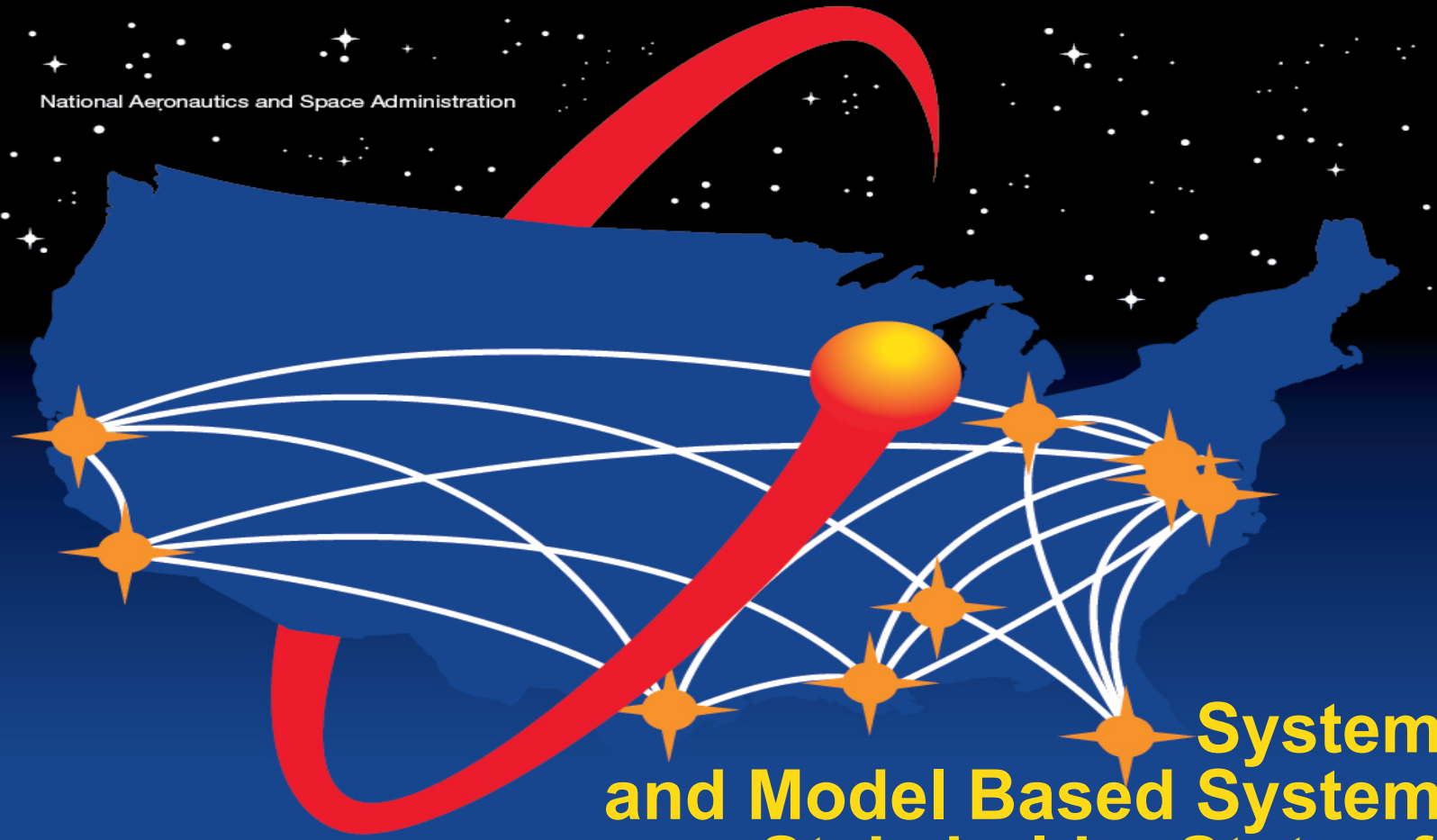
National Aeronautics and Space Administration



Systems Engineering and Model Based Systems Engineering Stakeholder State of the Discipline

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NASA Systems Engineering
MODEL BASED SYSTEMS ENGINEERING

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MBSE

Executive Summary

Background:

NASA Systems Engineering queried external SE organizations to

1. Understand where they are now and where they are going
2. Identify possible partnerships

Results Overview:

- NASA and study sources agree that SE workforce technical, systems management, and people leadership skills are all healthy
  - Skills increase with experience
- SE organizations overwhelmingly agree that SE should emphasize innovation
- Most sources agree that MBSE can be beneficial, but benefits are difficult to measure
  - Cultural issues represent the #1 MBSE challenge
- MBSE is in its infancy – A majority have <25% adoption and a plurality have <10% adoption

NASA and its stakeholders have an opportunity to grow in SE and MBSE together!

Sources and Methodology

- Information gathered through in-depth **interviews Summer 2019**
- Each report was **developed independently** of one another
- **50 reports from over 56 sources** specified by NASA for contact
- Sources were **individuals working to promote MBSE**

Interviews conducted via Harlan Brown & Company, Inc.

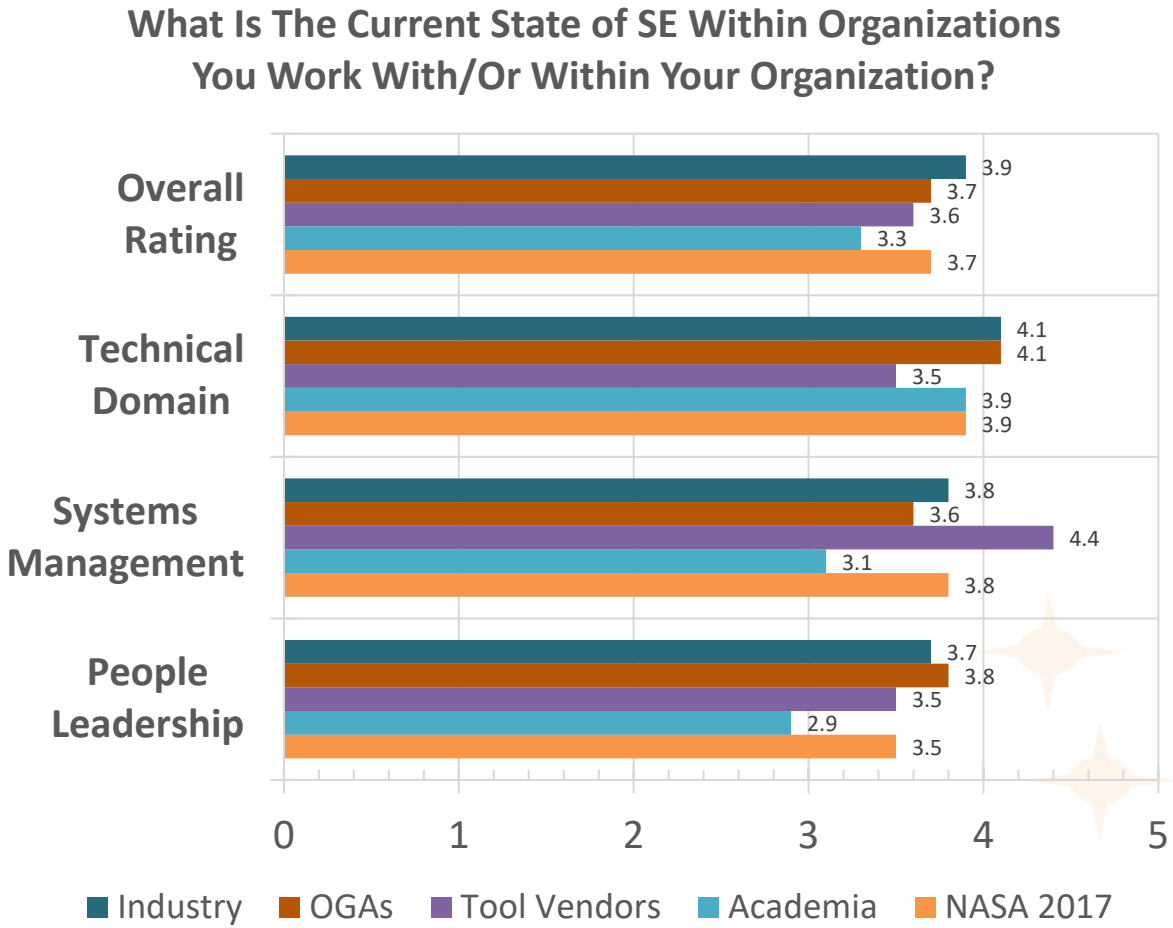
Academia	12, 24%
SE/MBSE Researchers	9, 75%
Instructors	8, 67%
Department Chairs	4, 33%
Worked with industry	7, 58%

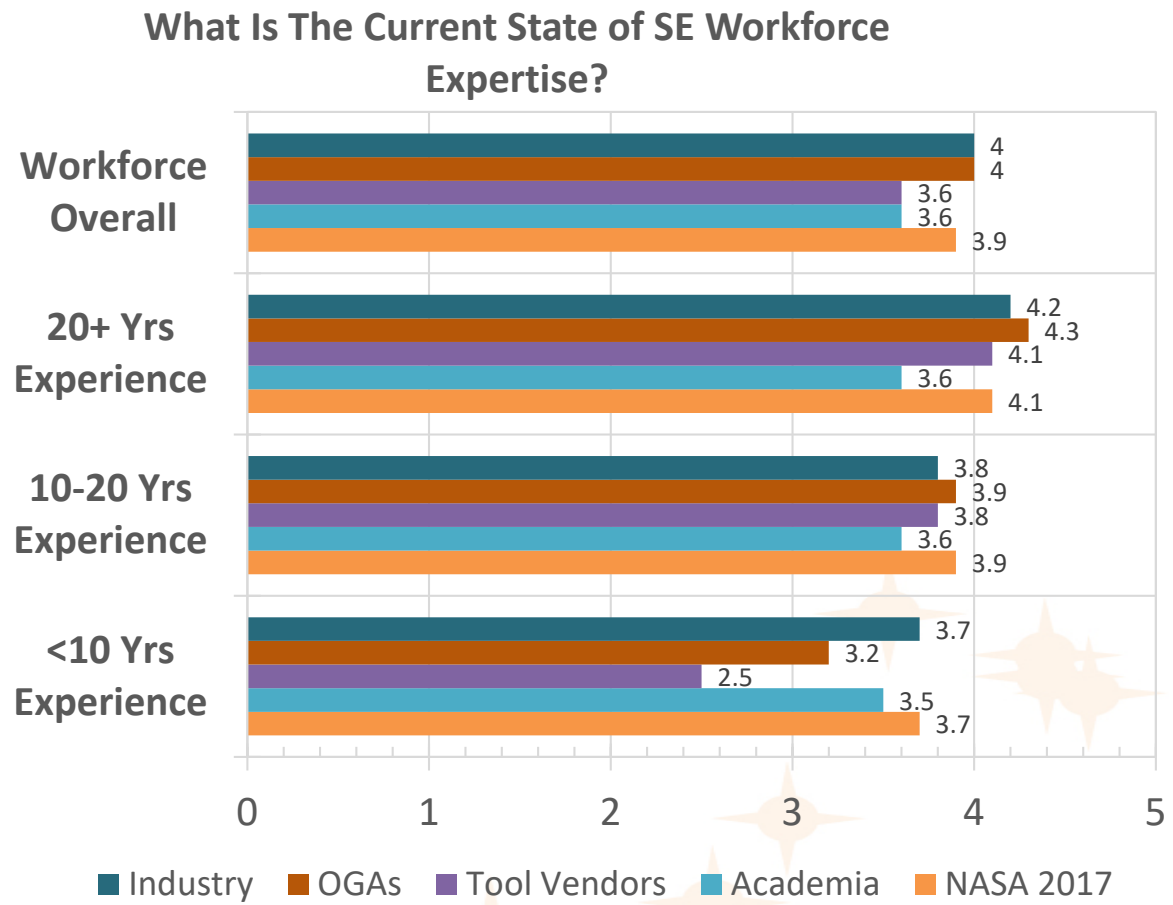
OGAs	10, 20%
Directors or Department Heads	7, 70%
Systems Development	2, 20%
SE Fellow	1, 10%
Central Office	4, 40%
Field/Branch Locations	4, 40%
Pentagon	2, 20%

Tool Vendors	5, 10%
MBSE Software	3, 60%
Other Software	2, 40%
Marketing/Sales	2, 40%
Chief MBSE Solutions Architect	2, 40%
President	1, 20%
Product Manager	1, 20%

Industry	23,46%
Subcontractors	12, 52%
Consultants	5, 22%
Primes	4, 17%
Suppliers	2, 9%
Space	11, 48%
Defense	3, 13%
Space & Defense	9, 39%
Large	13, 57%
Small	10, 43%
Domestic (US)	19, 83%
International	4, 17%
Division/other level	18, 78%
Corporate	5, 22%
Engineer/Practitioner	12, 52%
Management	11, 48%

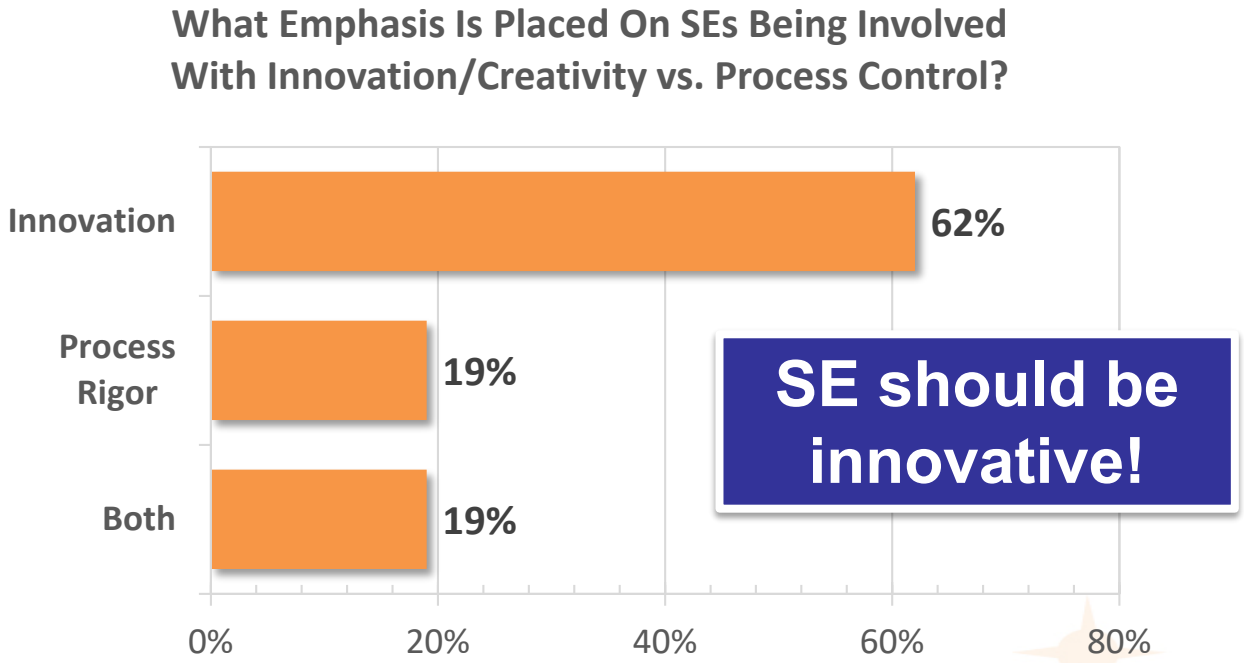
State of Systems Engineering

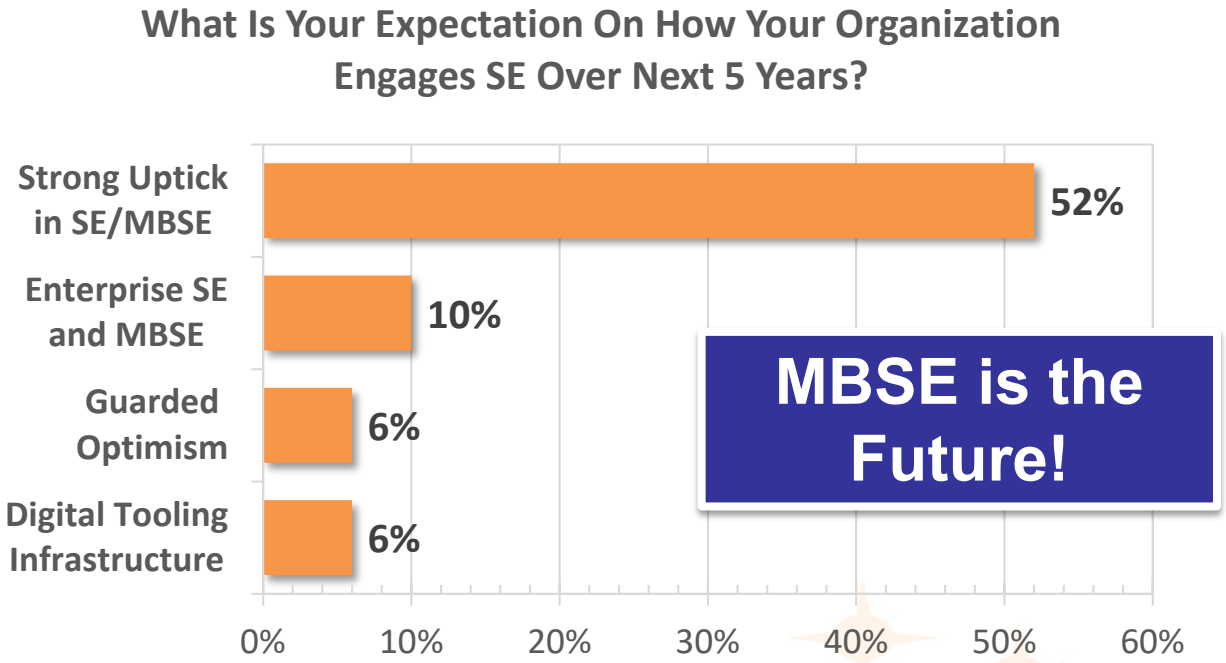




Systems Engineering is progressing similarly well across NASA and its partners!

Systems Engineering Emphasis and Future Expectations





"**Innovation is *fundamental* to systems engineering**; SEs do tradeoffs and look at alternative ways of doing things. Systems engineering is inherently innovative." *(Industry Source)*

MBSE Benefits and Challenges

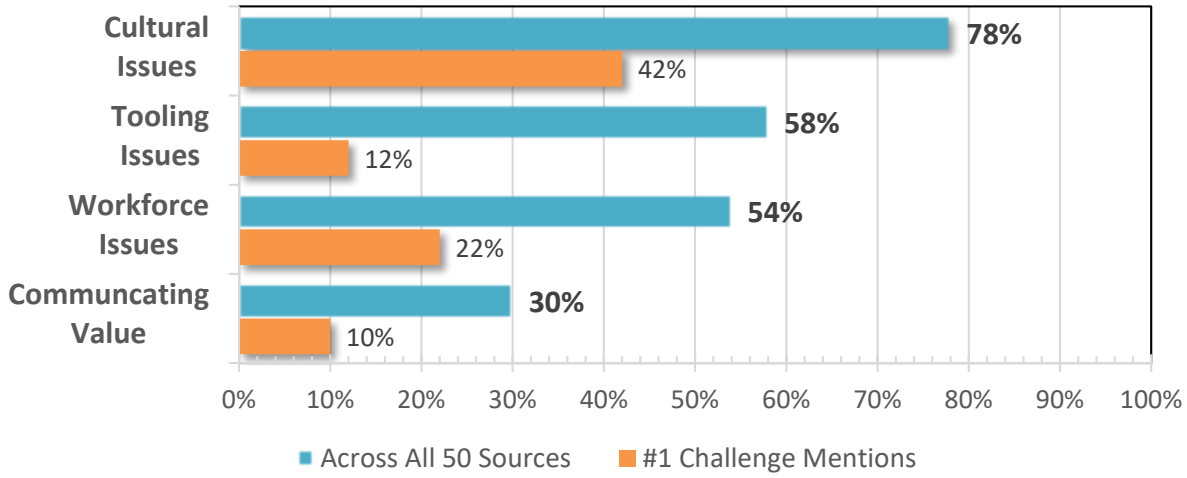
Benefits

59% have seen some MBSE benefits, but benefits are diverse.

41% believe it is not yet clear or it is difficult to measure how successful MBSE has been.

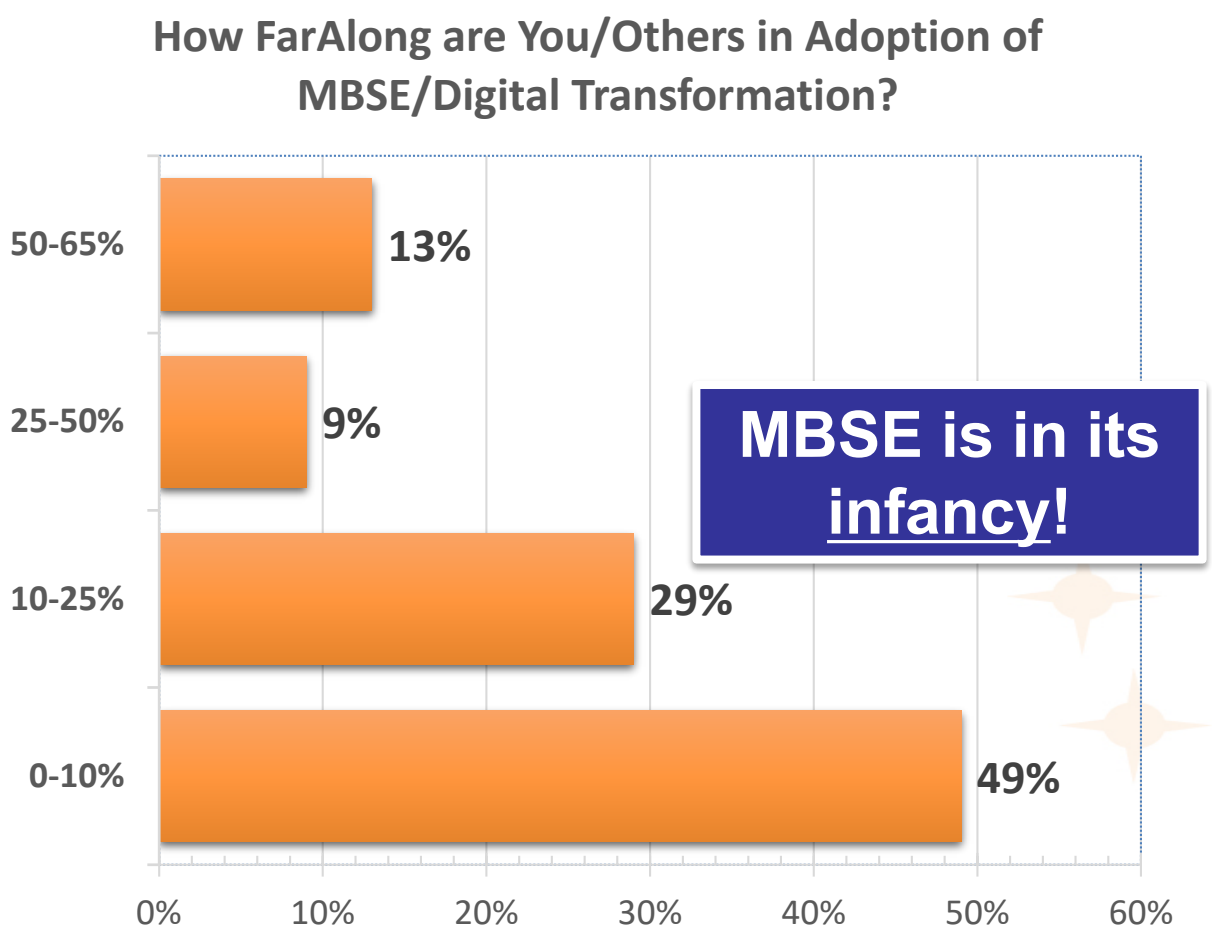
- "… during I&T; we are seeing **a 5-15% reduction in out of phase defects** through use of MBSE." ***(Industry Source)***
- "We have developed **at least 20%, maybe up to 40%, time reduction for early phases** of the project up to PDR." ***(Industry Source)***
- "… we see a substantial**, more than 50%, reduction of trivial RIDs** (Review Item Discrepancies) in reviews." ***(OGA)***

Challenges



- "**Dealing with customers demanding it, who don't really know what they want.** MBSE means different things to different people/is not being fully utilized." ***(Industry Source)***
- "… getting people comfortable with sharing and accept that **there will be some loss in autonomy and power**." ***(Industry Source)***
- "Technical issues such as **concurrent engineering and collecting a true single source of truth and getting the disparate systems connected.**" ***(Industry Source)***

Organizational MBSE Adoption



- "**Helping people understand the value of making the upfront investment** in both SE and MBSE and that payout may take 5+ years." (***Industry Source)***
- **"We are trying to standardize use of MBSE for space programs."** ***(Industry Source)***
- **"I have guarded optimism.** Deployment is the key to continued growth. **The ability to make improvements in automating SE is directly related to the value that companies place on SE in the first place."** ***(MBSE Consultant)***
- "**We are well over 70% MB in the early phases of a project.** It's easier to support a model in the earlier phases." ***(Industry Source)***
- "**We jumped into our SE Transformation initiative in 2014.** We are now five years into it, and it is expected that we will complete the majority of the work over the next couple of years. **We have been leveraging a lot what JPL has been doing in MBSE."** ***(OGA)***

Harlan Brown Suggested Considerations for NASA

- **Communicate MBSE success stories and the MBSE value proposition.**
  "We have a team that is charged with working with our partners, collecting good news stories and developing a PR package to promote MBSE." *(OGA)*

- **Consider partnering with study sources involved with innovative ideas**, such as:
  - An OGA who recently started a MBSE Advisory Group with all its contractors; they appear well coordinated in their MBSE activities.
  - Several organizations that appear actively involved with growing MBSE in defense.
  - An OGA who has extensive in-house training and is highly active in enterprise MB.
  - Two active academia, one who recently established a new SE department and one with its consortium.
  - A key MBSE tool vendor and other tool vendors.
  - Others such as 3 OGAs, 2 industry sources and the two MBSE consultants.

- **Brainstorm/further study the key challenges for MBSE adoption** identified in this study to identify potential ways NASA, Industry, OGAs, Academia, and tool vendors **can work together in address them together.**

- **Maintain/grow MBSE conferences and working groups** to foster communication, collaboration, and lessons learned sharing between NASA, industry partners, OGAs and others.

Final Thoughts

Systems Engineering:

- SE workforce technical, systems management, and people leadership skills are healthy
  - People leadership skills present an opportunity for improvement
- Innovation is fundamental to systems engineering
- MBSE is the future of SE

Model Based Systems Engineering:

- MBSE benefits are still difficult to characterize
  - Even though 59% of study sources have seen at least one major benefit at their organization
- Significant effort should be placed on solving MBSE adoption's culture change challenge
  - Tool and workforce issues are the #2 and #3 challenges respectively
- NASA's partners are just now starting to adopt MBSE in earnest

NASA and its stakeholders have learned and can continue to learn from each other!

Thank You!!

- Thank you to all of our study sources who contributed their valuable time and opinions!
  - **Great potential exists for collaboration**
- A special thank you to Gerald Pawlikowski of Harlan Brown for performing this study!!
  - If you are interested in his services, you can contact him at gjpawlikowski@verizon.net

For More Information…

- Full 88 slide report available at:
  - https://go.nasa.gov/3ikvYV1
- Contact NASA Systems Engineering and Model Based Systems Engineering:
  - Jon Holladay – jon.holladay@nasa.gov
  - Jessica Knizhnik – jessica.knizhnik@nasa.gov
- Contact NASA MBSE Community of Practice
  - Trevor Grondin – trevor.a.grondin@nasa.gov
  - Samantha Infeld – samantha.i.infeld@nasa.gov
- All are invited to a verbal presentation of these slides with NASA SE and MBSE
  - Monday, July 20th at 2pm EDT
  - NASA link: https://go.nasa.gov/31v5t9j
  - Public link: https://go.nasa.gov/2ZcAOLp