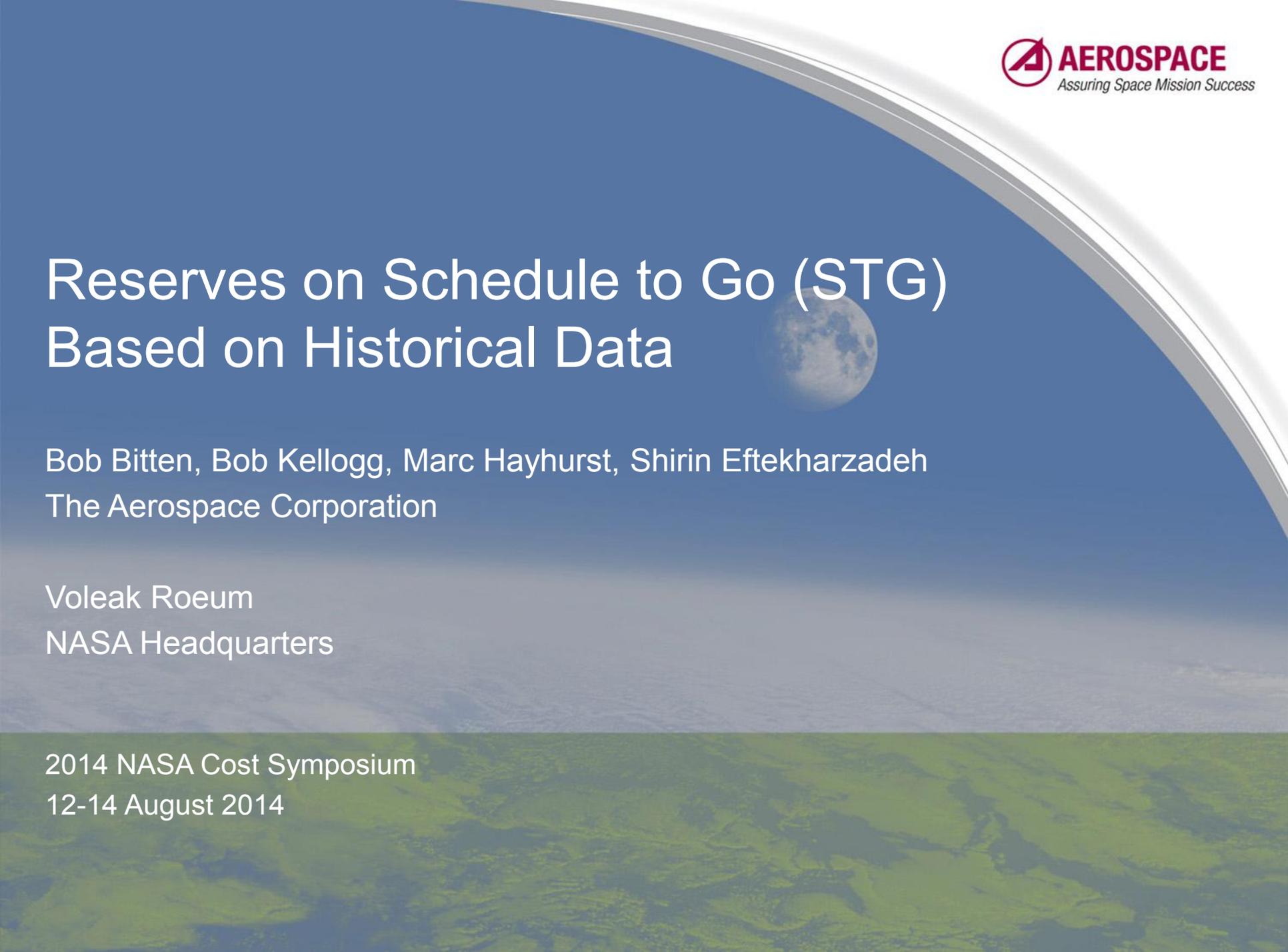


Reserves on Schedule to Go (STG) Based on Historical Data



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Outline

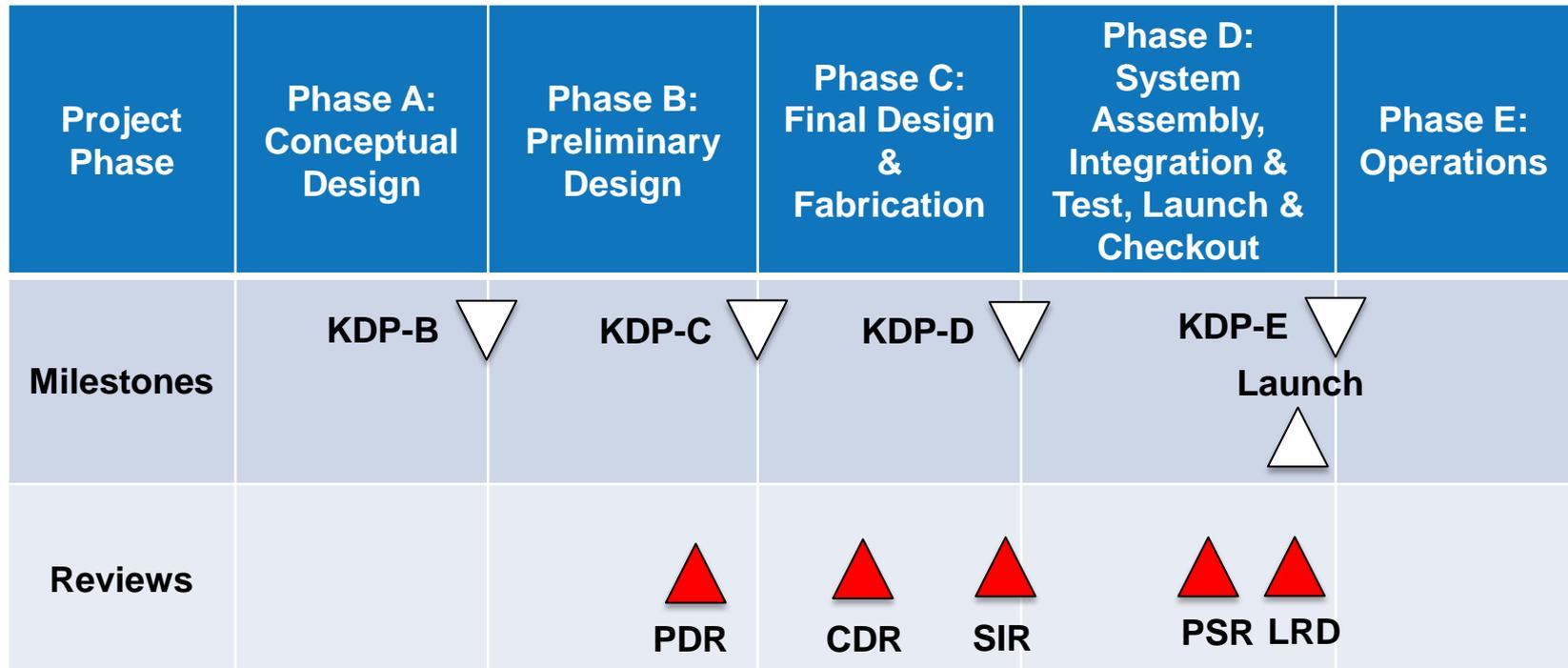


- Introduction/Background
- Methodology
- Results from PDR, CDR, SIR, and PSR
- Recommendations & Summary

Introduction

- NASA Center guidance requires that a mission hold Funded Schedule Reserve (FSR) corresponding to the remaining Schedule to Go (STG) at an increasing rate over the development lifecycle
- The rates of required FSR may not be adequate given that many projects have experienced significant schedule growth
- This study looks at the project-held FSR and actual schedule growth for a variety of NASA missions at the Preliminary Design Review (PDR), Critical Design Review (CDR), Systems Integration Review (SIR), and Pre-Ship Review (PSR)
- The data can then be used as guidance for adjusting project FSR requirements and for establishing additional reserves at the center or HQ level for future missions

NASA Project Lifecycle



- Definitions:

- *KDP = Key Decision Point = Transition from one Phase to the next*
- *PDR = Preliminary Design Review*
- *CDR = Critical Design Review*
- *SIR = Systems Integration Review*
- *PSR = Pre-Ship Review*
- *LRD = Launch Readiness Date*

Reserve Tracking Assumptions

- JPL and GSFC Guidelines specify funded schedule reserves in months for Phases C & D

Milestone	PDR (KDP-C) to SIR (KDP-D)	SIR (KDP-D) to Ship	Ship to Launch
JPL & GSFC Reserve Guidelines Schedule Margin Rate	1 month/year	2 month/year	1 week/month

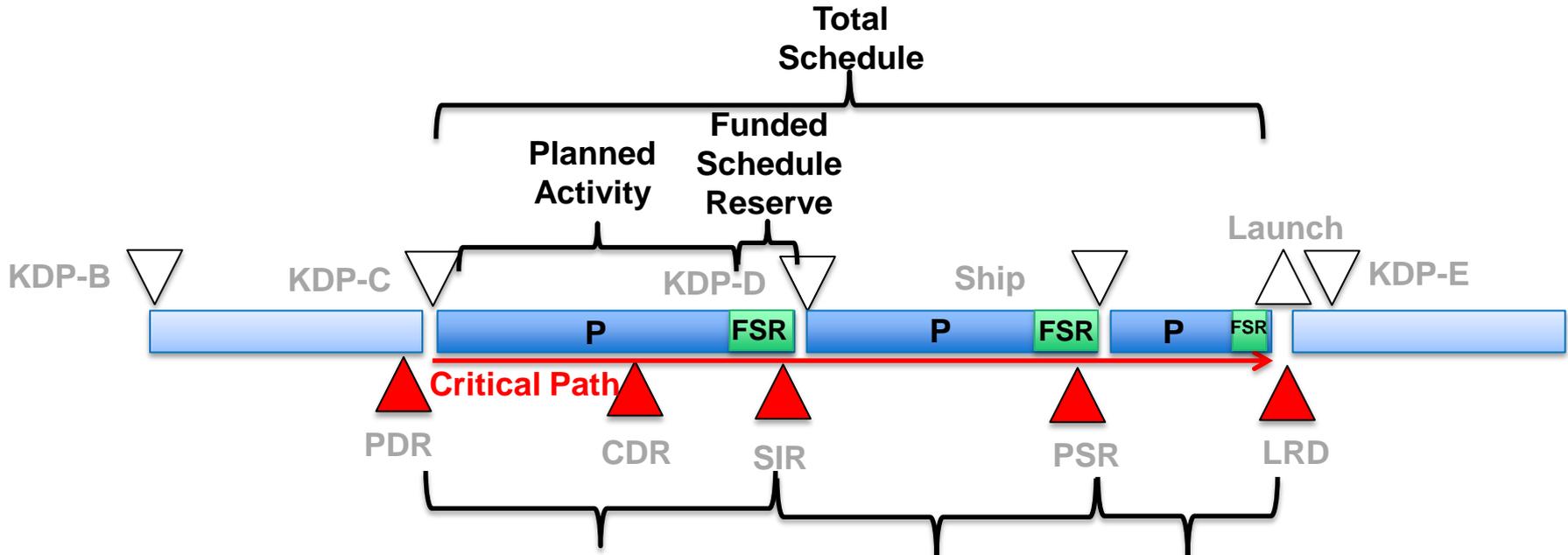
- Most projects track Funded Schedule Reserve (FSR) in weeks or days
 - 1 Month = 4 weeks
 - 1 Week = 5 working days

Phase	Months/Year	Weeks/Year	Days/Year
KDP-C to KDP-D	1	4	20
KDP-D to Ship	2	8	40
Ship to Launch	3	12	60

- Weeks used in this analysis for consistency across all projects

Example Project Lifecycle

- Funded Schedule Reserve (FSR) = No planned activities, but funded schedule
- FSR Rate = $FSR / (\text{Planned Activity} + FSR) = FSR / (P + FSR)$



Phase	ATP to PDR	PDR to SIR	SIR to PSR	PSR to Launch	Total
Example Duration (years)	0.75	2.0	1.0	0.25	4.0
Guideline FSR Rate	0	4 weeks/year	8 weeks/year	12 weeks/year	
Guideline FSR (weeks)	0	8	8	3	19

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Large Diversity of Missions Included in Analysis

- Data collected from 37 science missions providing a representative mix

Mission	Launch Date	Theme	Mission Type	Lead Org.
AIM	Apr-07	Helio	CAT 3	Other
Cloudsat	Apr-06	Earth	CAT 2	JPL
DAWN	Sep-07	Planetary	CAT 2	JPL
Deep Impa	Jan-05	Planetary	CAT 2	JPL
EO-1	Nov-00	Earth	CAT 2	GSFC
GALEX	Apr-03	Astro	CAT 3	JPL
GENESIS	Aug-01	Planetary	CAT 2	JPL
GLAST	Jun-08	Astro	CAT 2	GSFC
GRAIL	Sep-11	Planetary	CAT 2	JPL
IBEX	Oct-08	Helio	CAT 3	Other
ICESAT	Jan-03	Earth	CAT 2	GSFC
Kepler	Mar-09	Astro	CAT 2	JPL
LRO	Jun-09	Planetary	CAT 2	GSFC
MER	Jul-03	Planetary	CAT 1	JPL
MESSENGE	Aug-04	Planetary	CAT 2	APL
MRO	Aug-05	Planetary	CAT 1	JPL
New Horiz	Jan-06	Planetary	CAT 1	APL
OCO	Feb-09	Earth	CAT 2	JPL
PHOENIX	Aug-07	Planetary	CAT 2	JPL

Mission	Launch Date	Theme	Mission Type	Lead Org.
RHESSI	Feb-02	Helio	CAT 3	Other
SDO	Feb-10	Helio	CAT 1	GSFC
Spitzer	Aug-03	Astro	CAT 1	JPL
Stardust	Feb-99	Planetary	CAT 2	JPL
STEREO	Oct-06	Helio	CAT 2	GSFC
Swift	Apr-04	Astro	CAT 2	GSFC
Terra	Dec-99	Earth	CAT 1	GSFC
WISE	Jun-09	Astro	CAT 2	JPL
GLORY	Mar-11	Earth	CAT 2	GSFC
GPM	Feb-14	Earth	CAT 2	GSFC
IRIS	Jun-13	Helio	CAT 3	LM
Juno	Aug-11	Planetary	CAT 1	JPL
LADEE	Sep-13	Planetary	CAT 2	ARC
LDCM	Feb-13	Earth	CAT 2	GSFC
MAVEN	Nov-13	Planetary	CAT 3	GSFC
MSL	Nov-11	Planetary	CAT 1	JPL
RBSP	Aug-12	Helio	CAT 2	APL
NuSTAR	Jun-12	Astro	CAT 3	JPL

- Includes mix of Science Themes
 - 15 Planetary, 7 Astrophysics, 8 Earth Science and 7 Heliophysics
- Includes mix of different sized missions based on NASA 7120.5E Mission Category
 - 8 Category 1 (CAT 1) missions with Life Cycle Cost (LCC) > \$1B FY12\$
 - 22 Category 2 (CAT 2) missions with LCC >\$250M but < \$1B FY12\$
 - 7 Category 3 (CAT 3) missions with LCC < \$250M FY12\$

Study Definitions

- *Project Actual Margin (FSR) = Actual historical margin held by project at milestone*
- *Actual Required Margin = Project Actual Margin + Schedule Growth = FSR + G*
- *Actual Schedule Margin Rate =*
 - $\text{Actual Required Margin} / (\text{Planned Activity} + \text{Project Actual Margin}) = (FSR + G) / (P + FSR)$



- *External Events: factors resulting increased schedule growth which were outside of the control of NASA and/or the project and unreasonable to anticipate and plan for*
 - NASA External: Contractor closes and relocates facility; labor strike; Hurricane delays launch
 - Project External (Including above): center/headquarters directed launch date move; funding cut; stand down
- *Actual Required Margin less External Events =*
 - $\text{Actual Required Margin} - \text{External Event Duration} = (FSR + G) - E$
- *Actual Required Margin Rate less External =*
 - $\text{Actual Required Margin less External Events} / (\text{Planned Activity} + \text{Project Actual Margin})$
 - $((FSR + G) - E) / (P + FSR)$

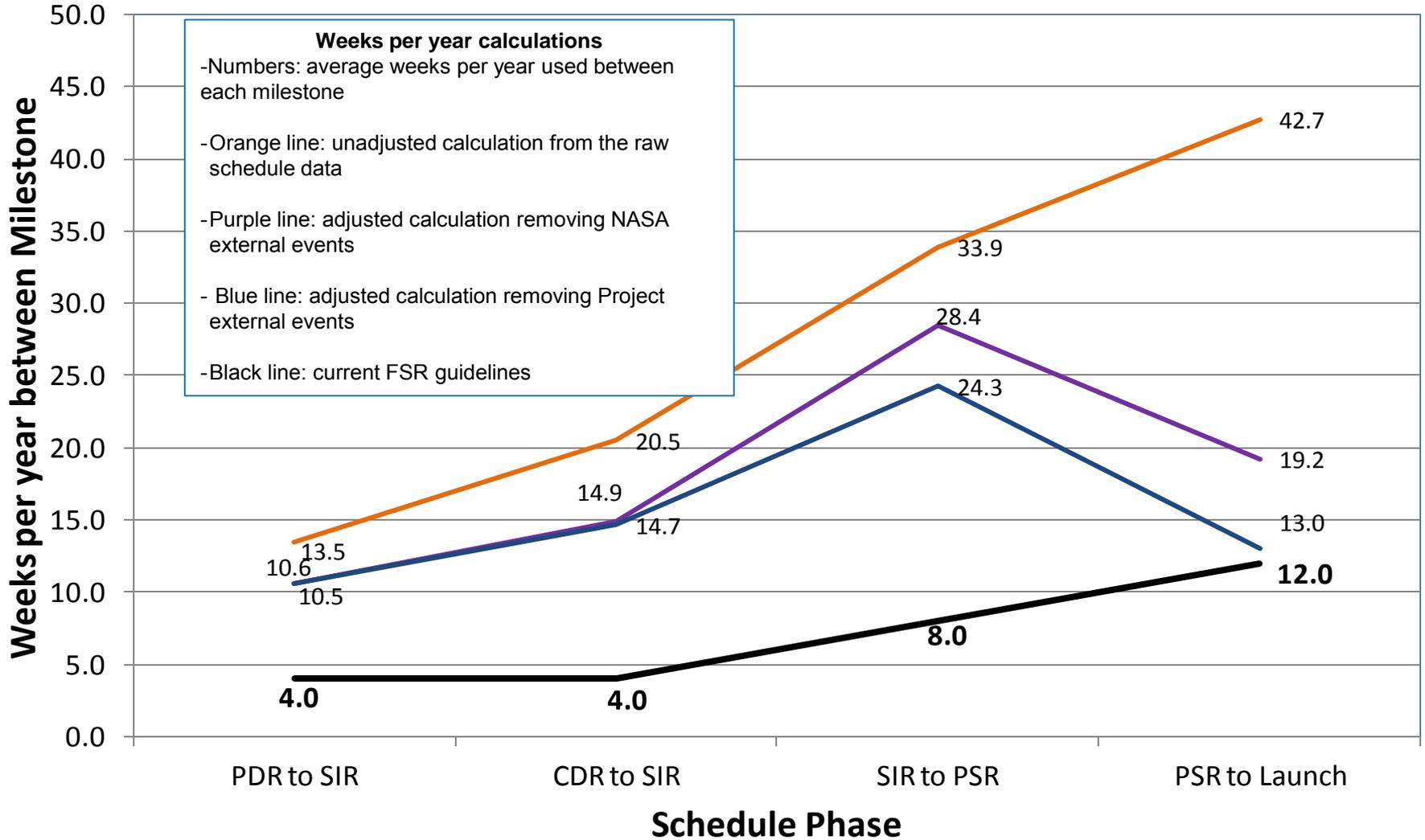


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Results of Historical Mission Examination

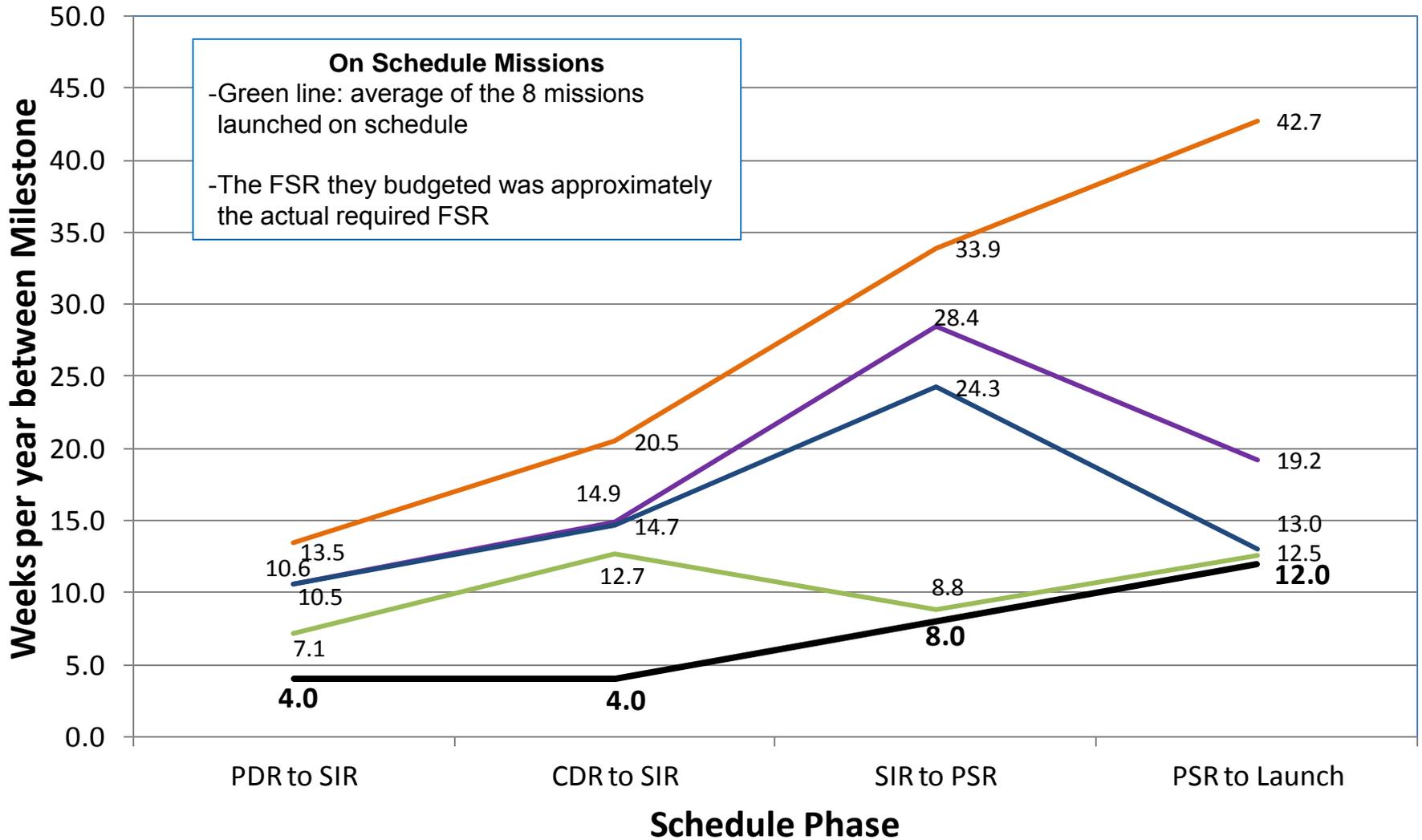
FSR Rates - All Missions



— Average All Causes
 — Average NASA External Removed
— Average Project External Removed
 — Current FSR Guidelines

Results of Historical Mission Examination

FSR Rates - All Missions

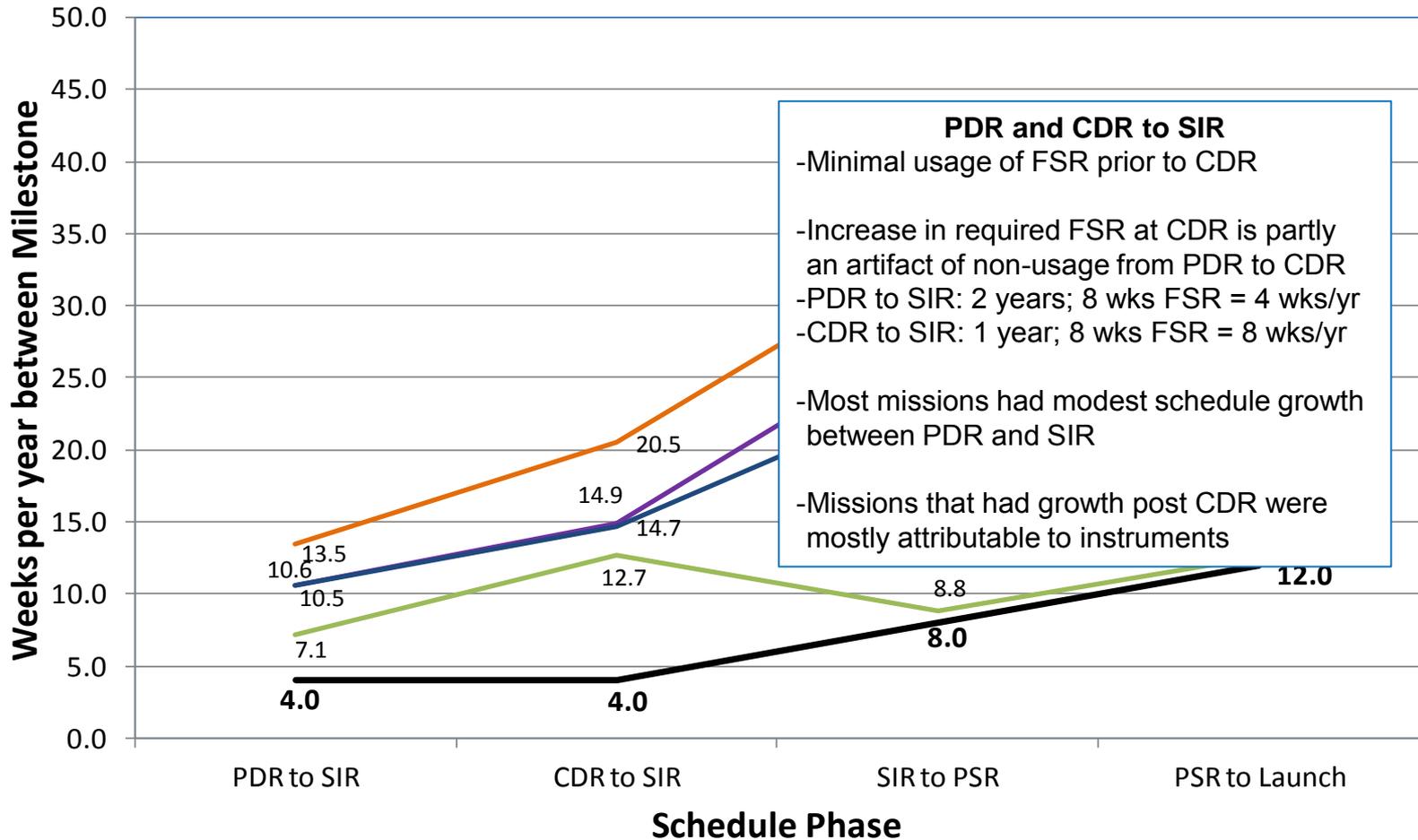


— Average All Causes
 — Average NASA External Removed
 — Average Project External Removed
— Current FSR Guidelines
 — Avg. Launched On Schedule



Results of Historical Mission Examination

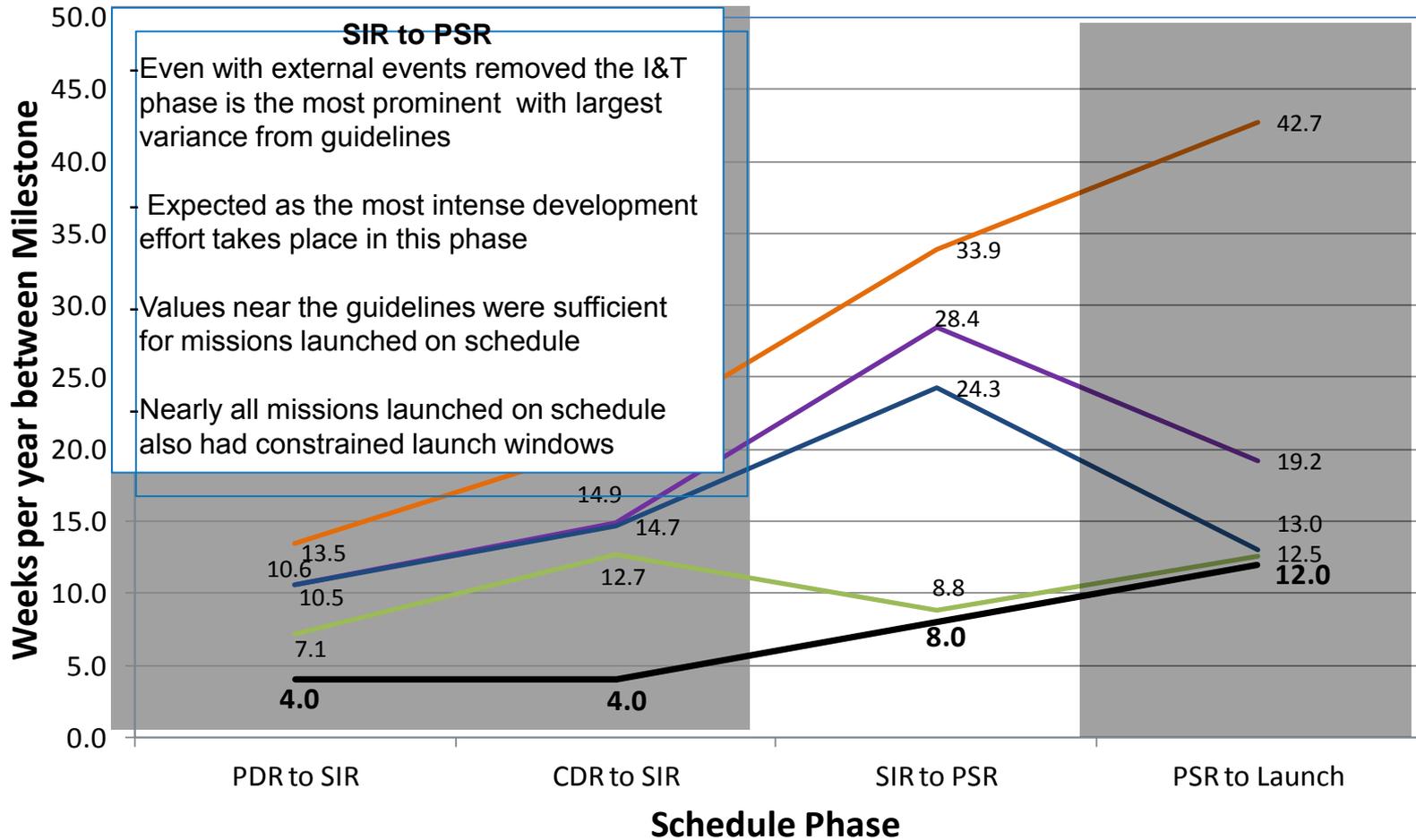
FSR Rates - All Missions



— Average All Causes
 — Average NASA External Removed
 — Average Project External Removed
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Results of Historical Mission Examination

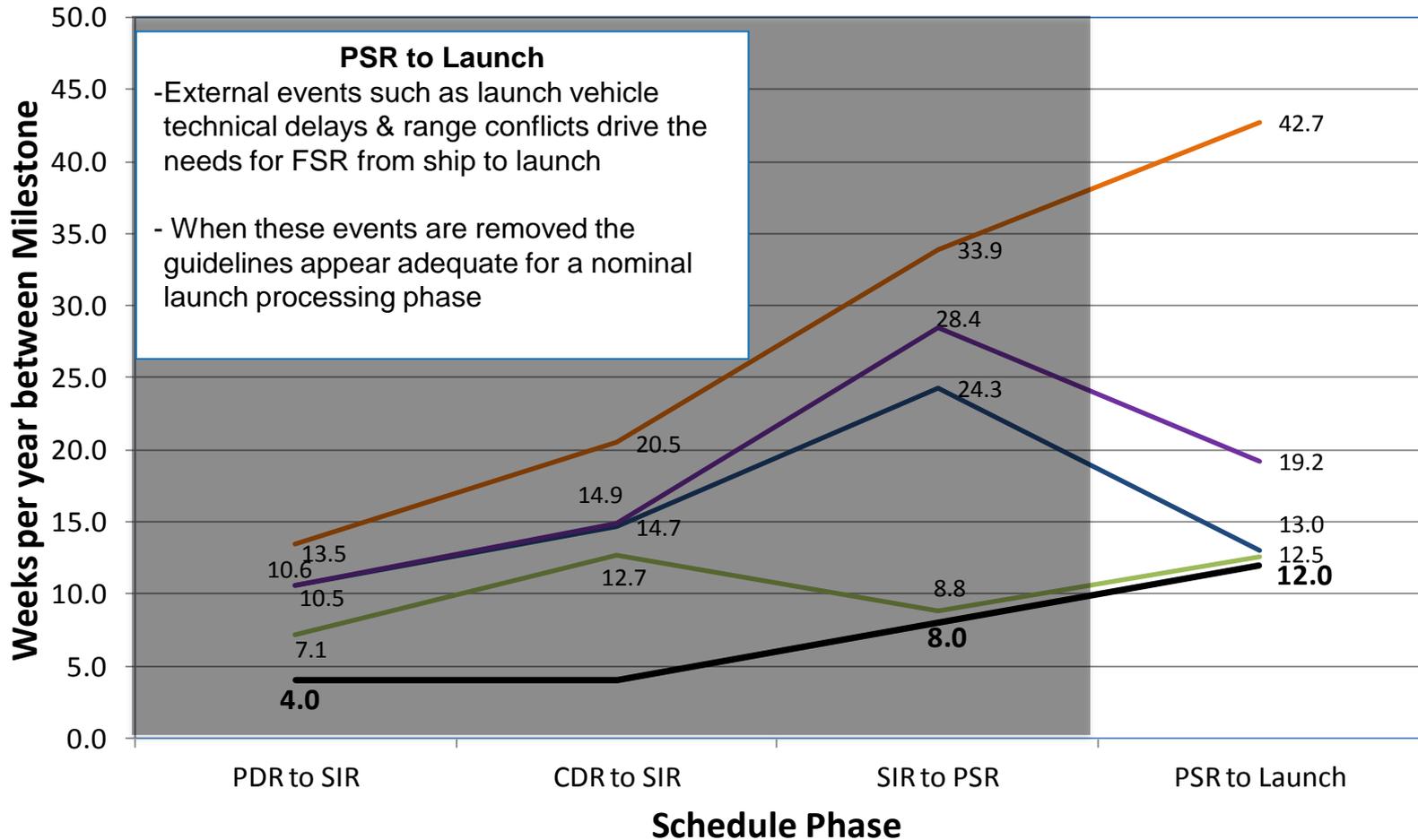
FSR Rates - All Missions



— Average All Causes
 — Average NASA External Removed
 — Average Project External Removed
— Current FSR Guidelines
 — Avg. Launched On Schedule

Results of Historical Mission Examination

FSR Rates - All Missions



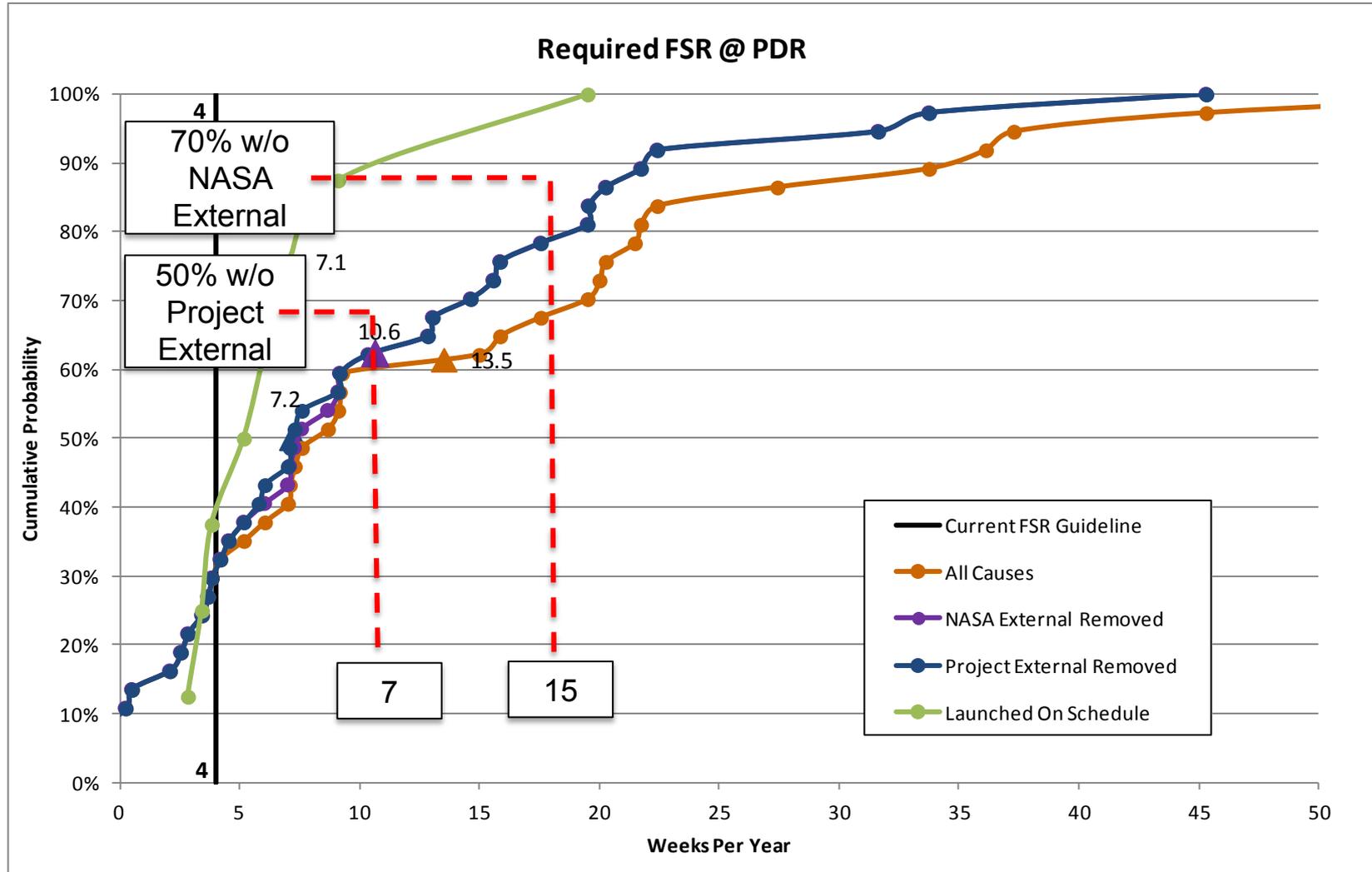
— Average All Causes
 — Average NASA External Removed
 — Average Project External Removed
— Current FSR Guidelines
 — Avg. Launched On Schedule

Further Analysis

- Examination of the average can be useful to assess overall trends
 - *However, there is much variation present in the schedule data*
 - *Some missions were affected by “extraordinary” events which could not be planned for*
 - *Data points to the far right can unfairly influence the average*
- Another approach is to examine a cumulative distribution of the data to identify the most probable outcomes
 - *Distributions were examined for potential FSR guidance consistent with NASA policy*
 - The 50% confidence level on the curve with Project External events removed is suggested for Project held reserves
 - The 70% confidence level on the curve with NASA External events removed is suggested for HQ/Center held reserves
- The following slides show the cumulative distributions at the guideline specified milestones (PDR, SIR, PSR) with the 50% and 70% levels highlighted

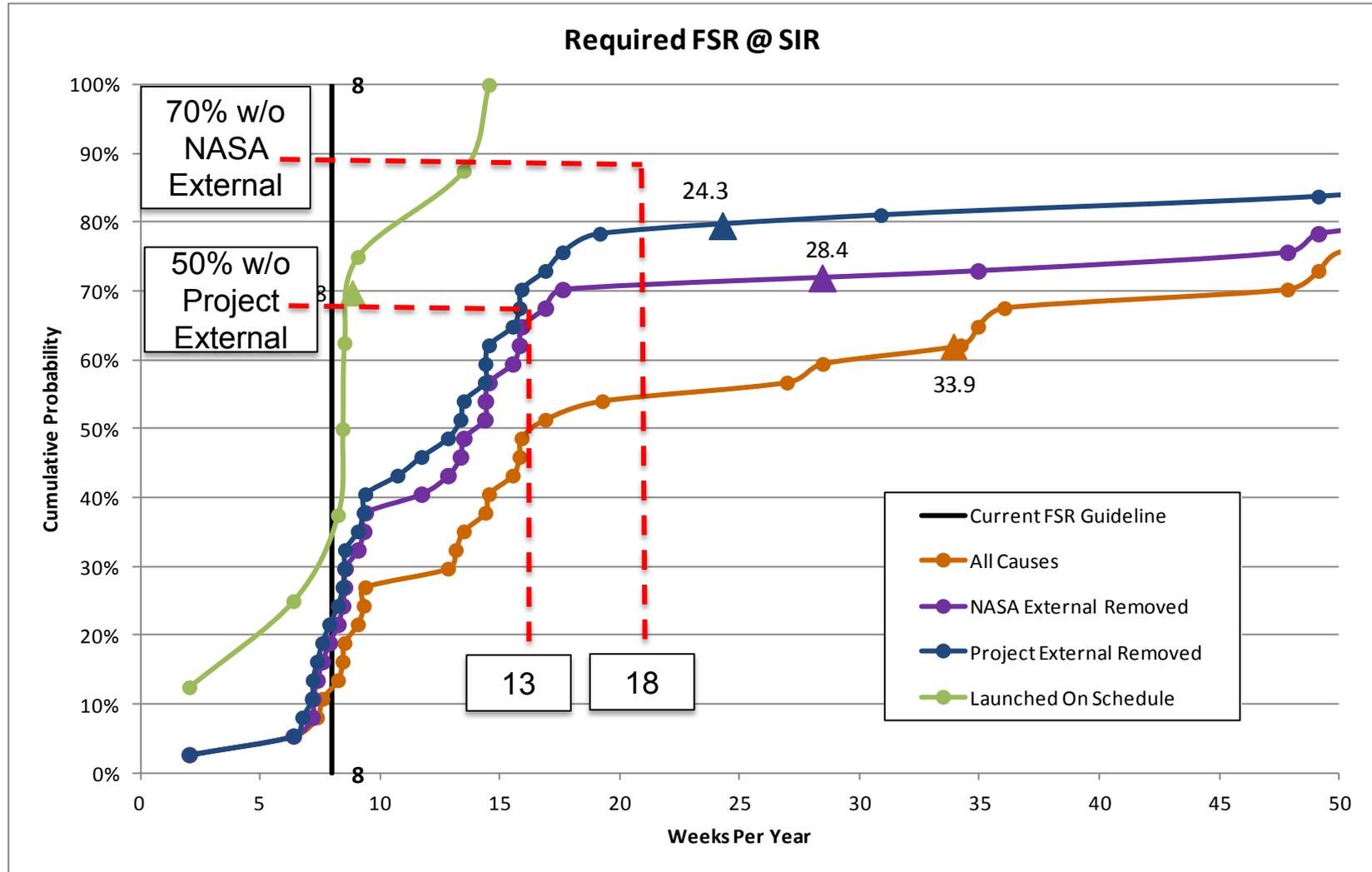
Required Schedule Reserve at PDR

Guideline: 4 weeks/year



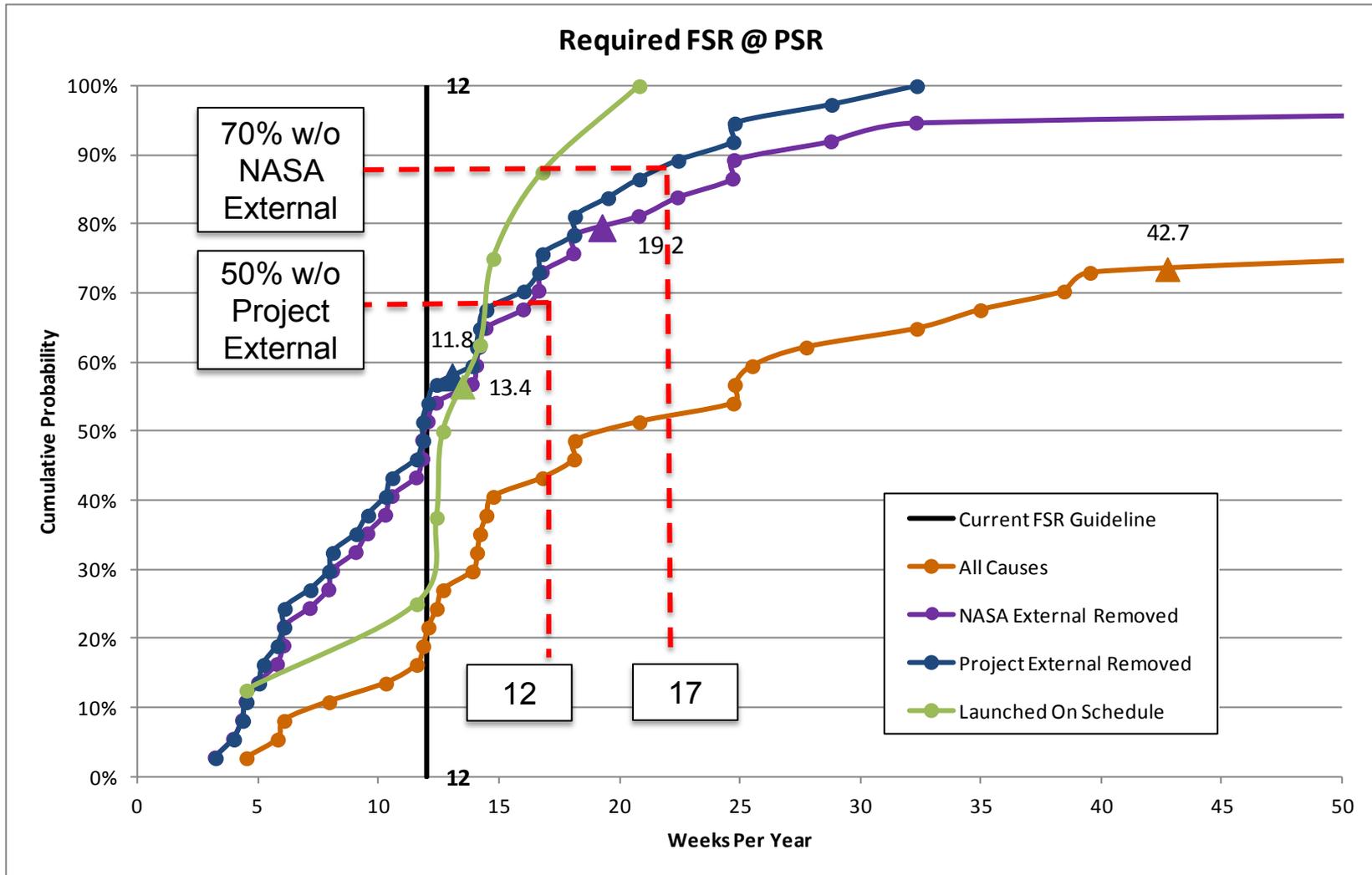
Required Schedule Reserve at SIR

Guideline: 8 weeks/year



Required Schedule Reserve at PSR

Guideline: 12 weeks/year



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Recommendations

- Examination of the cumulative distributions of historical data yielded the following recommended values of FSR given the example project schedule

Phase	ATP to PDR	PDR to SIR	SIR to PSR	PSR to Launch	Total (Years)	Total (months)
Example Duration (years)	0.75	2.0	1.0	0.25	4.0	48

Current Guidelines

FSR Rate (wks/year)	0	4	8	12	Total (Weeks)	Total (months)
Total FSR (weeks)	0	8	8	3	19	4

Recommended Project FSR at 50% confidence level

FSR Rate (wks/year)	0	7	13	12	Total (Weeks)	Total (months)
Total FSR (weeks)	0	14	13	3	30	7

Recommended Center/HQ FSR at 70% confidence level

FSR Rate (wks/year)	0	15	18	17	Total (Weeks)	Total (months)
Total FSR (weeks)	0	30	18	4.25	52.25	12
FSR above Proj. (wks)	0	16	5	1.25	22.25	5

Summary

- This study aimed to assess if the adequacy of the current guidelines for carrying funded schedule reserve based on schedule-to-go
- Historical data from 37 missions were assessed to determine required FSR over the project lifecycles
 - *Average weeks per year assessed for overall trends*
 - *Cumulative distributions examined to establish recommendations for specific confidence levels*
- Recommended FSR rates are listed below

Phase	PDR to SIR	SIR to PSR	PSR to Launch
Current Guidelines	4	8	12
Recommended Project FSR at 50% confidence (weeks per year)	7	13	12
Recommended Additional Center/Headquarters FSR at 70% confidence (weeks per year)	8	5	5
Recommended Total Project + Center/Headquarters FSR at 70% confidence (weeks per year)	15	18	17