

Growth Estimating Relationship

Forecast cost, schedule, and mass growth

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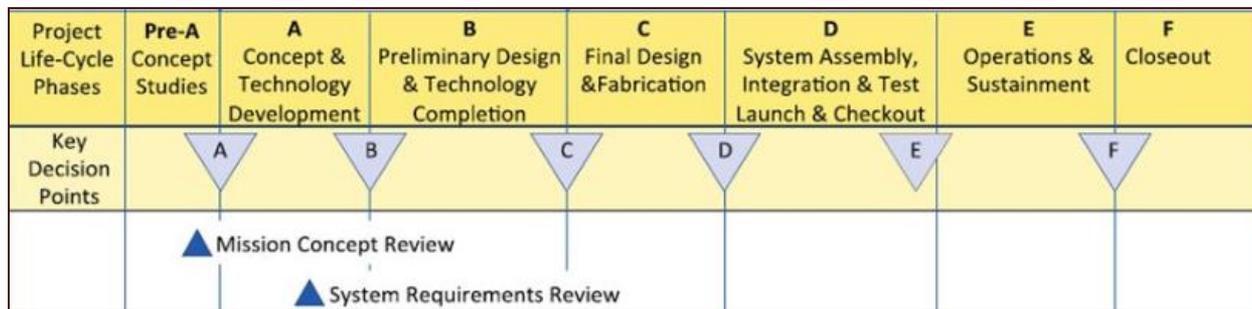


Discovery

- In the on-going struggle to capture a true estimate of a project we have found a **new** and **simple** way to estimate the **total growth of a project**
- We found that there is a relationship between **The ratio of actual reserve use, or contingency to actual total growth** and **total project growth**
- This relationship is exhibited in **mass, cost, and schedule**

Analogies to CERs, SERs...GERs

- Cost estimating relationship (CER) and Schedule Estimating Relationship (SER) use “actuals” from historical data to estimate future values
- CADRe historical data provides:
 - Projects’ SRR performance data (mass, cost, schedule)
 - Projects’ SRR mass margin, cost reserve, and schedule reserve
 - Projects’ at launch mass, cost, and schedule actuals



SRR Metrics

**At Launch:
Mass Growth
Cost Growth
Schedule Growth**

CADRe Historical Data Points used for GER Developments

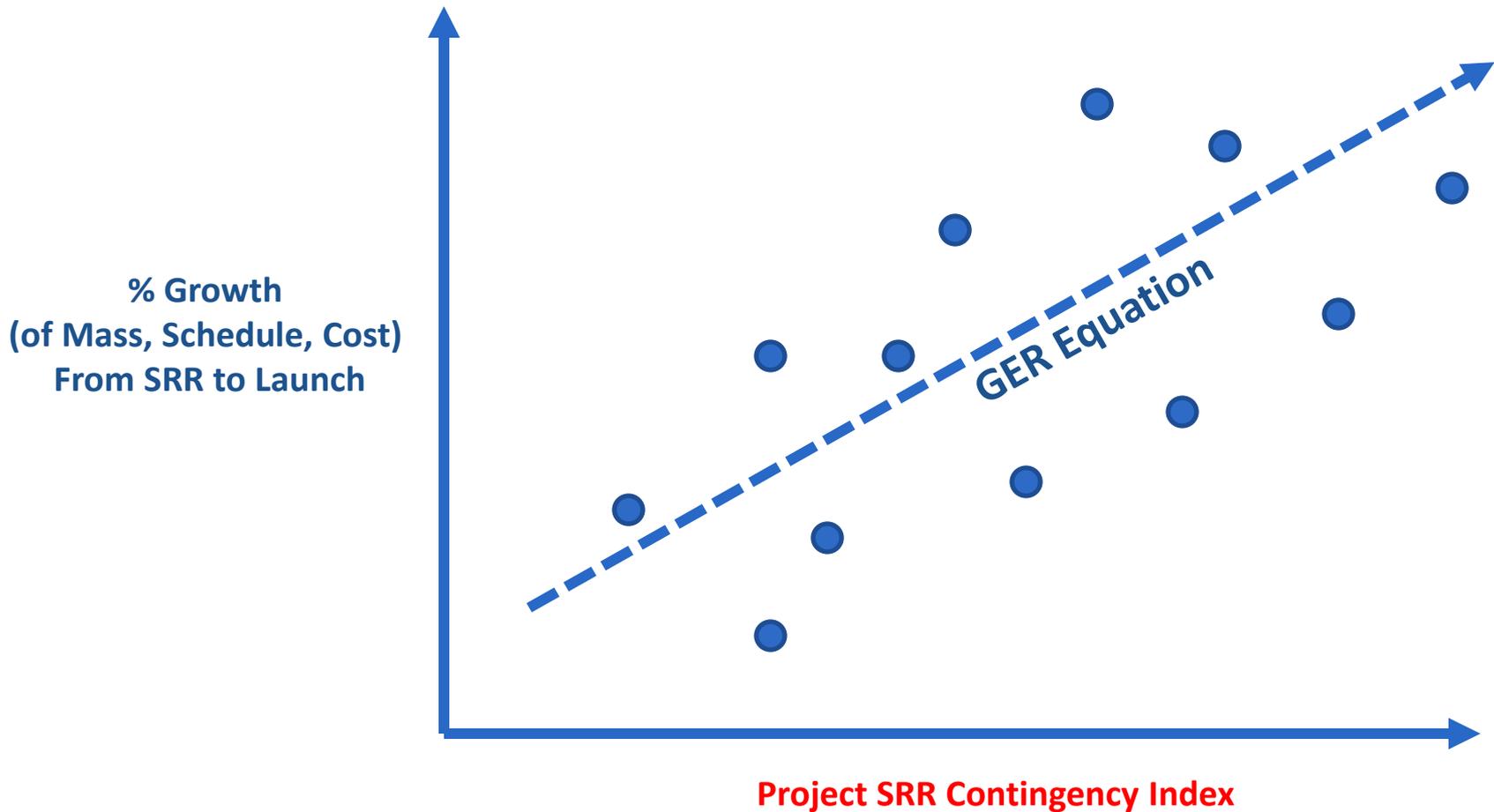
Mass Growth
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DEEP IMPACT
GLAST
GRAIL
IBEX
IRIS
JUNO
KEPLER
LRO
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- All data points came from CADRe
- 3 sets of GERs—Mass, Cost, & Schedule
- Some data points did not have “complete & useable” data in cost, schedule, or mass
- “Scatters” are reflective of data point characteristics, e.g., interplanetary, earth observatory, time frame, etc.

GER Axis: % Growth from SRR to Launch and Project SRR Contingency Index



SRR Contingency Index (SCI)

- SCI is a ratio of amount actual growth between SRR and PDR to the amount of contingency at SRR
 - Contingency for Mass is mass margin
 - Contingency for Cost is cost reserve
 - Contingency for Schedule is schedule reserve

$$\text{SRR Contingency Index (SCI)} = \frac{\text{Actual Growth between SRR \& PDR}}{\text{Contingency at SRR}}$$

SCI for Mass, Cost, and Schedule

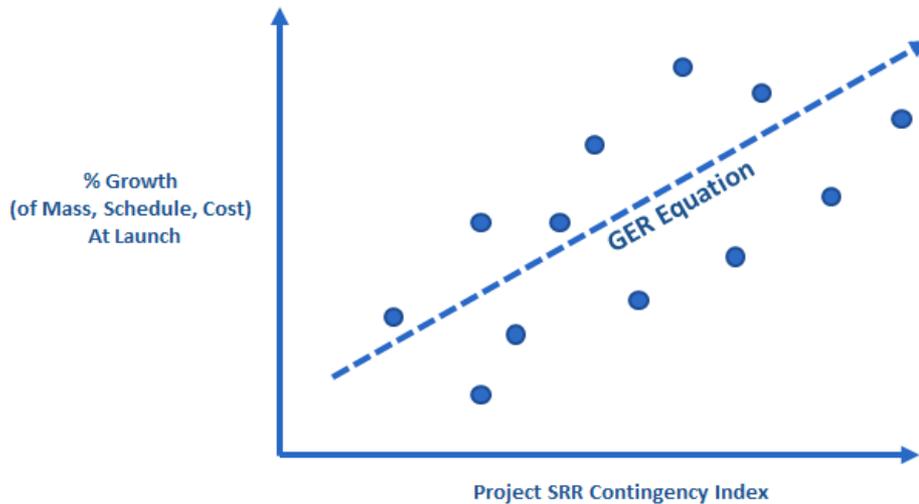
$$\text{SRR Contingency Index (SCI) for Mass} = \frac{\text{CBE Mass@PDR} - \text{CBE Mass@SRR}}{(\text{CBE Mass@SRR} + \text{Contingency}) - \text{CBE Mass@SRR}}$$

$$\text{SRR Contingency Index (SCI) for Cost} = \frac{\text{Total_Cost@PDR} - \text{Total_Cost@SRR}}{(\text{Total_Cost@SRR} + \text{Reserve}) - \text{Total_Cost@SRR}}$$

$$\text{SRR Contingency Index (SCI) for Schedule} = \frac{\text{Total_Duration@PDR} - \text{Total_Duration@SRR}}{(\text{Total_Duration@SRR} + \text{Schedule_Reserve}) - \text{Total_Duration@SRR}}$$

*Schedule duration: from SRR to Launch; Schedule_Reserve 1 month/year guideline

GER Development for Mass, Cost, & Schedule



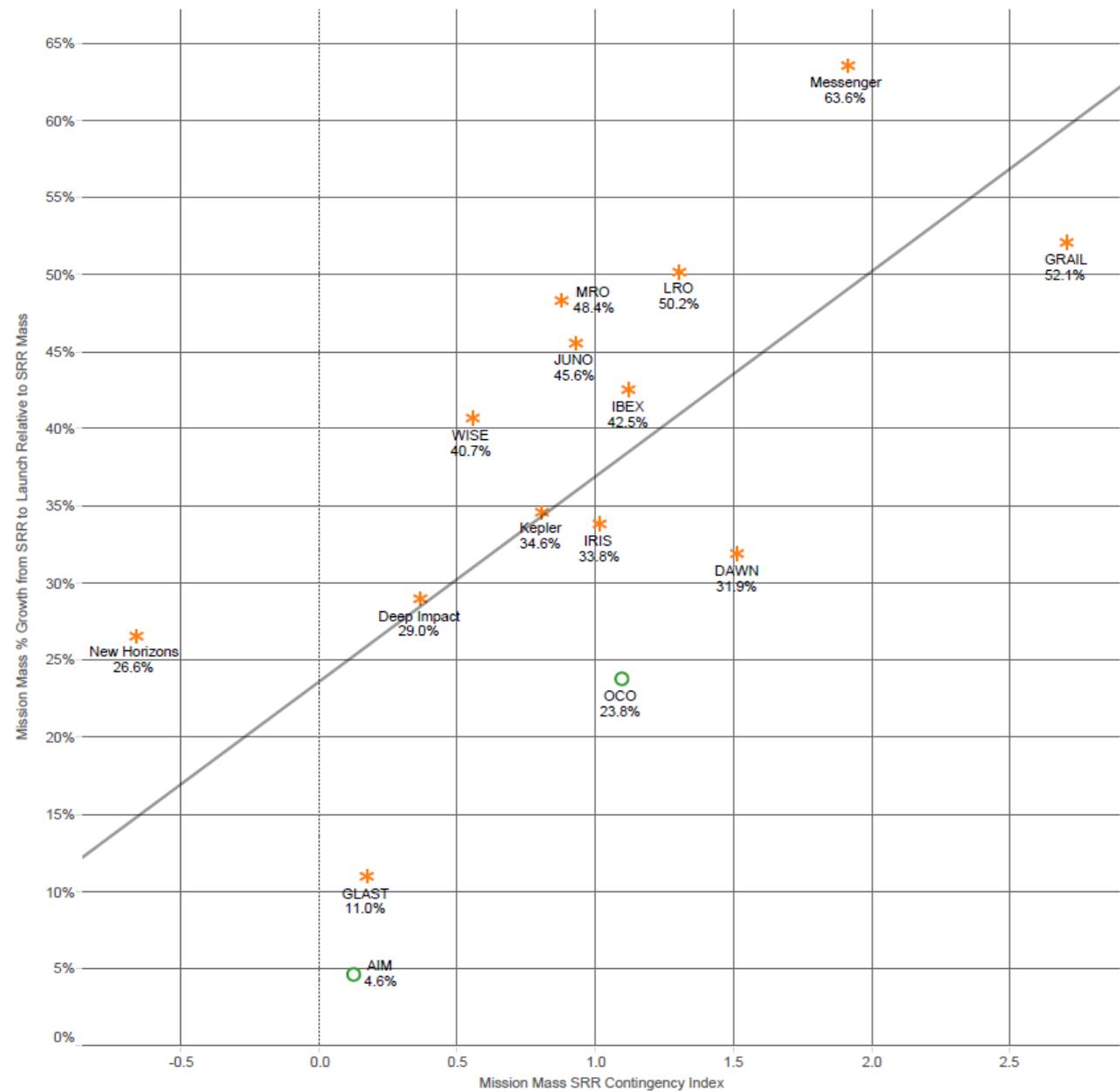
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- Y-axis: calculated % growth at launch (mass, cost, schedule)
- X-axis: calculated the SRR Contingency Indices
- Developed three GER regression equations for mass, cost, schedule

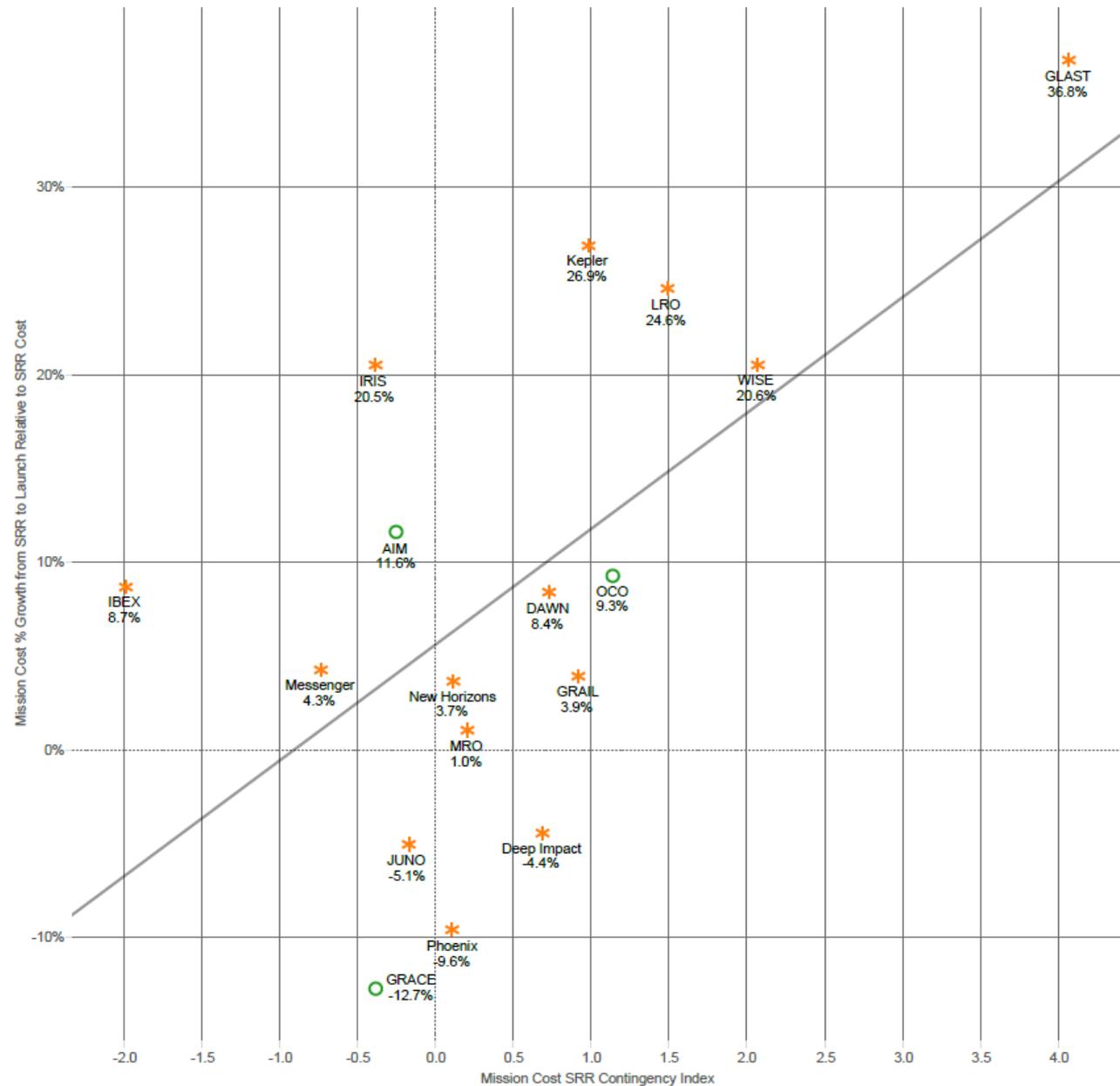
Mission Mass SCI & Percent Growth to Launch



Mass GER

- Equation:
 - Mission Mass % Growth from SRR to Launch relative to SRR Mass = $(0.132899 * \text{Mission Mass SRR Contingency Index}) + 0.236072$
- Linear trend model
 - Number of modeled observations: 15
 - R-Square: **0.45734**
 - Standard error: 0.120039
 - p-value (significance): 0.0056383
- Data:
 - Labels: Missions and % of Mission Mass Growth
 - Shape & Color: Green Circles represent Earth Orbiting Projects & Orange Stars represent Interplanetary Projects

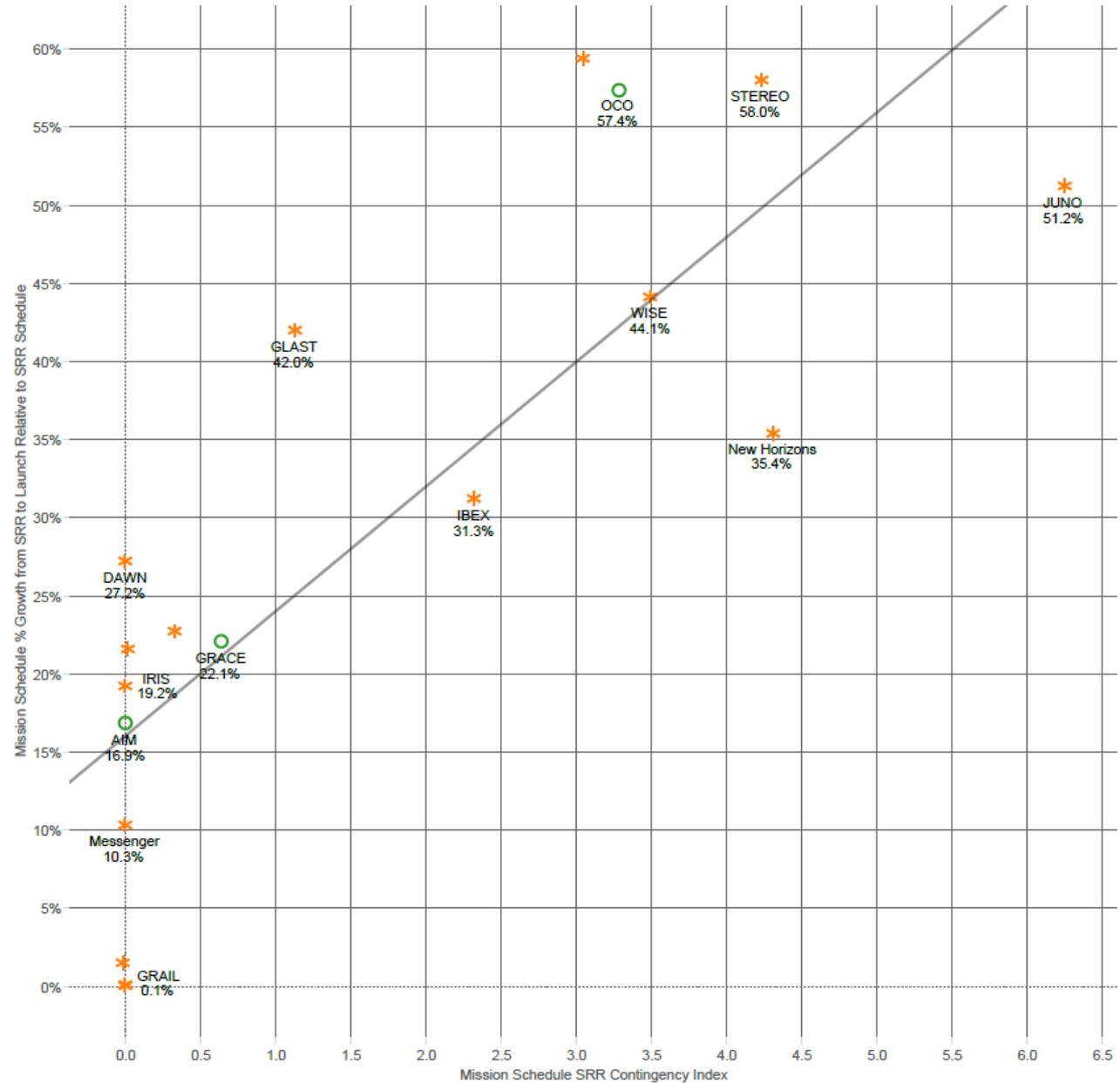
Mission Cost SCI & Percent Growth to Launch



Cost GER

- Equation:
 - Mission Cost % Growth from SRR to Launch relative to SRR Cost = $(0.061743 * \text{Mission Cost SRR Contingency Index}) + 0.0562448$
- Linear trend model
 - Number of modeled observations: 17
 - R-Squared: 0.359803
 - Standard error: 0.112075
 - p-value (significance): 0.010917
- Data:
 - Labels: Missions and % of Mission Cost Growth
 - Shape & Color: Green Circles represent Earth Orbiting Projects & Orange Stars represent Interplanetary Projects

Mission Schedule SCI & Percent Growth to Launch



Schedule GER

- Equation:
 - Mission Schedule % Growth from SRR to Launch relative to SRR Mass = $(0.079776 * \text{Mission Schedule SRR Contingency Index}) + 0.160815$
- Linear trend model
 - Number of modeled observations: 18
 - R-Squared: 0.650078
 - Standard error: 0.120815
 - p-value (significance): <0.0001
- Data:
 - Labels: Missions and % of Mission Schedule Growth
 - Shape & Color: Green Circles represent Earth Orbiting Projects & Orange Stars represent Inter-planetary Projects

Future GER Application :

NPR 7120, Appendix F.3 Formulation Agreement

- “Project or single-project programs develop and maintain the status of a set of programmatic and technical leading indicators...”
 - Formulation Cost Trends
 - Schedule Trends
 - Technical Performance Measures (Mass Margins)

- At the Preliminary Design Review, GERs will diagnose trends and provide immediate metrics

- Next Steps:
 - Collect more CADRe data for cost, schedule, and mass
 - Update reporting

Backup

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Acronyms & Definitions

- CI – Contingency Index
- SCI – SRR Contingency Index
- SRR – System Requirements Review
- PDR – Preliminary Design Review
- EO – Earth Orbiting
- IP – Interplanetary
- Variable (metric) – Either refers to Cost, Schedule Duration or Mass depending on the referenced title of the chart
- Contingency – Refers to Slack or Reserves
- Mon – Months
- M – Mass
- S – Schedule
- C – Cost

*Guideline Sources

- Suggested Contingency Allocation determined by: GSFC-STD-1000F GOLD Rules.pdf – 30% At Pre-Phase A (25% at Phase A)
- Suggested Contingency Allocation determined by: JPL Guidance for Cost Project Reserves – 30% At A-B transition Proposal to AO Response
- *Suggested Contingency Allocation determined by: JPL Guidance for Schedule Project Reserves – 1 month per year of schedule
- For any questions please contact Rey Carpio

How Percent Growth was Calculated

■ % Growth is Calculated with Actuals:

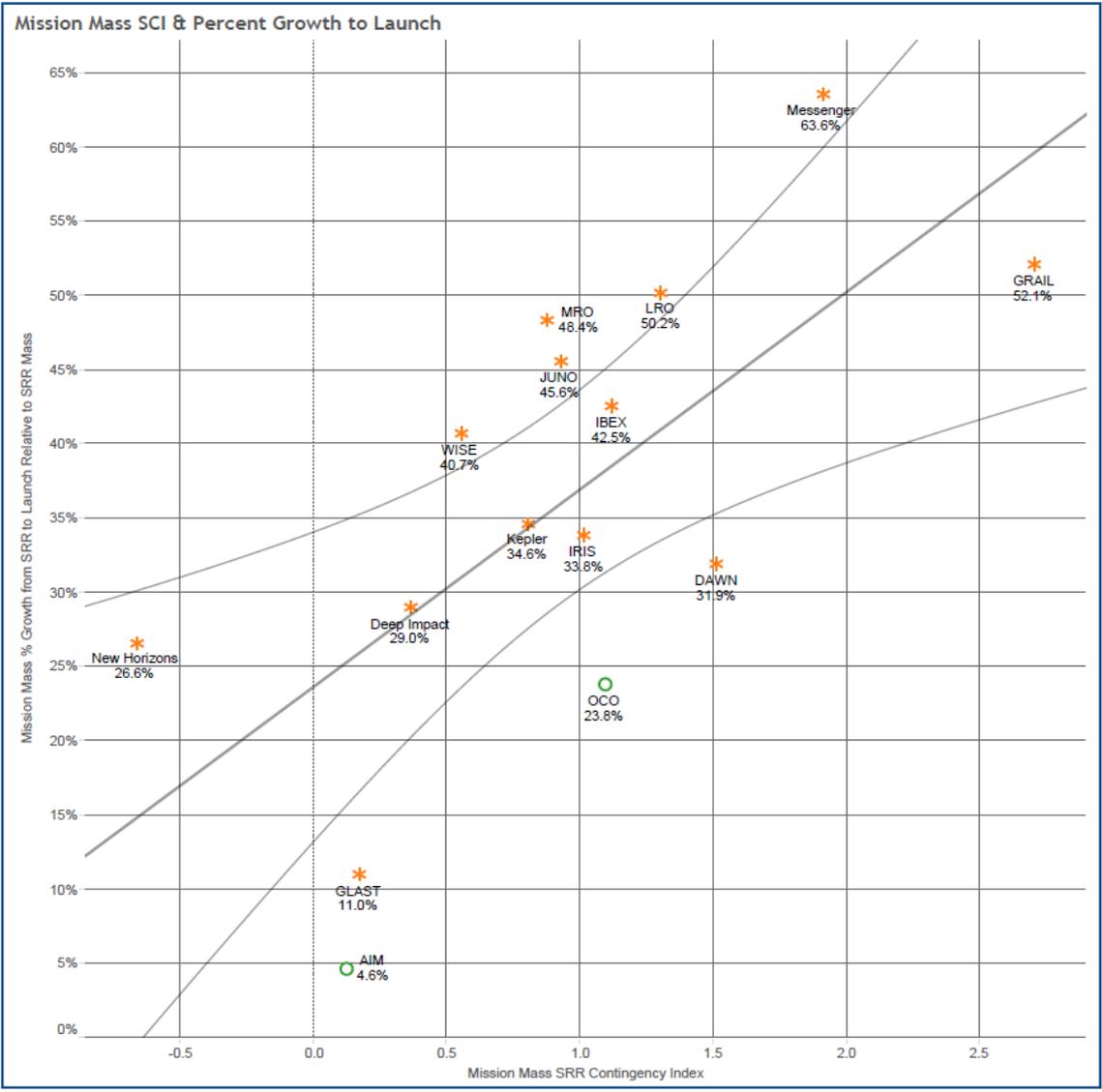
- Mission Launch value
- Mission SRR value

■ The Equation is as follows:

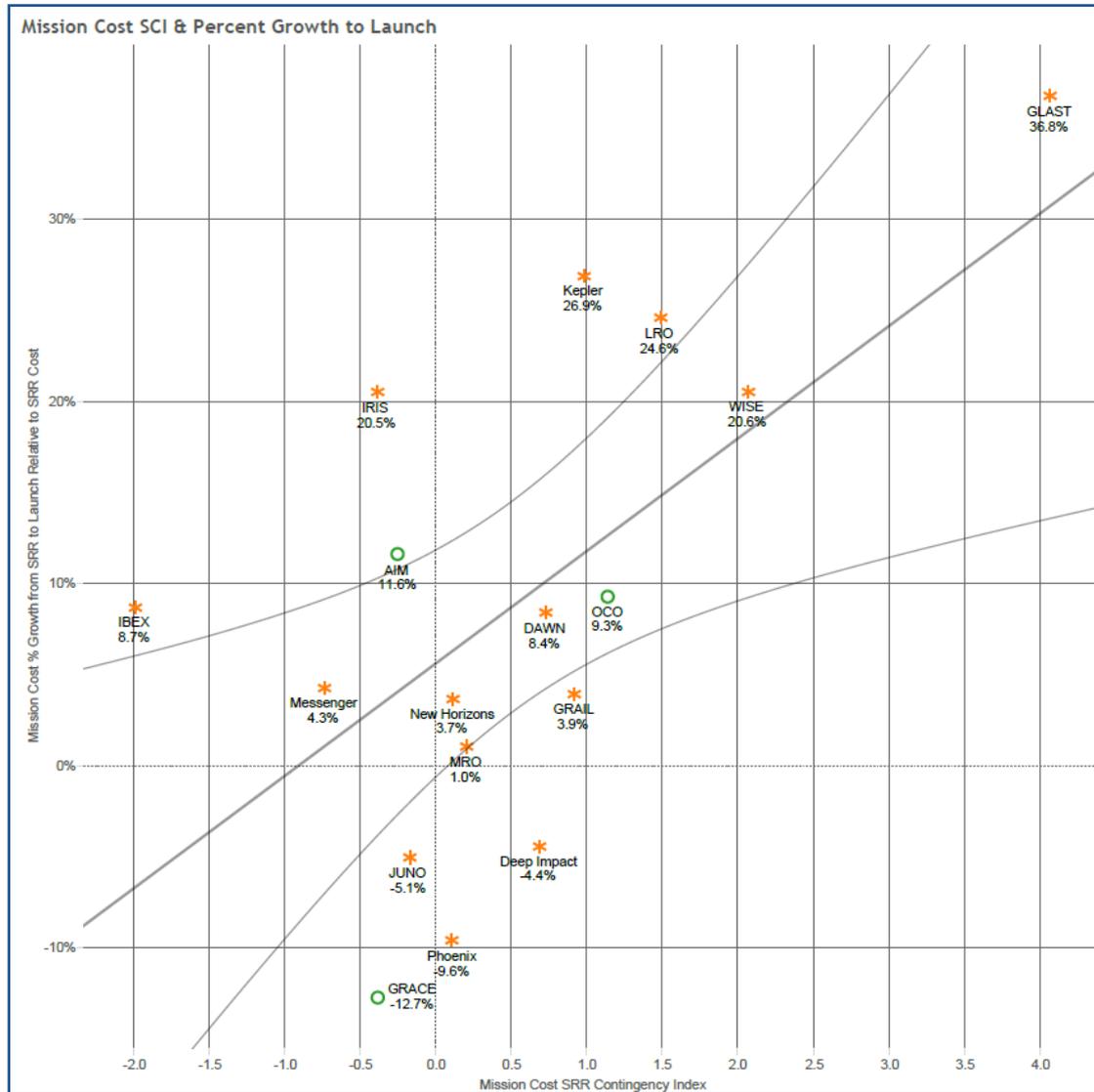
- $$\frac{(\text{Mission Launch value} - \text{Mission SRR value})}{\text{Mission SRR value}}$$

- For Example: If Launch Mass is 199.5kg and SRR Mass is 190.7kg the equation would be :
$$\frac{(199.5 - 190.7)}{190.7} = 4.61\%$$

Mass Confidence Bands GER



Cost Confidence Bands GER



Schedule Confidence Bands GER

