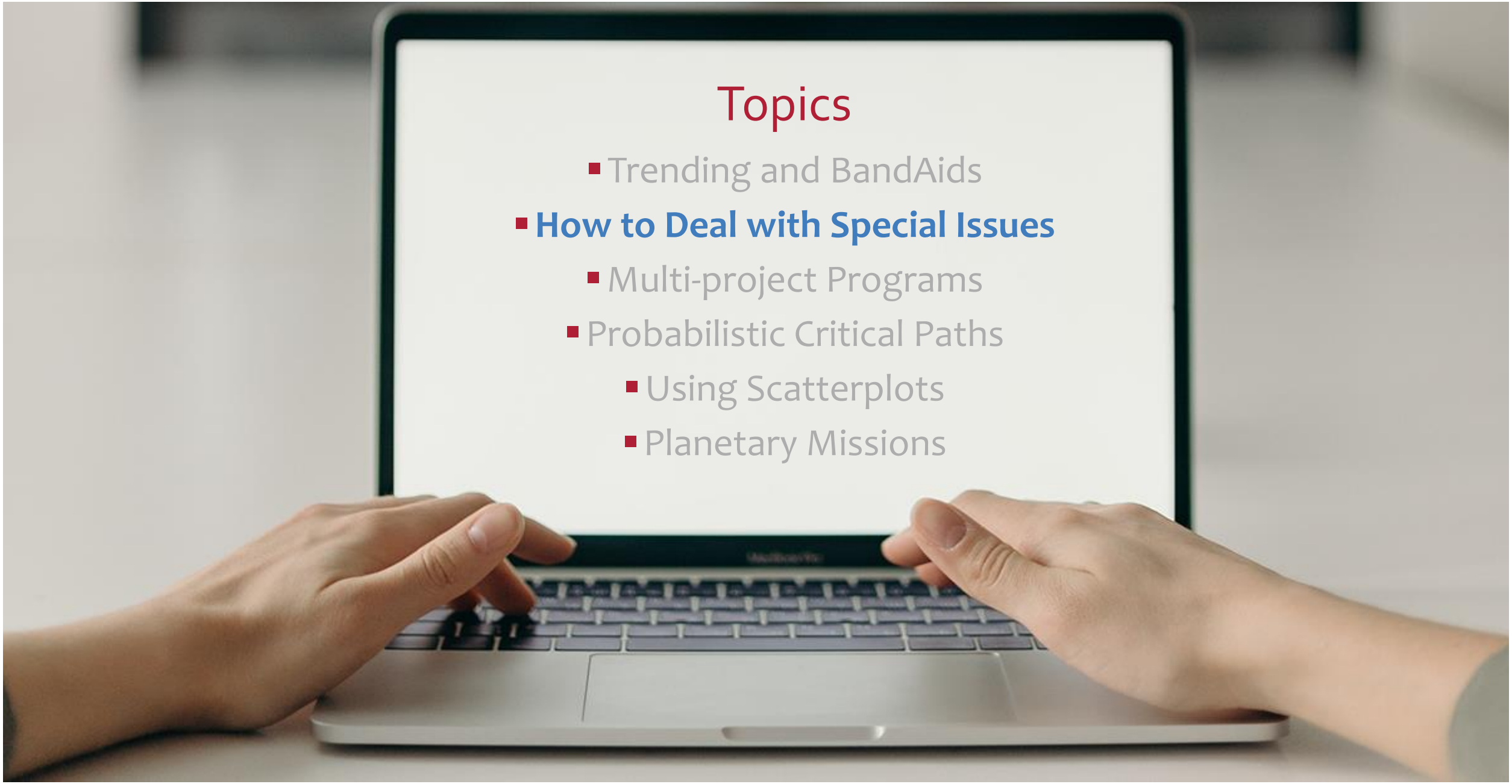
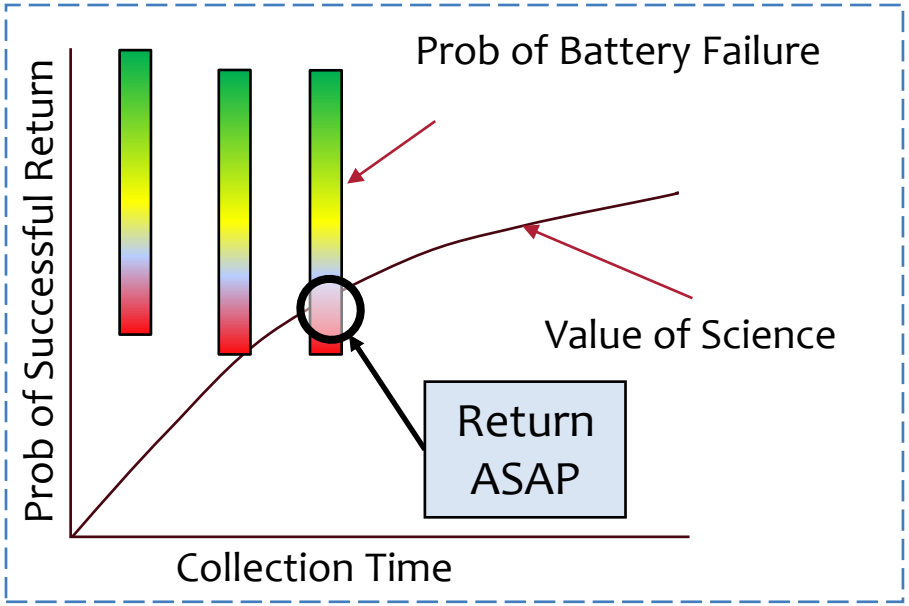


Creating Useful Decision Support Products

- Draw a picture of what is needed to make a decision, then figure out how to create that chart.
- ***Example:*** **Genesis mission:** Collect solar wind particles on witness plates and return to Earth for research.
- **Problem:** Sample Return Canister battery overheating. Question, "Will the batteries be able to support return of the capsule?" "Do we need to return early?" "Will we have enough science if we return early?"
- Whiteboard discussion with Mission Manager.
- **Address the question:** "What kind of information would we need to be able to make a decision?"
- We needed expected performance of SRC batteries versus value of the science collected.



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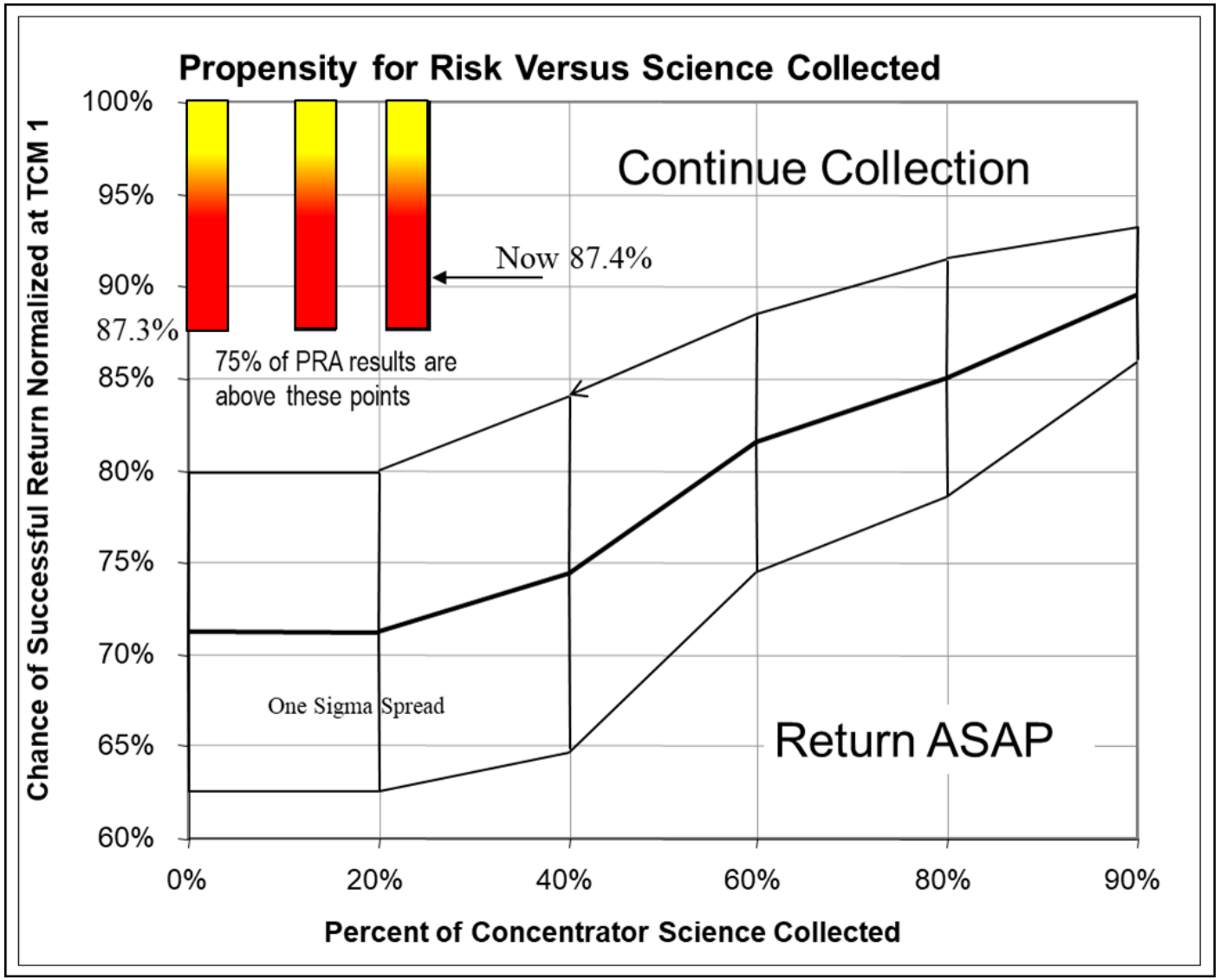
Results and How We Used Them

- Science team's propensity for risk versus sample collection time was determined via a Delphi survey.
- Concern for the large uncertainty range on the responses – considered a 2-round Delphi.
- However, after the third update to the battery PRA, it appeared that we would be good through completion – confirmed by ground stress testing.

So, if you have a tricky problem, sketch something on a whiteboard then go figure out how to produce it.



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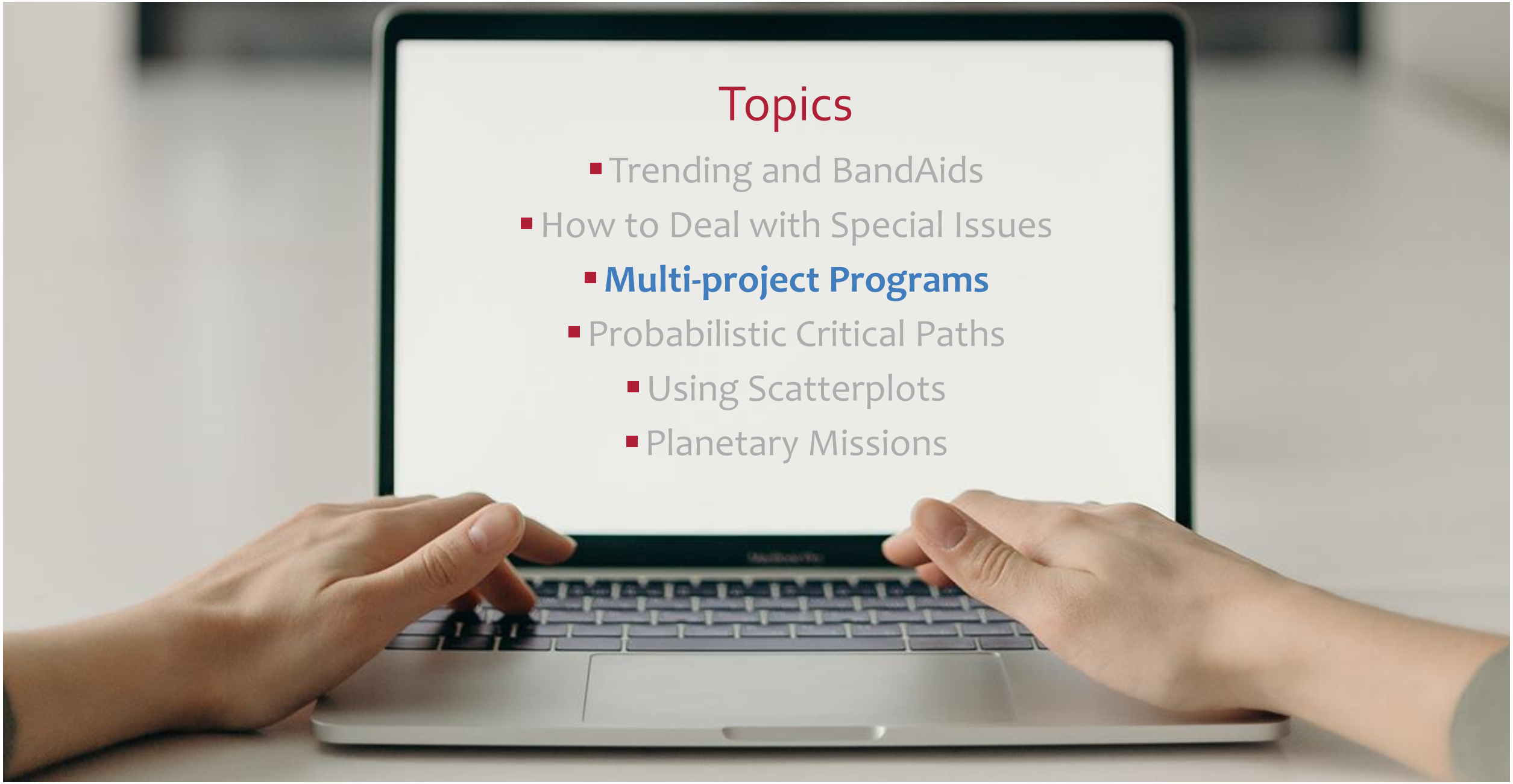
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Multi-project Programs

I have been involved in two multi-project programs; Constellation and JPSS

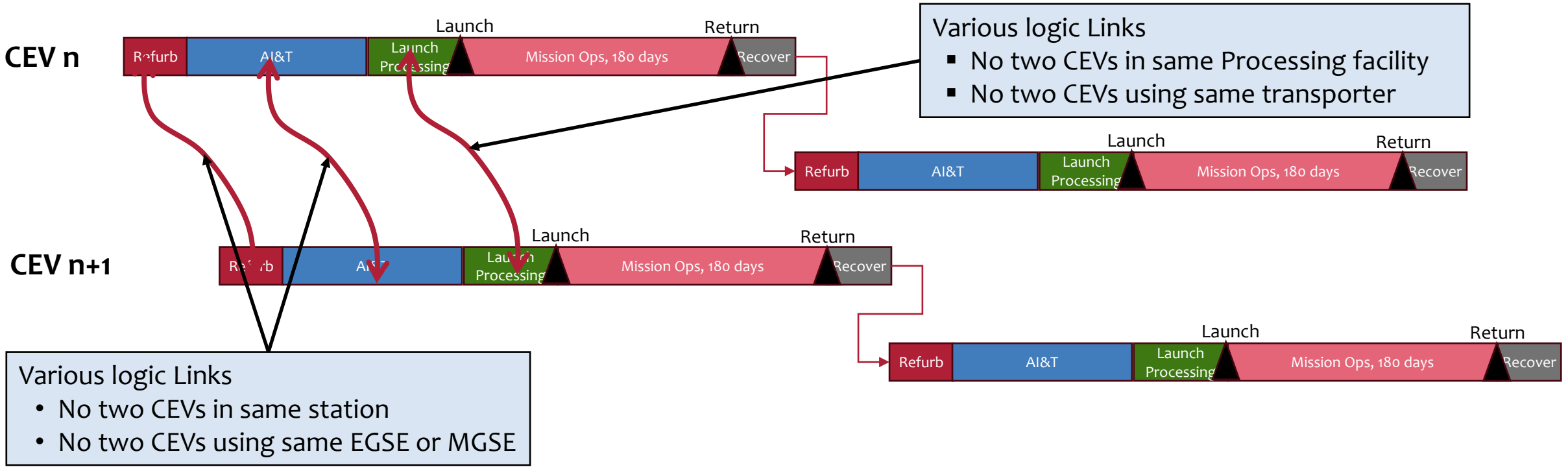
- **Constellation** (Circa mid-2009) – *deconflicting GSE and facilities*
  - Planning on 2 launches to the lunar surface per year with 180-day stay time.
  - Before all schedules were available for integration, e.g. capsule AI&T, ground servicing, launch and flight, mission ops, return flight landing and recovery, refurbishment and repeat, it was assumed that three capsules were sufficient.
  - Integrating all schedules changed need from 3 to 6.
- **JPSS** (Circa mid-2019) – *deconflicting human resources*
  - 4 satellites in production.
  - When one goes into the launch campaign, there is a conflict for resources – launch campaign and integration and test (I&T) cannot be executed simultaneously.
  - The program's schedule was structured to account for this by halting start of I&T as a previous vehicle was ready for launch (LBO, Launch Blockout pseudo-activity).
  - However, risks and uncertainties move things around in complex ways and other conflicts may occur.

In the following slides, tips are provided on modeling multi-project programs

Linking Multiple Project Programs-1, Constellation

Constellation program at PDR

- The initial assumption was that 3 Crew Exploration Vehicles were sufficient to service continuous 180-day missions on the moon.
- However, when a complete integrated schedule was assembled, risks and other constraints added, 6 CEVs were needed.



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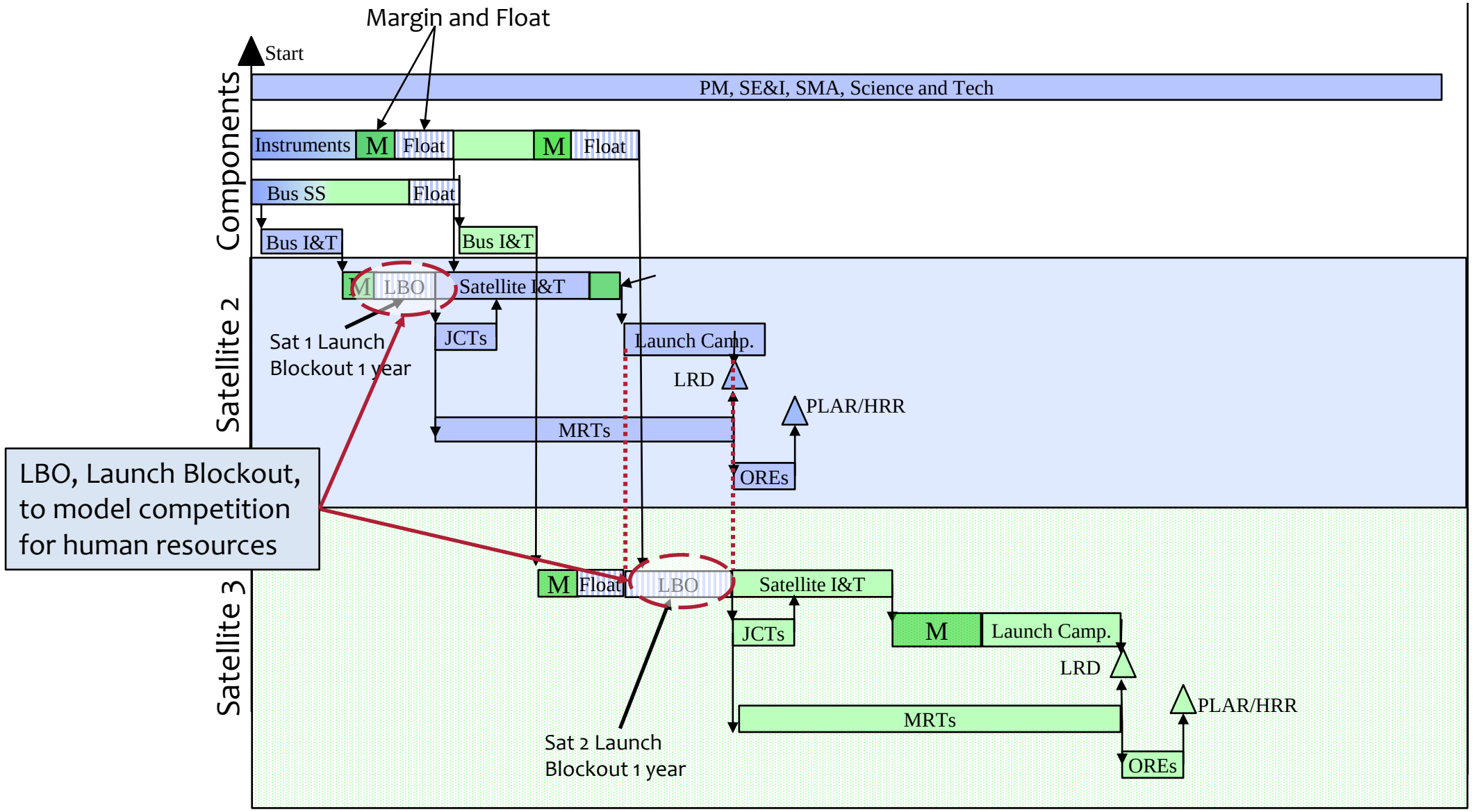
Linking Multiple Project Programs-2, Multiple Satellites



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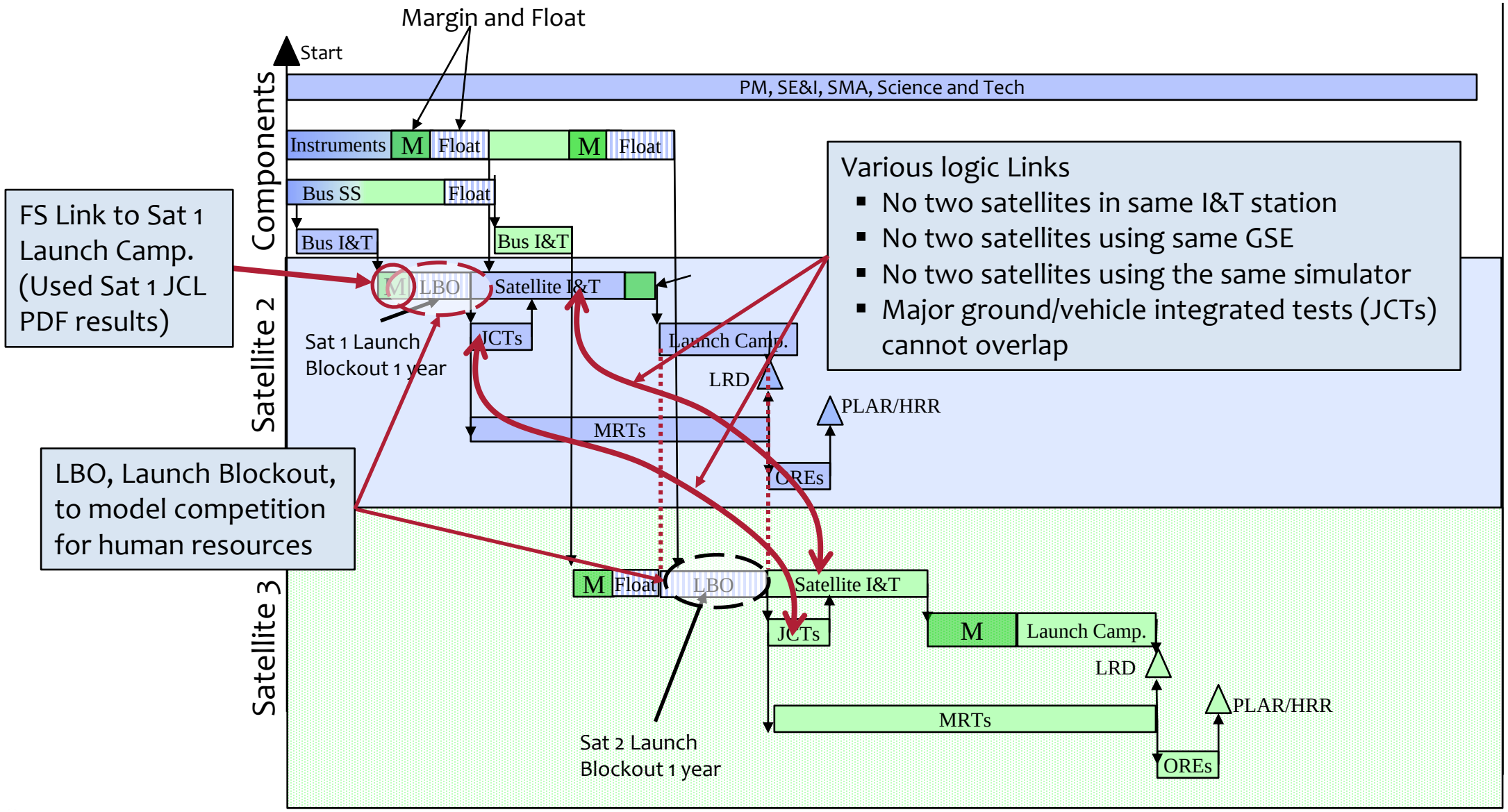
Linking Multiple Project Programs-2, Multiple Satellites



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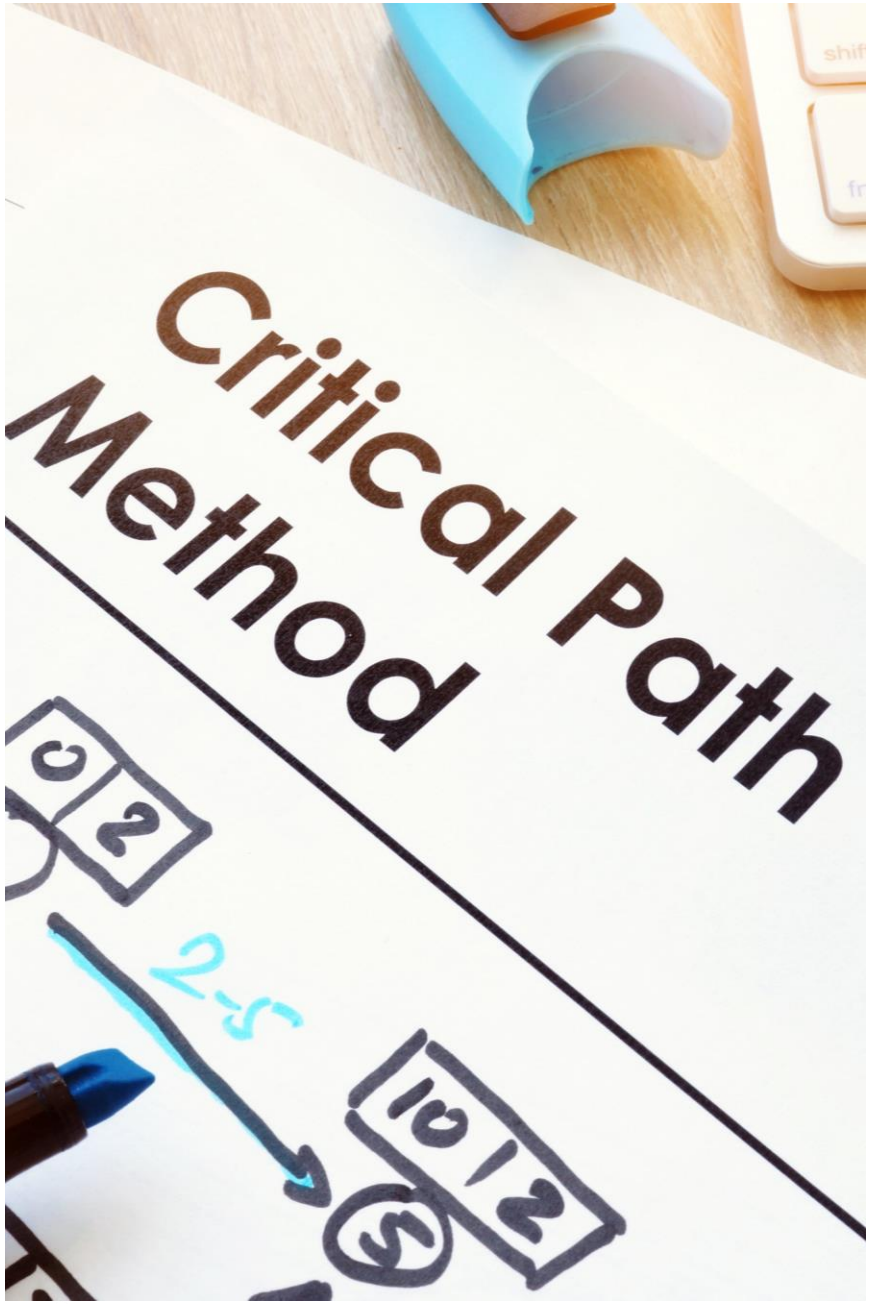


Probabilistic critical paths, Tricks

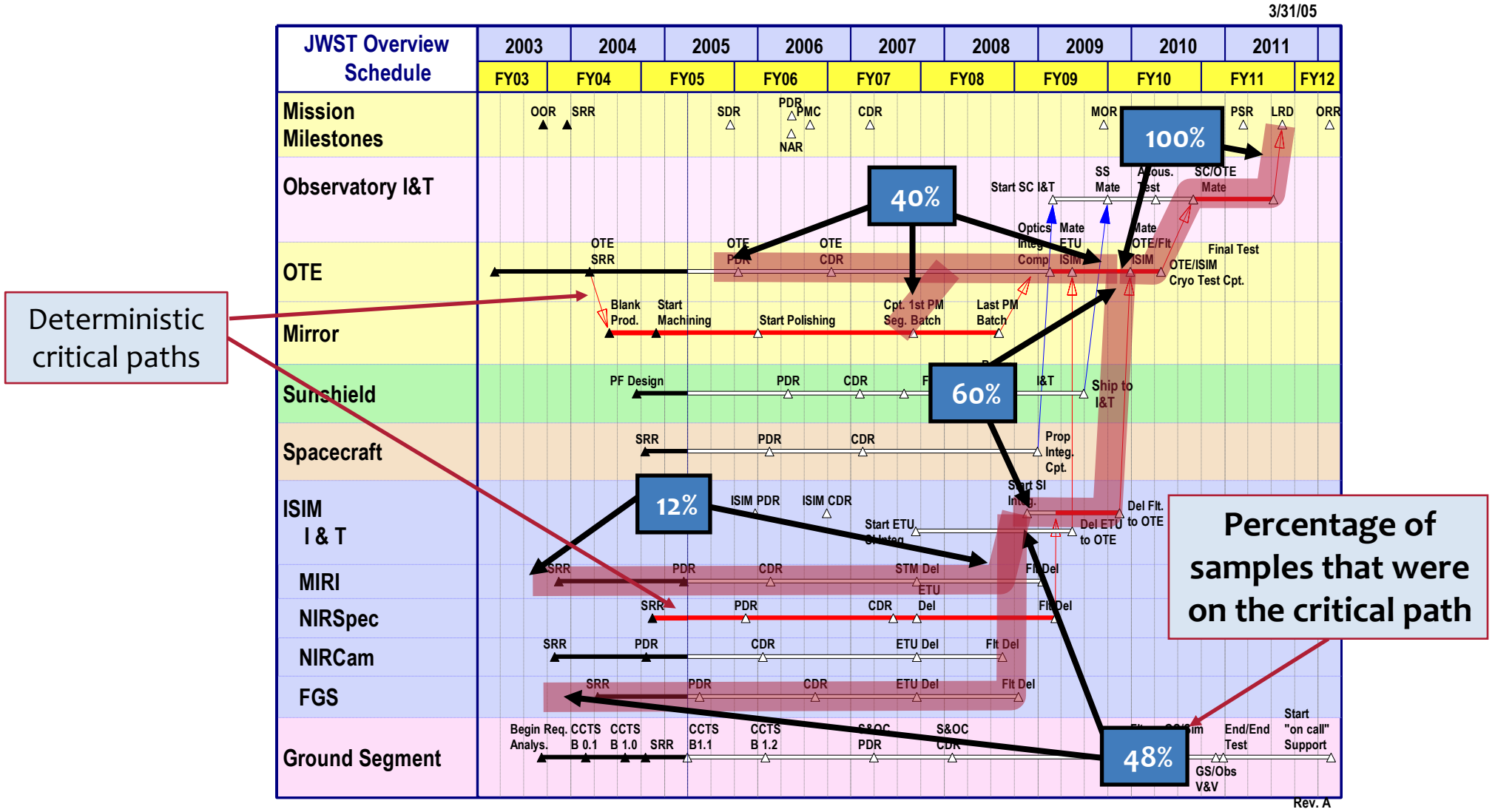
How to find

- The three Monte Carlo tools used, @Risk, JACS, and Polaris can be instructed to collect criticality indices for each task.
- Criticality index counts the number of times that the activity was on the critical path then computes the probability of being on the critical path.
- Viewing the criticality indices shows groupings with negligible differences resulting in a few probabilistic critical paths.

Three examples:

1. **JWST:** Schedule Overlay – visual comparison of deterministic and stochastic CPs
2. **Maven:** ATLO Activity Flow
3. **MSL:** Fishbone

JWST, Schedule Overlay Approach



Deterministic critical paths

Percentage of samples that were on the critical path

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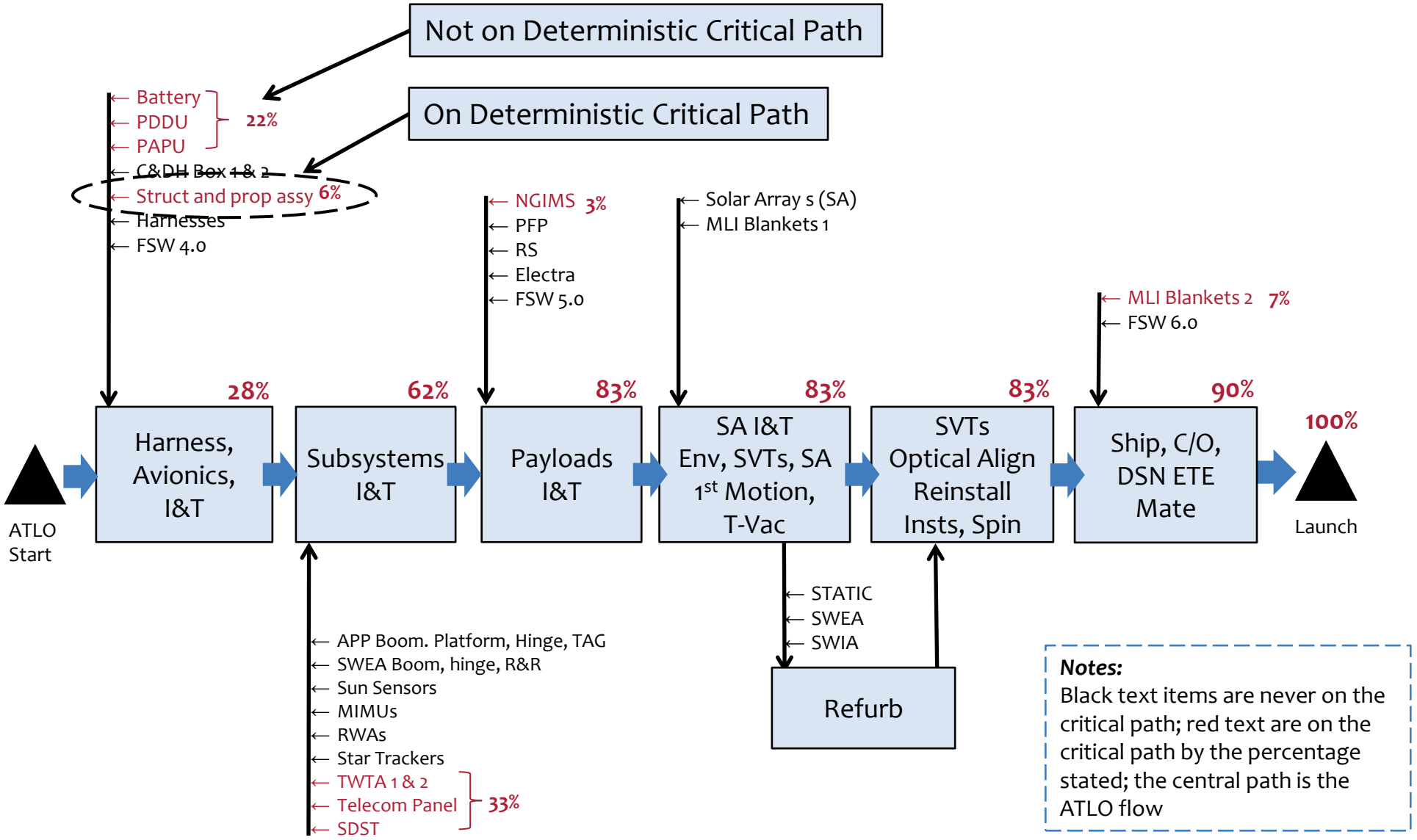
MAVEN, ATLO Activity Flowchart Approach



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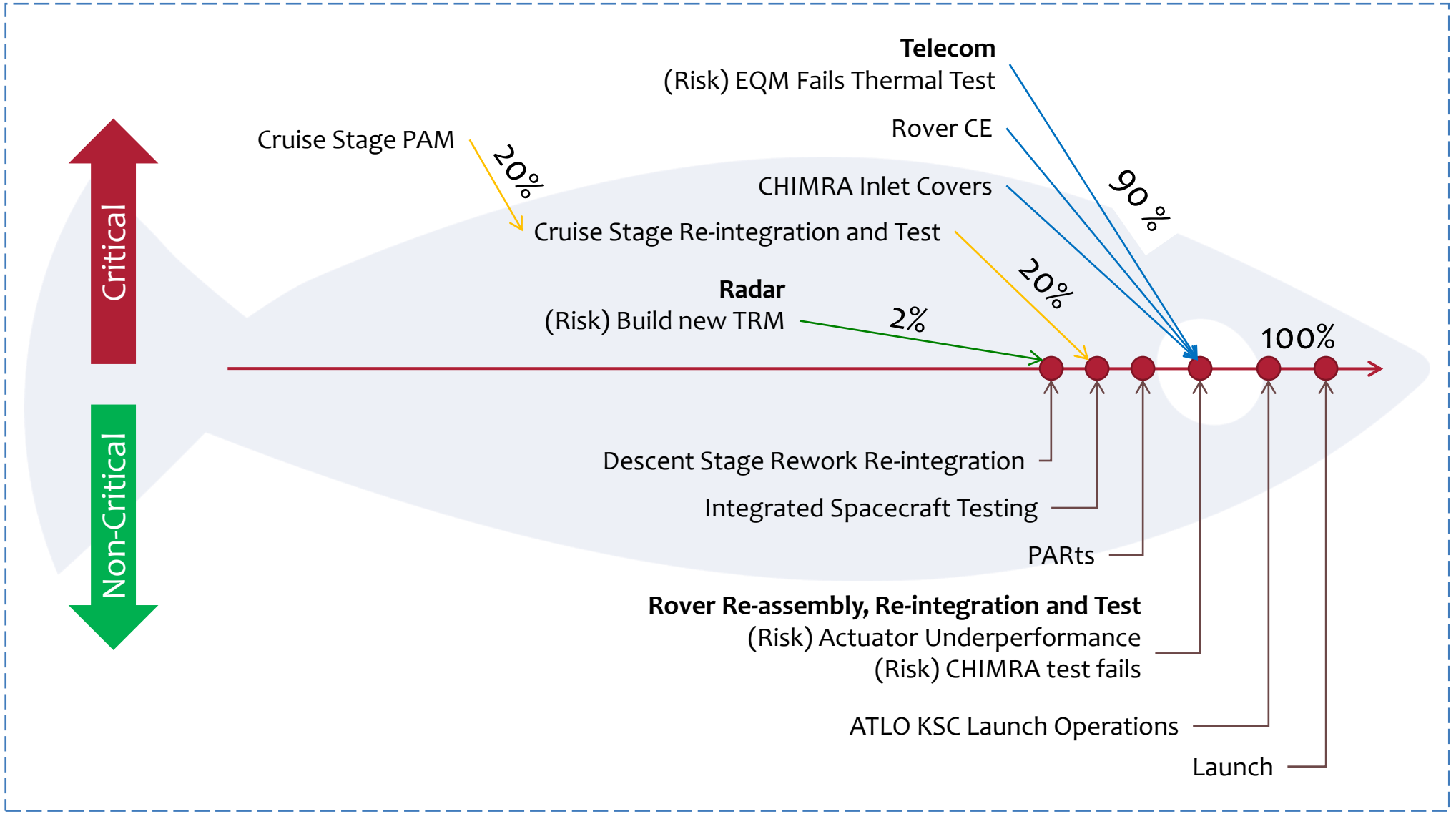
MSL, Fishbone Approach



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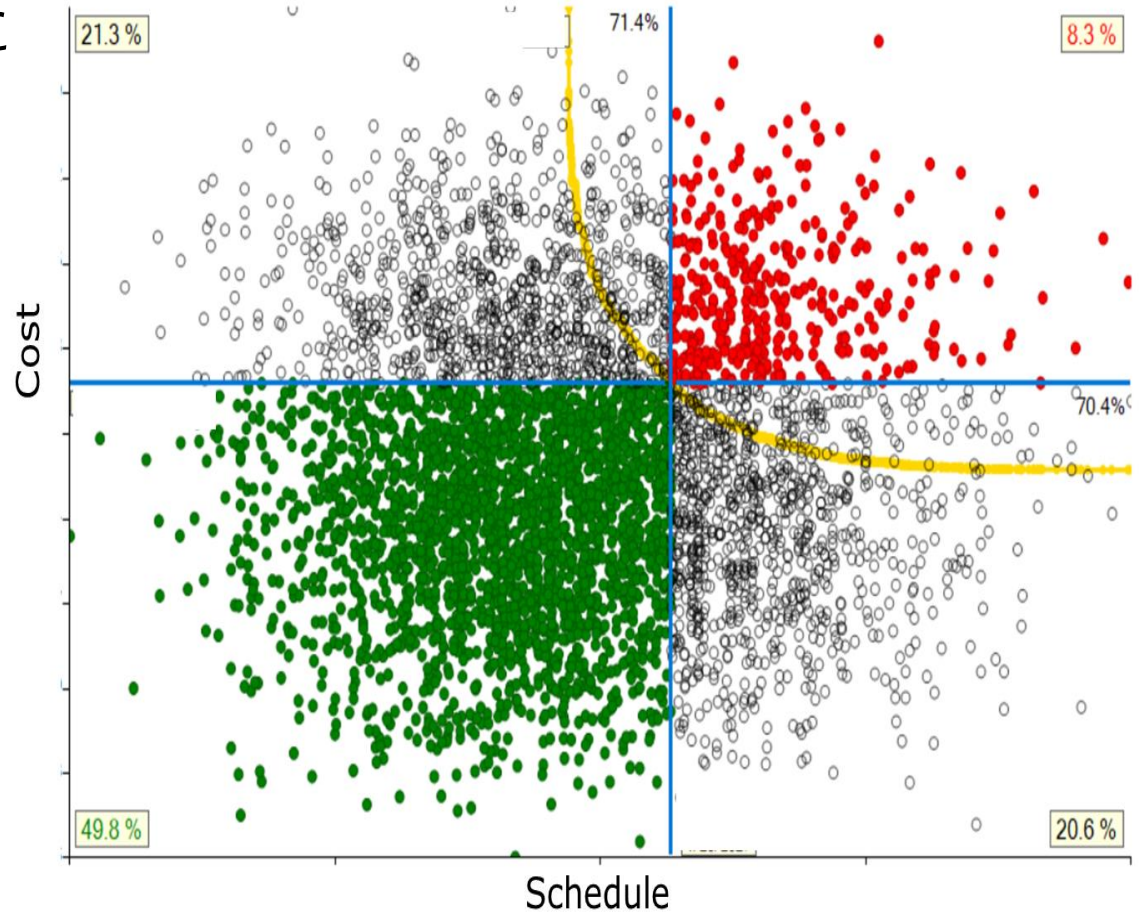
On Using Scatterplots

A tip. Don't pick a point! Rather, what does the analysis tell you?

- Understandably, our primary focus is on the JCL and the "Knee" in order to extract a recommended ABC and MA – but there is so much more.
- Unfortunately - **Misinterpretations:**
  - "Extend the schedule and save some cost?"
  - "Increase the budget, shorten the schedule?"
  - *Either of the above requires a re-plan and a reassessment.*
  - One cannot pick a point – need to look at what the scatterplot tells us **as a whole**.
- Finding asymptotes, making "boxes" has been much more useful.
- Linear regression – or other curve-fitting:
  - Provides short-term approximations for costs associated with schedule changes



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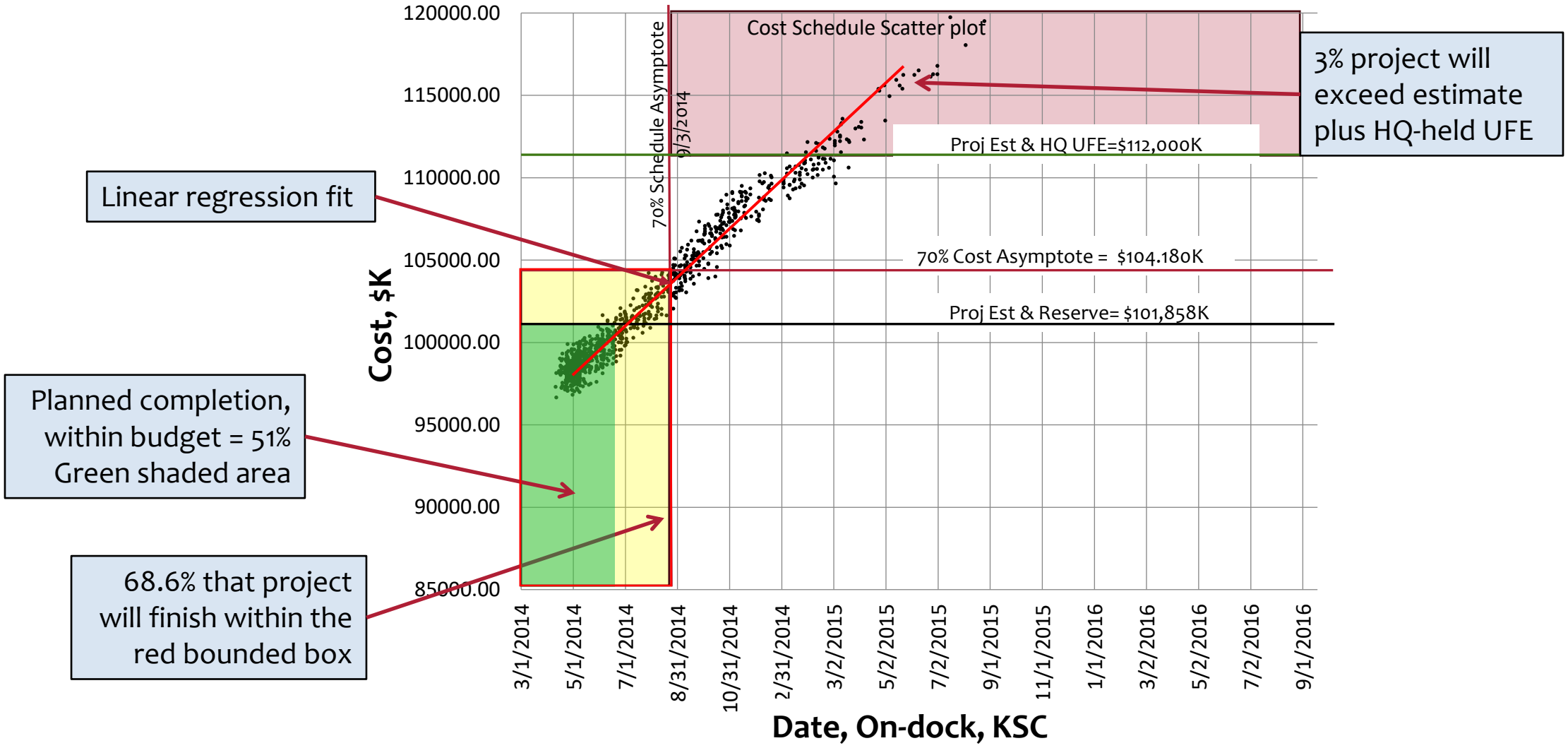
Scatter-plot for Delivery to KSC; PDR



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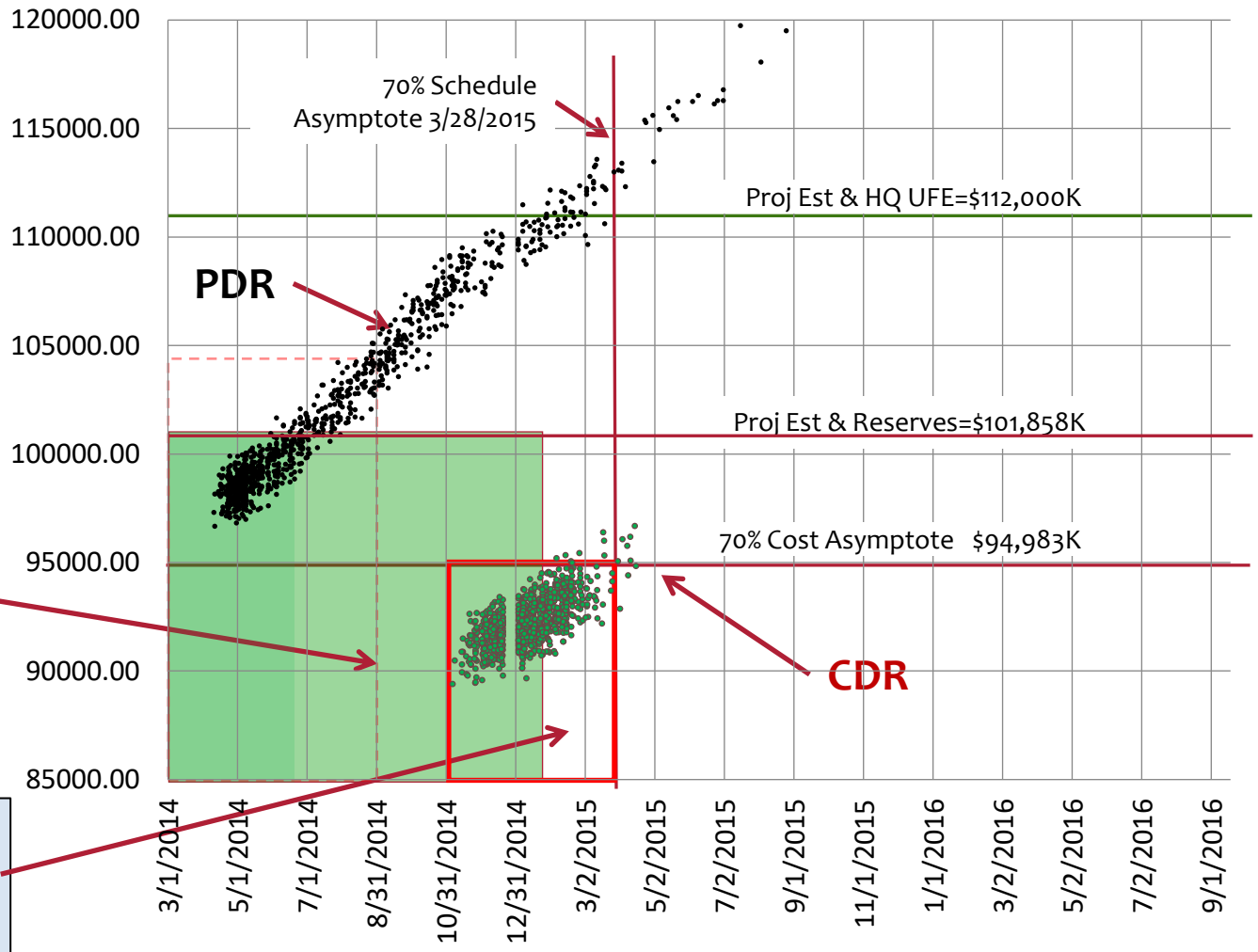
Combined Scatter-plot Trend Plot - PDR to CDR Mitigated Case



Planned completion, within budget = 59% Green shaded area

99% that project will finish within the red bounded box

Question: *How effective is our risk mitigation planning?*

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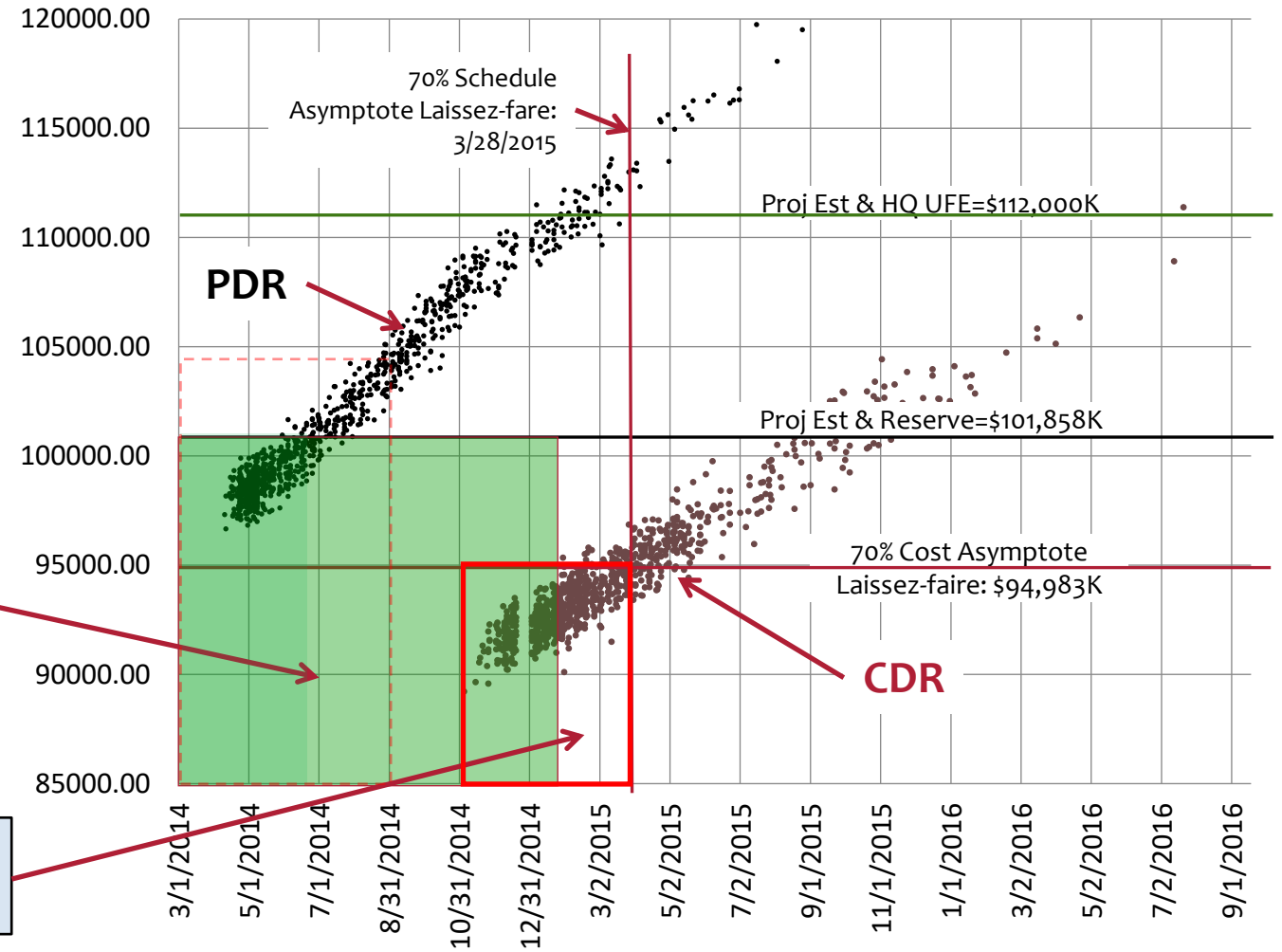
Combined Scatter-plot Trend Plot - PDR to CDR - Unmitigated



On-time, within budget = 24%
Green shaded area

66% to 99%

66% that project will finish within the red bounded box

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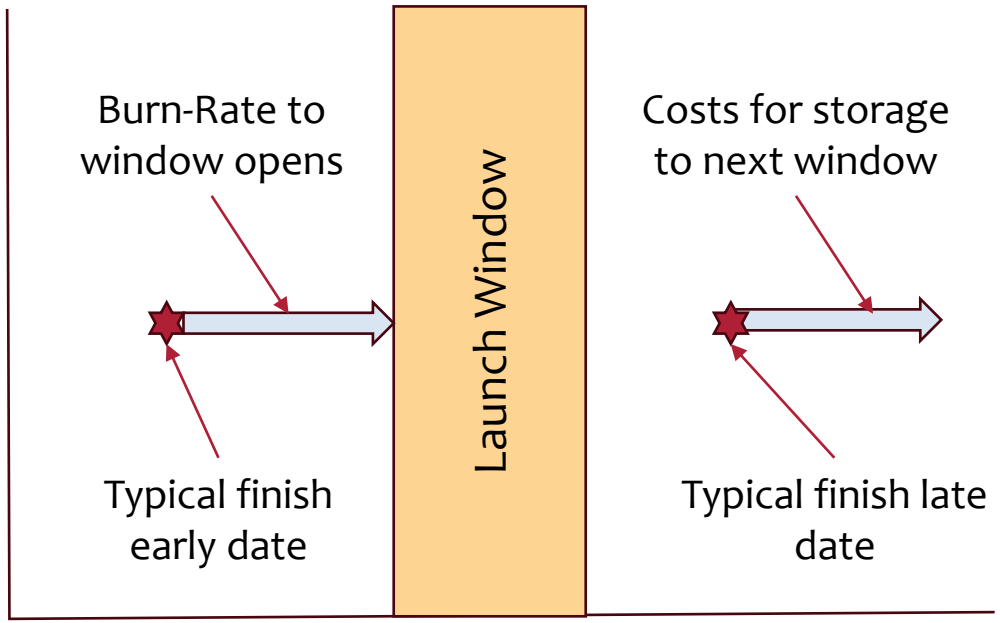
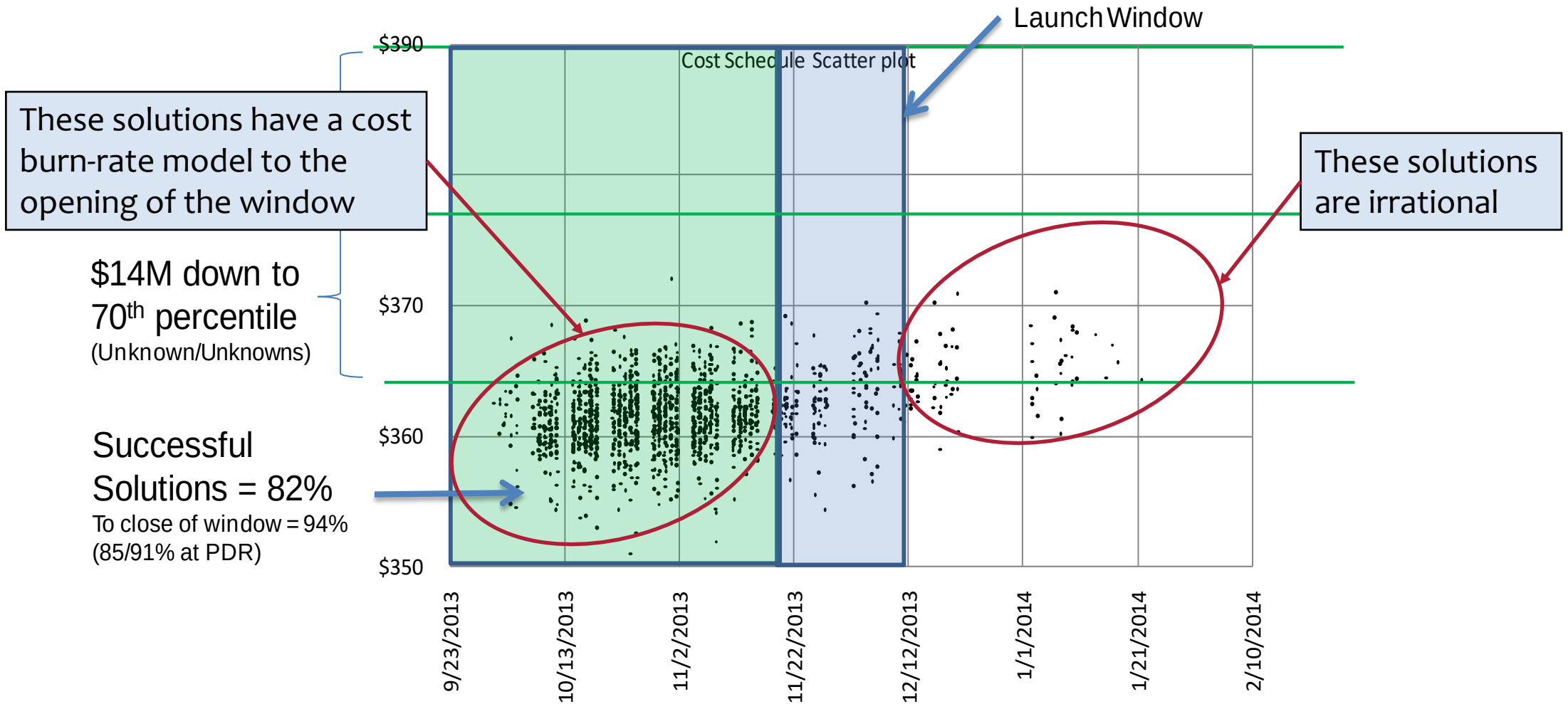
Some Tips on Planetary Missions

- **On modeling,** a pseudo-task must be added to model burn-rate for cases that finish early and need to await opening of the launch window.
- Cases that exit the launch window are irrational unless a model is added for storage until the next window opens - typically, never considered, at least not on the reviews that I have done.
- Typical JCL results, *i.e.* finding 30, 50 and 70 percentiles are not always useful since they may include irrational points:
  - A 30% LRD may be before the launch window opens
  - 70% LRD may be after the window closes
  - 50% is not really 50% because of the two points above
- MAVEN and MSL example following.



Typical Mars Mission Scatterplot



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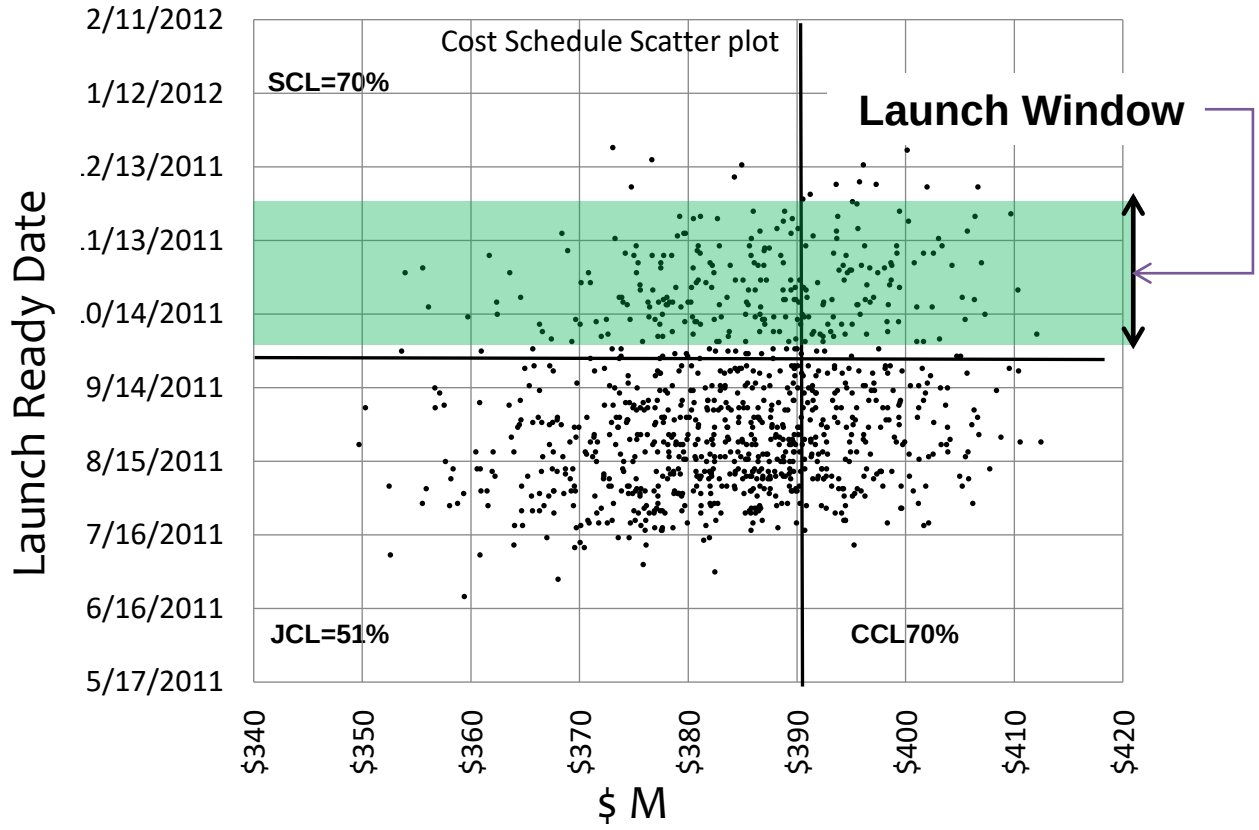
MSL Scatterplot, PDR Circa 2009

- **Note:** Scatterplot is backwards to what we do today.
- Vertical axis is completion date, horizontal axis is cost.
- All completion dates have a cost burn rate to opening of window.
- Completion dates outside of window do not have storage costs to next window.

So, how did we select the three points for our "JCL?" You can't launch early, and you can't launch late.



9/23/2011	< 70% Completion Date
390.2	<70% Cost
51%	<JCL
70%	<CCL
70%	<SCL

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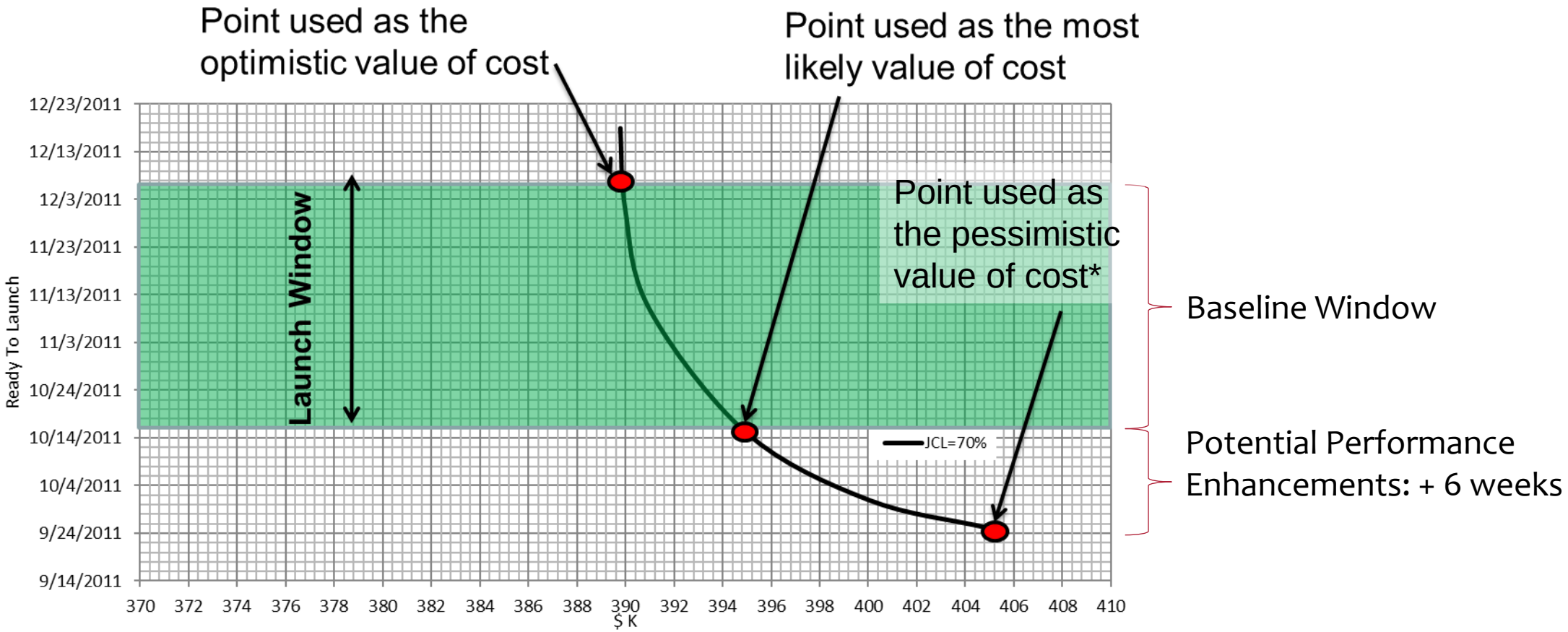
70% JCL For MSL



*Cost of performance enhancements added

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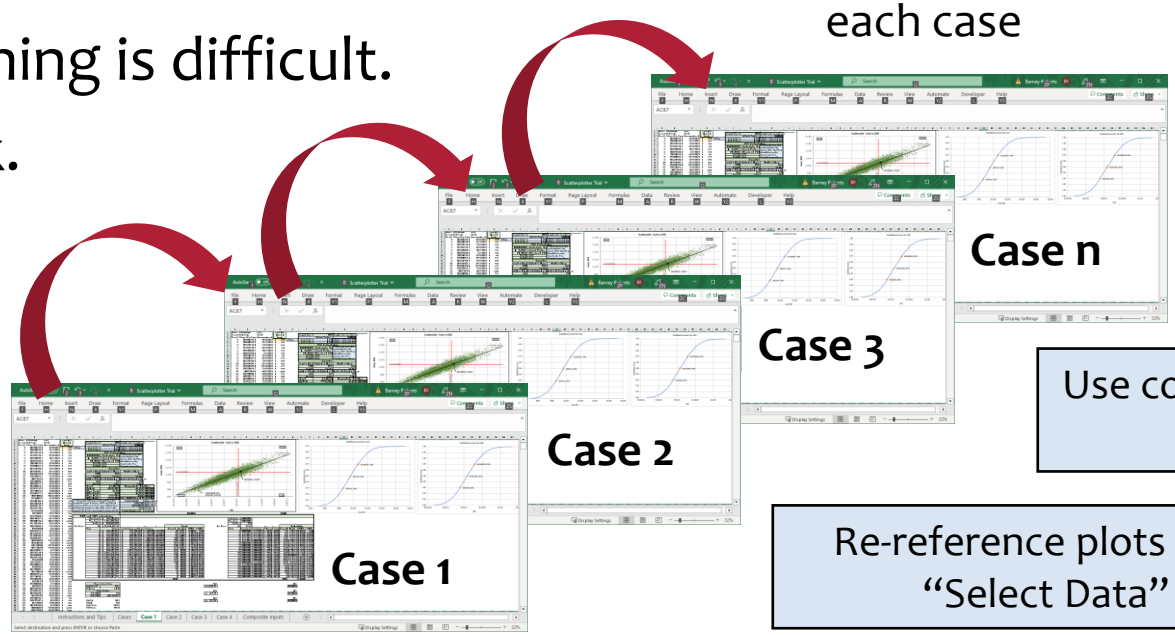
Keeping Track of Everything

- Many Monte Carlo runs are executed during a review; often as many as 30-50.
  - Different risk and uncertainty assessments
  - Compare this case with that case --- and so on
  - What happens if ---
- Keeping track of everything is difficult.
- I use an excel workbook.
- Keep every run in it:
  - Cases tab
  - Summary tab
  - Special Plots tab

Copy and paste for each case



Use consistent names for tabs; makes re-reference easier

Re-reference plots using the "Select Data" tool

See presentation "Using Excel to Facilitate JCL Analyses" from NCSS 2023 for details

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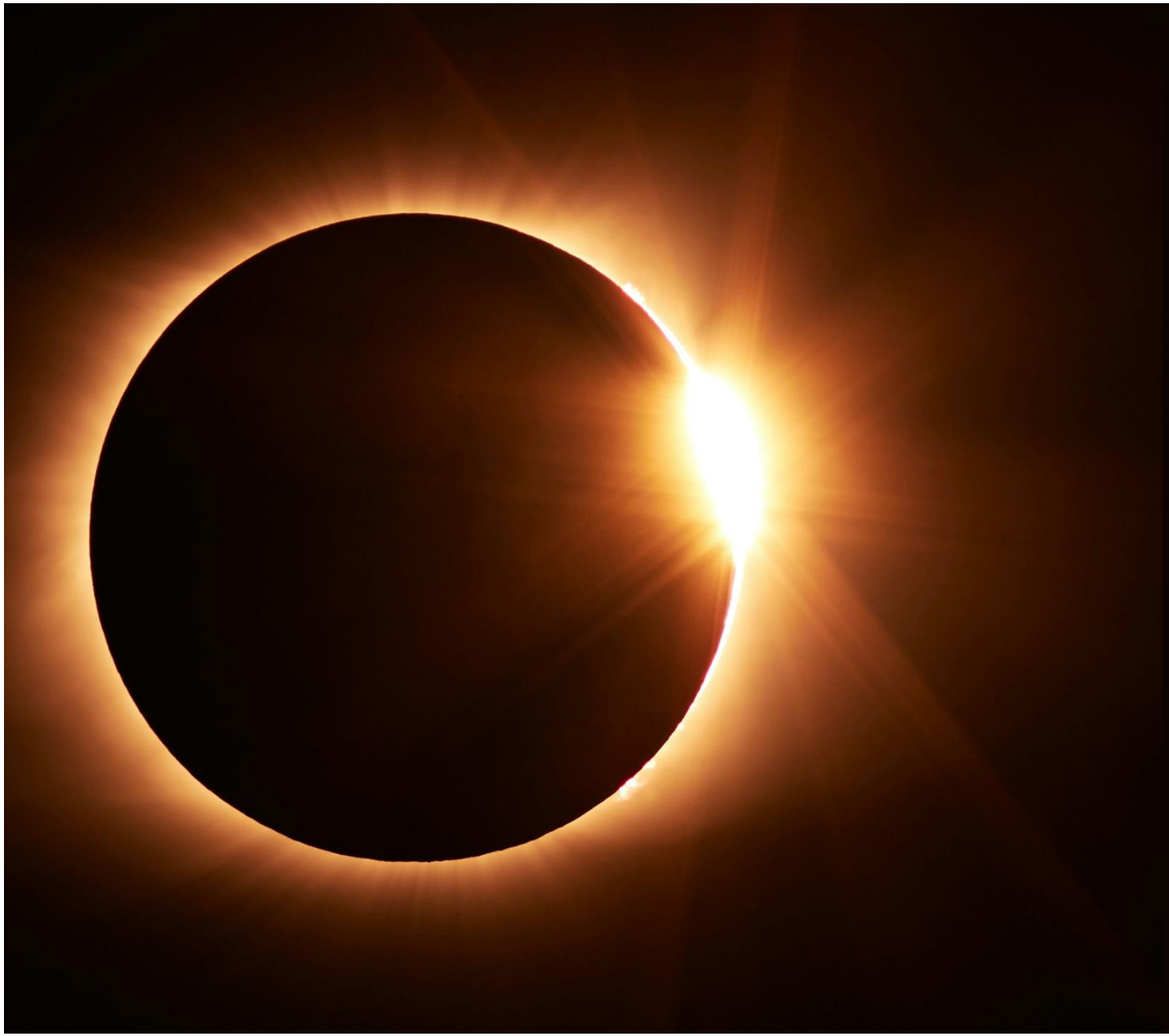
Get off the Stage Chart

I hope these tips and tricks are useful to you.

- If you need details, email me: broberts@reedintegration.com
- Tips and tricks I have not covered due to time:
  - Risks and uncertainties:
    - Common mistakes and how to model them correctly
    - Mitigation costs and uncertainty of final negotiated CCO
    - Double Booking – separate TD and TI costs
    - Uncertainties vs reality
  - Special cases from unusual projects; unique modeling problems

So, now I have something for next year?



Questions?