National Aeronautics and Space Administration

Getting Started Using MBSE on a Project: the Basics of What, How and Who

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June 8, 2020

NASA Systems Engineering
MODEL BASED SYSTEMS ENGINEERING

www.nasa.gov

MBSE

About the Presenter: Trevor Grondin

- **Title**
  - Systems Engineer, NASA's Langley Research Center (LaRC)
  - NASA MBSE CoP Lead
  - MIAMI Co-Lead
- **Education**
  - B.S. in Mechanical Engineering, Clarkson University in 2001
  - M.S. in Astronautical Engineering from University of Southern California in 2013.
- **NASA Experience**
  - 11 years working a wide variety of flight and technology development projects, including ARES-1, EFT-1, RaD-X, and most recently NDL.
- **MBSE Experience**
  - For the past 5 years, Trevor has been using his systems experience to develop the MBSE capability for the Agency.
  - As Co-Lead for the NESC-sponsored group MIAMI (MBSE Infusion and Modernization Initiative), Trevor has formed and cultivated a thriving community of MBSE practitioners from across NASA, established a strong online presence through the NASA Engineering Network (NEN), and continues to develop tools and processes to support Systems Engineering at NASA.

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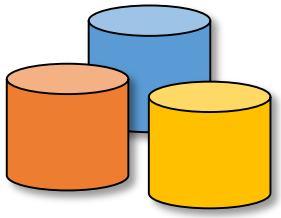
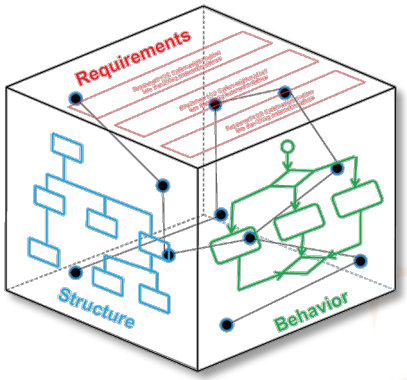
- What is MBSE?
- How do we do SE normally?
- How to Start MBSE on a Project
- Final Thoughts

What is MBSE?

- **INCOSE** defines Model-based systems engineering (**MBSE**) as:
  - "The formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases." **Source:** INCOSE-TP-2004-004-02 September, 2007, "SYSTEMS ENGINEERING VISION 2020"

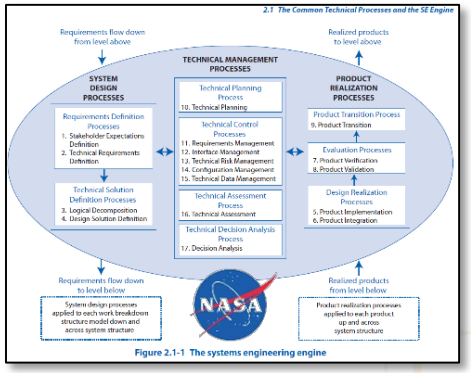


Project Data Sources



System Model

Analysis Tools

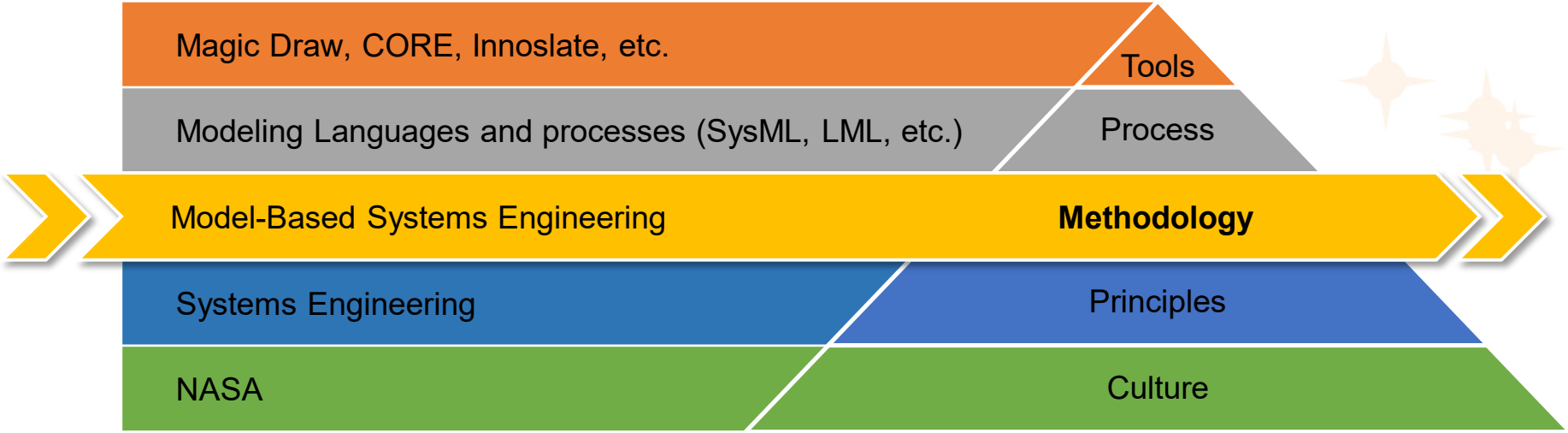


NASA Process

- In plainest terms, this means that MBSE **supports** the existing products and processes to **add** consistency, clarity, and connectedness to both

What is MBSE?: The Knowledge Pyramid

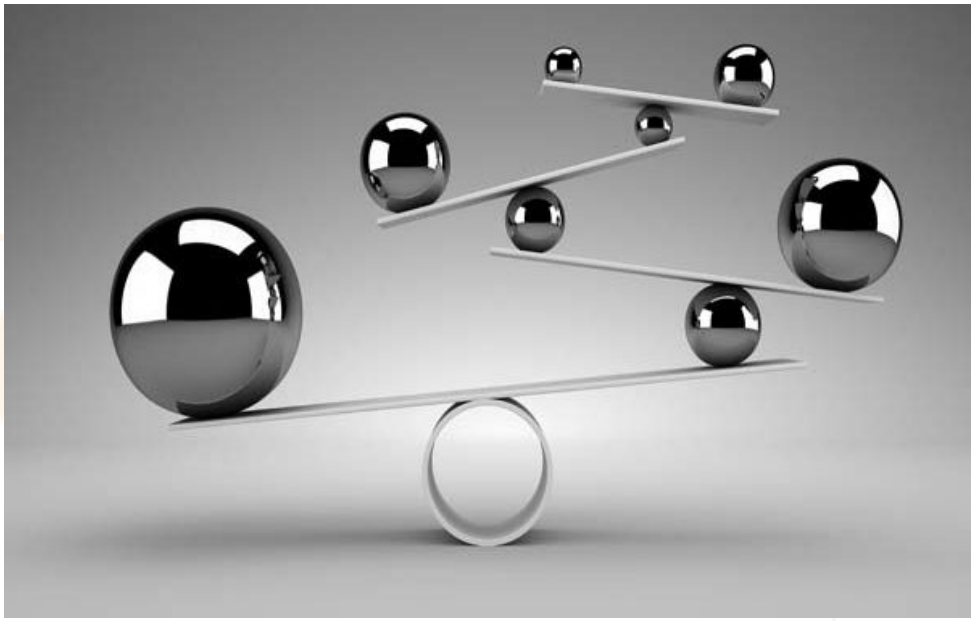
- **Where does MBSE fit in?**
  - Understanding how MBSE folds into the overall environment is essential to understanding the change that needs to happen, or the impact it will have on an organization
  - MBSE is a methodology that captures the Systems Engineering principles and formalizes the structure, behavior, and interaction these principles govern
  - This methodology can then be implemented using tools and processes to realize the actual models



What is MBSE?: Purpose-Driven Modeling

- Systems Engineering is in itself a data-driven, detail-oriented discipline
- It is incumbent on Systems Engineers to identify the proper balance of documentation/rigor to make the project successful
- Just as we have to be prudent with when and how we apply the Systems discipline to the project, so too must we measure our use of MBSE against the overall benefit:

- What is the overall intent of using MBSE?
- What are the benefits of using MBSE for this task?
- What are the impacts / risks associated with using MBSE?
- Is MBSE a binary choice?
- How much MBSE is enough?



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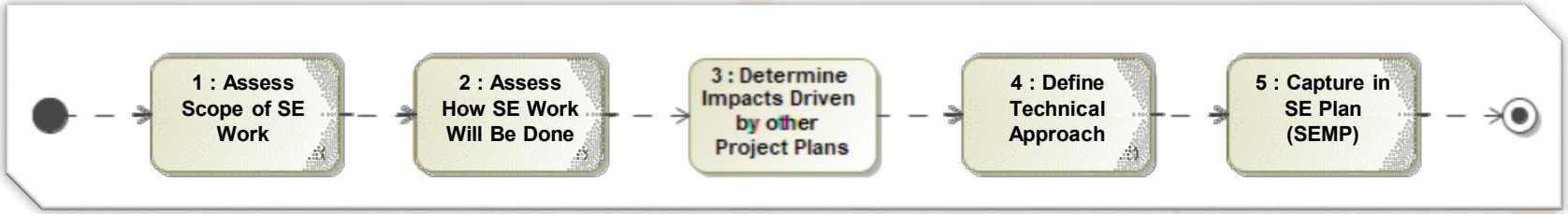
Big Answers:

- MBSE is not a binary choice; it can be applied to any part of the SE discipline to provide value
- The “right” amount of MBSE is that which supports the SE goals, and can be supported by the SE practitioners

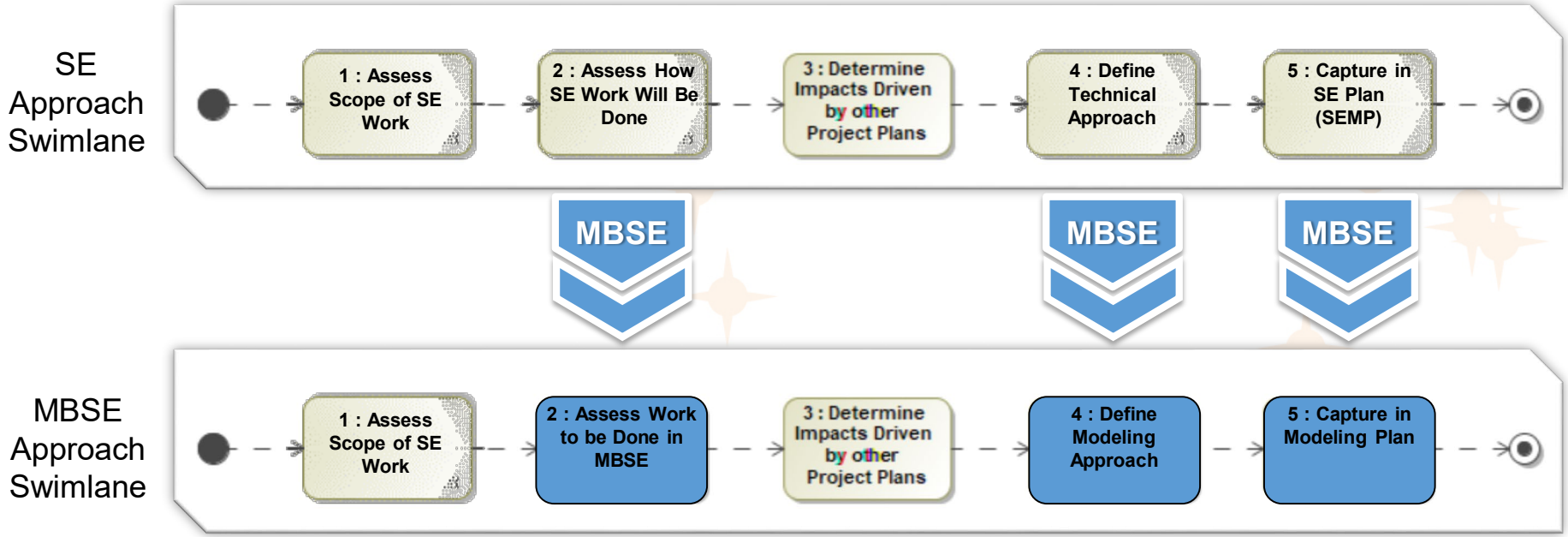
How is SE Normally Done?

- Systems Engineering at NASA is generally governed by NPR-7123
  - https://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=7123&s=1B
- The SE Function over the project lifecycle is captured by 17 Common Technical Processes
- Project information is captured in a series of documents that are gated for maturity by several milestone reviews across the lifecycle
- Systems Engineers may use a number of practices to capture project information between revisions of SE documents
  - Excel Sheets
  - Collaboration Sites (SharePoint, OneDrive)
  - OneNote, etc.
- In general the process for setting up an SE effort on a project is as follows:



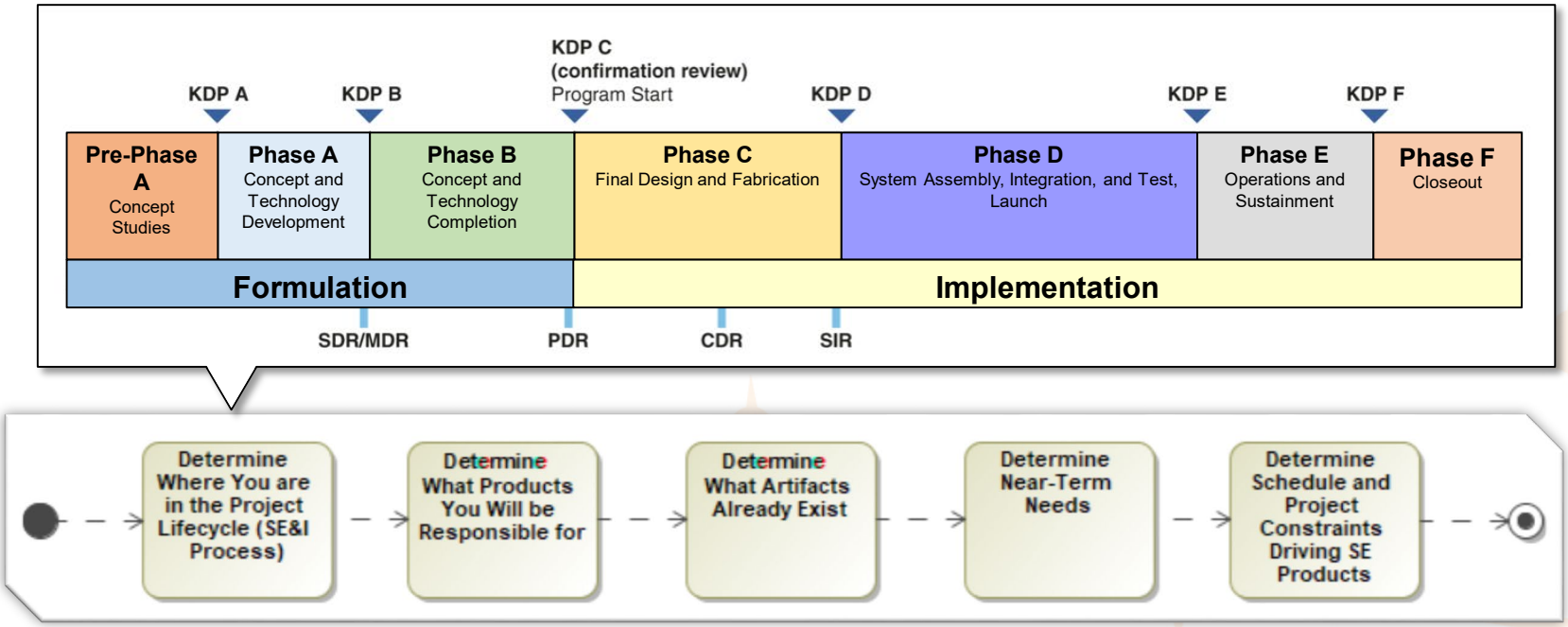
Overall Process (with MBSE)

- The process is not much different when considering MBSE in technical planning
  - The main difference is considering how using MBSE might impact resources and technical planning when assessing how the work will be done, and how the use of MBSE will be captured in the project documentation
- Planning for MBSE on a project will feed into the overall SE approach and likely impact other project documentation



Step 1.1: Determine Where You are in the Project Lifecycle

- Project phase can be a good indicator of what type of SE work is needed
- Discussions with the project team will give an understanding of what products the project needs and which ones are tailored, to align correctly with the project size and type.



Step 1.2 & 1.3: Determine What Products You Be Responsible For & What Artifacts Already Exist

- Based on project phase and project tailoring, determine what products your SE team will responsible for
- These products could be owned by the project team, by the project at another Center, or by external partners. Consider how the information in those artifacts will be used by other products you are considering for MBSE, and what the impact will be on your technical effort trying to align these products over the course of the project.

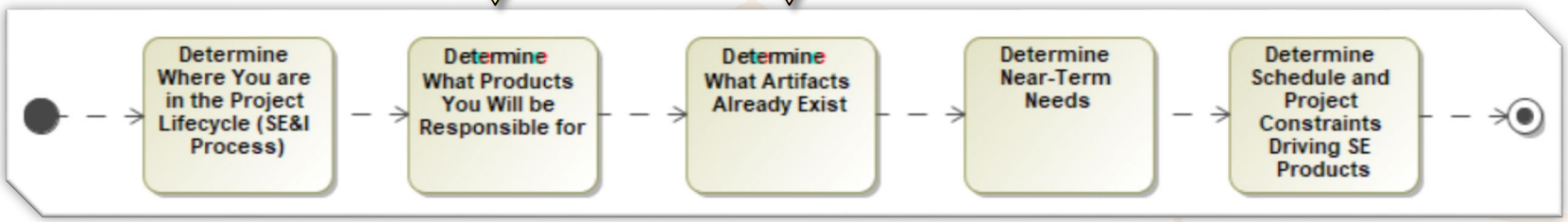
Products Responsible For

What format?
Do they (impact / depend on) existing products?
How will they be managed / aligned?

Existing Products / Artifacts

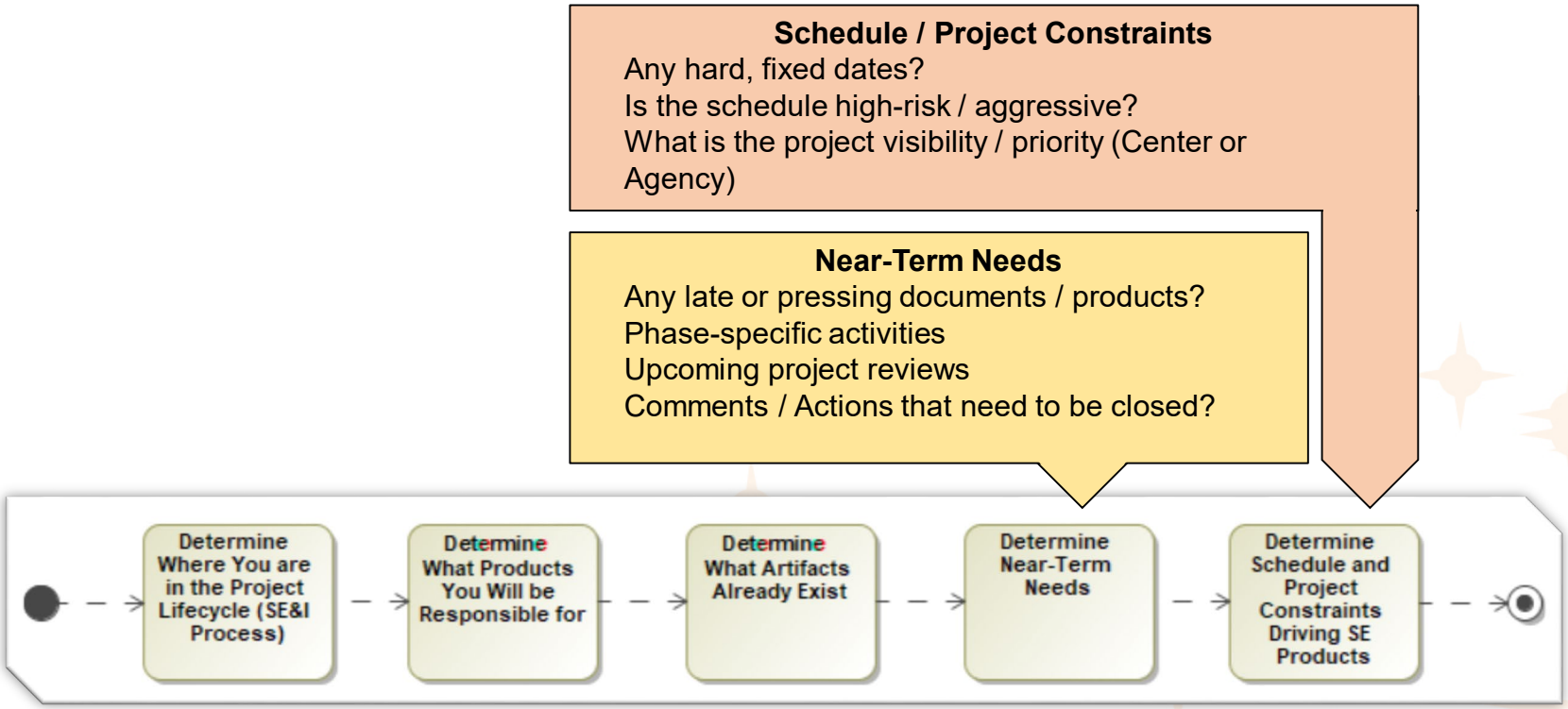
Who owns them?
- Project Team
- Project at another Center
- External Partner

What format?
Do they affect other products I'm responsible for?
How will they be managed / aligned?



Step 1.4 & 1.5: Determine Near-Term Needs and Schedule Constraints

- Understanding the time you will have to prepare and maintain certain products is also a concern when planning where to use MBSE on your project
- Schedule pressures may not allow time for training, or the time necessary to build a model to support the project milestone

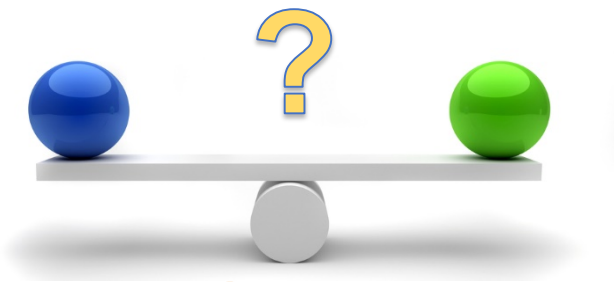


Step 2: Assess the Work to be Done in MBSE

- Having already assessed what the scope of the SE effort will be for the project, how do we next assess what will be done in MBSE and what will be left out? The answer to this question, outside of the constraints identified above, can be summed up in these two questions:
  - **What is the value over traditional methods?**
  - **Do we have the team to do the work?**

MBSE

- System Definition Explicitly Captured in Model
- Auditing for Consistency, Correctness & Completeness
- Deeper Insight to System to Assess Impacts
- "Single Source of Truth" to feed products downstream
- Reusable Models
- Requires Specilized Training
- Steeper Learning Curve



Traditional SE

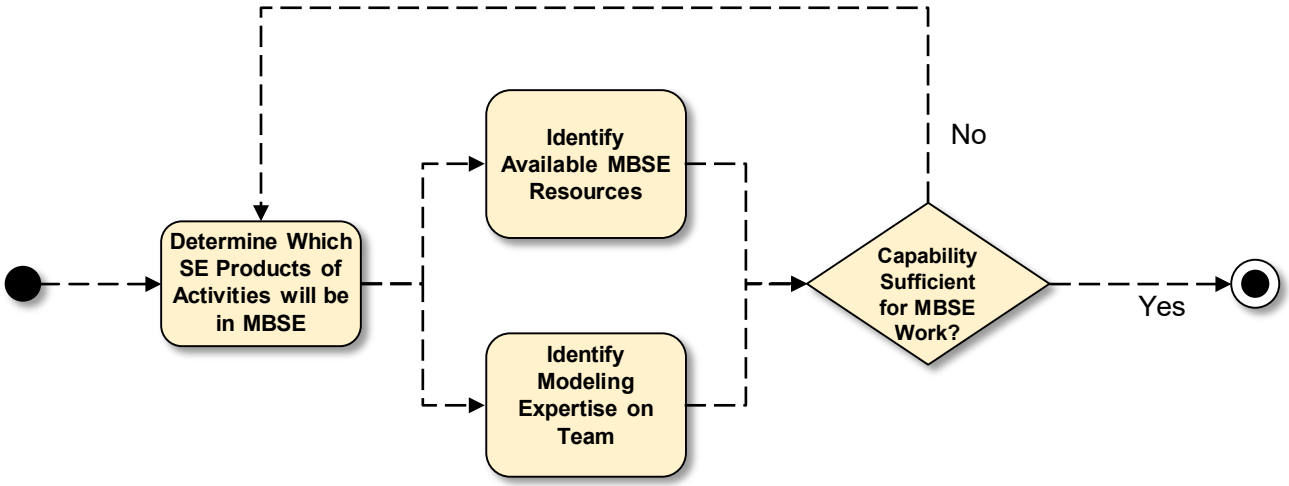
- System Definition Captured across multiple documents
- Auditing of documents spread over multiple reviews
- Impacts assessed by team, discipline leads
- "Source of Truth" harder to determine
- Document Templates may exist
- Training is part of Org culture
- Org has significant institutional knowledge

Step 2: Assess the Work to be Done in MBSE

- **NASA MBSE Community of Practice** (https://nen.nasa.gov/web/mbse)
  - examples of work that have been done in MBSE that might apply to your project
  - POCs for each Center for expertise on their successes with MBSE
  - Tutorials and Specialized Topics for applying MBSE

- **Some Useful Links for assessing when/how to use MBSE on a project:**
  - **Understanding the benefits of MBSE and SysML Modeling**: A summary of when and how to use MBSE and SysML modeling and determining the benefits it can provide to a project.
  - **The Myth and Reality of MBSE**: A webinar on the nature and purpose of MBSE, and some of the key factors for successful MBSE deployment on real world projects, from INCOSE fellow Rick Steiner.
  - **Model-Based Systems Engineering in the Real World:** MSFC, May 2018, Rick Steiner and Thad Henry on the nature and purpose of the MBSE approach and how key information is used for successful MBSE deployment within real world projects.

Step 2.1: Determine SE Products To Be Done in MBSE



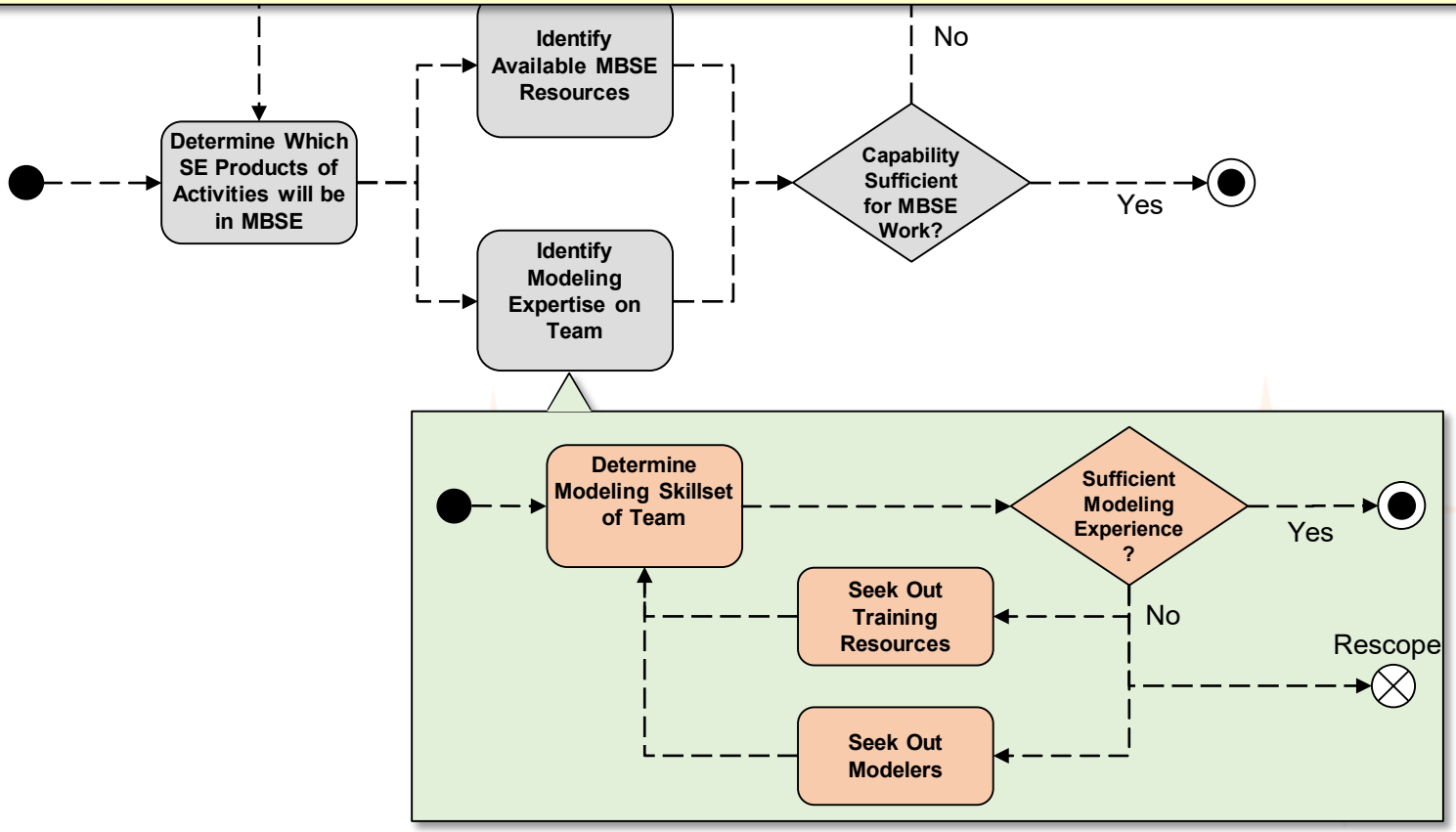
- After identifying the work you would like to do in MBSE, it's important to assess whether you have the team and resources to support the MBSE work
- This process can be iterative in your planning, and may require a rescope of the MBSE work if the right resources are not available

This is not a unique property of MBSE, however since it is newer to NASA, this exercise is necessary to properly support the work and avoid delays during execution of the project

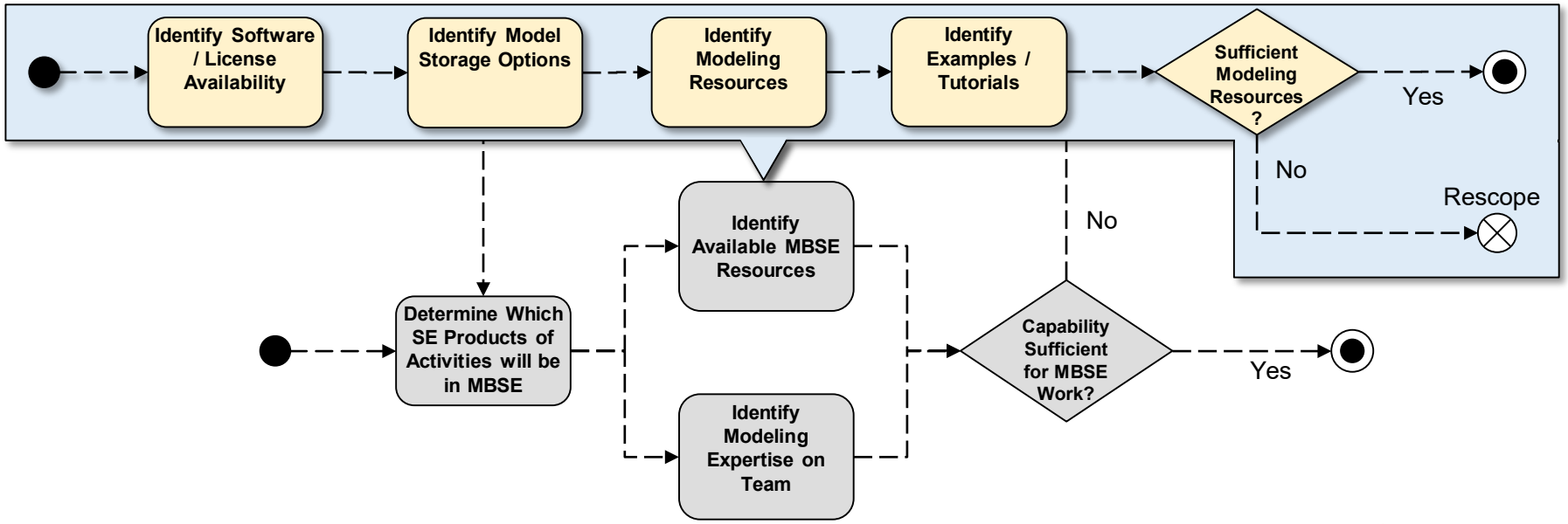
Step 2.2: Identify Modeling Resources on Team

MBSE Training
- APPEL MBSE course
- Online Courses / Examples
- External Training

MBSE Modelers
- Org / Center
- Agency contacts through MBSE CoP
- Contractors



Step 2.3: Identify Resources Available for MBSE Efforts



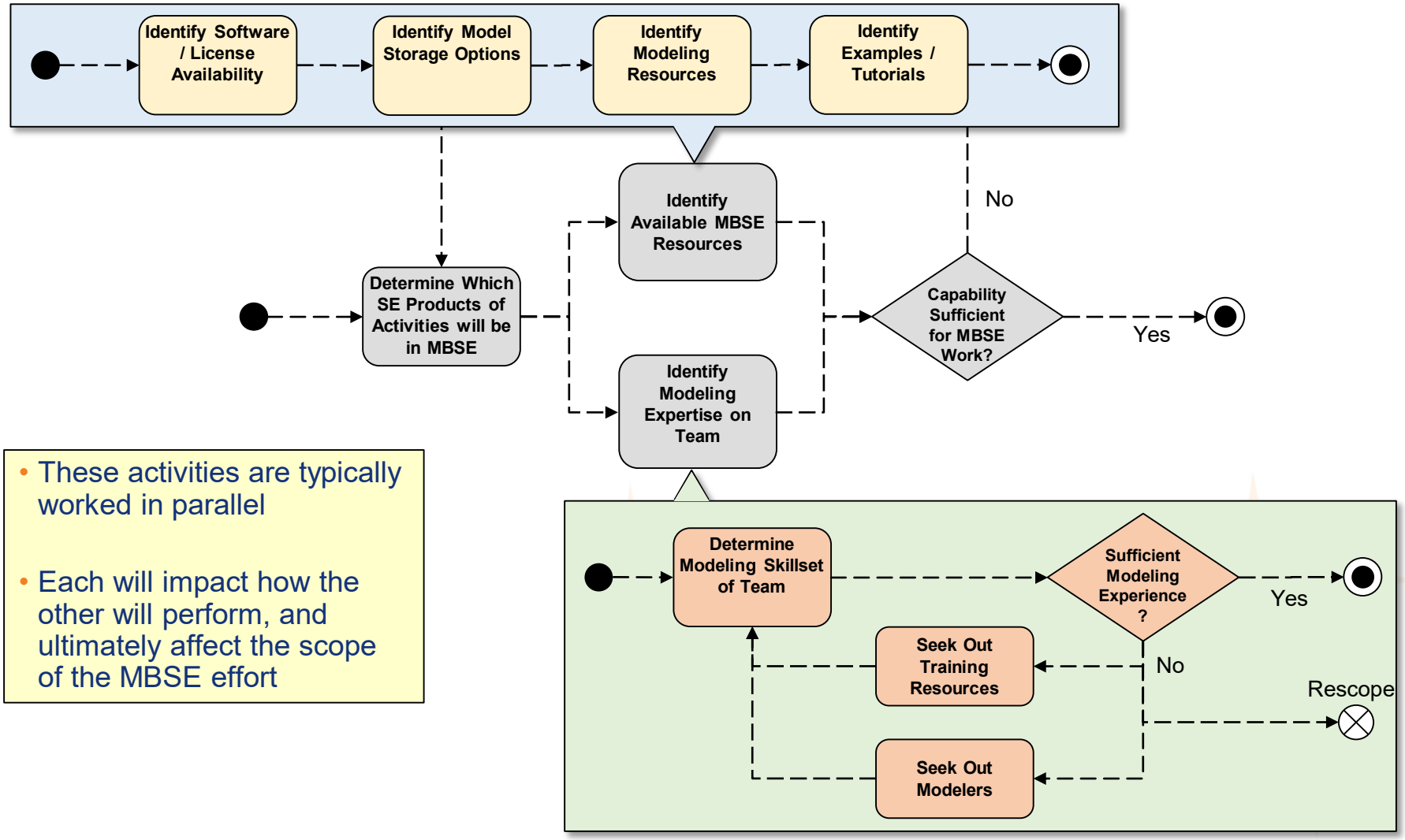
MBSE Infrastructure

- Toolchain
  - What tools need to work with each other?
- Local / Network Storage
  - Who needs access to the model?

Modeling Resources

- Profiles / Patterns
- Examples / Starter Templates
- Tutorials

Step 2: MBSE Resources in Parallel

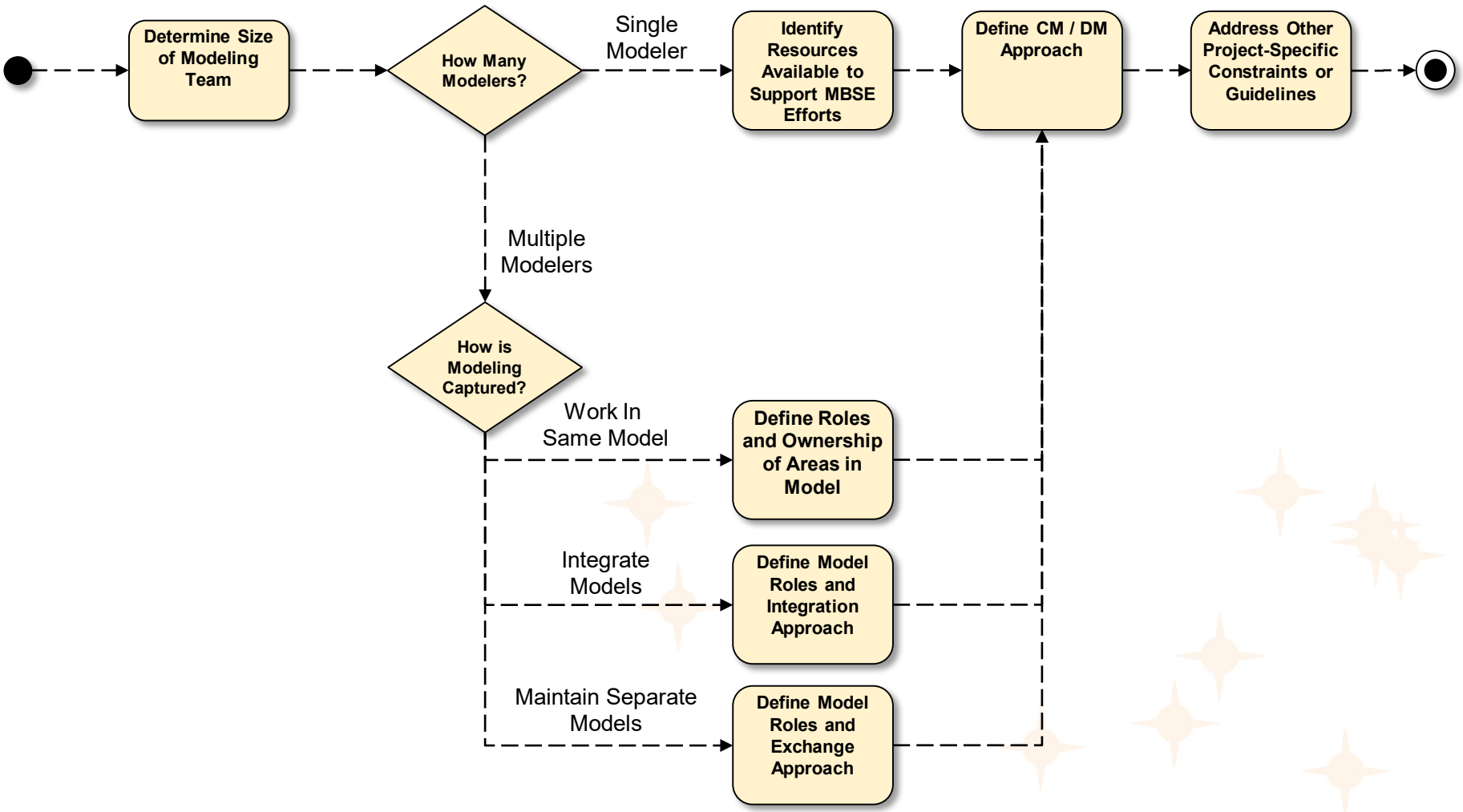


- These activities are typically worked in parallel
- Each will impact how the other will perform, and ultimately affect the scope of the MBSE effort

Step 3: Determine Impacts by Other Project Plans

- After assessing which products will be done in MBSE, and how the team will generate these products, it is also important to consider what constraints may exist due to existing project plans.
  - SM&A approach
  - CM and DM considerations
  - External partnerships and agreements
- These documents may outline what types of documents are necessary and in what format, which could impact the extent of your MBSE effort.

Step 4: Define Modeling Approach



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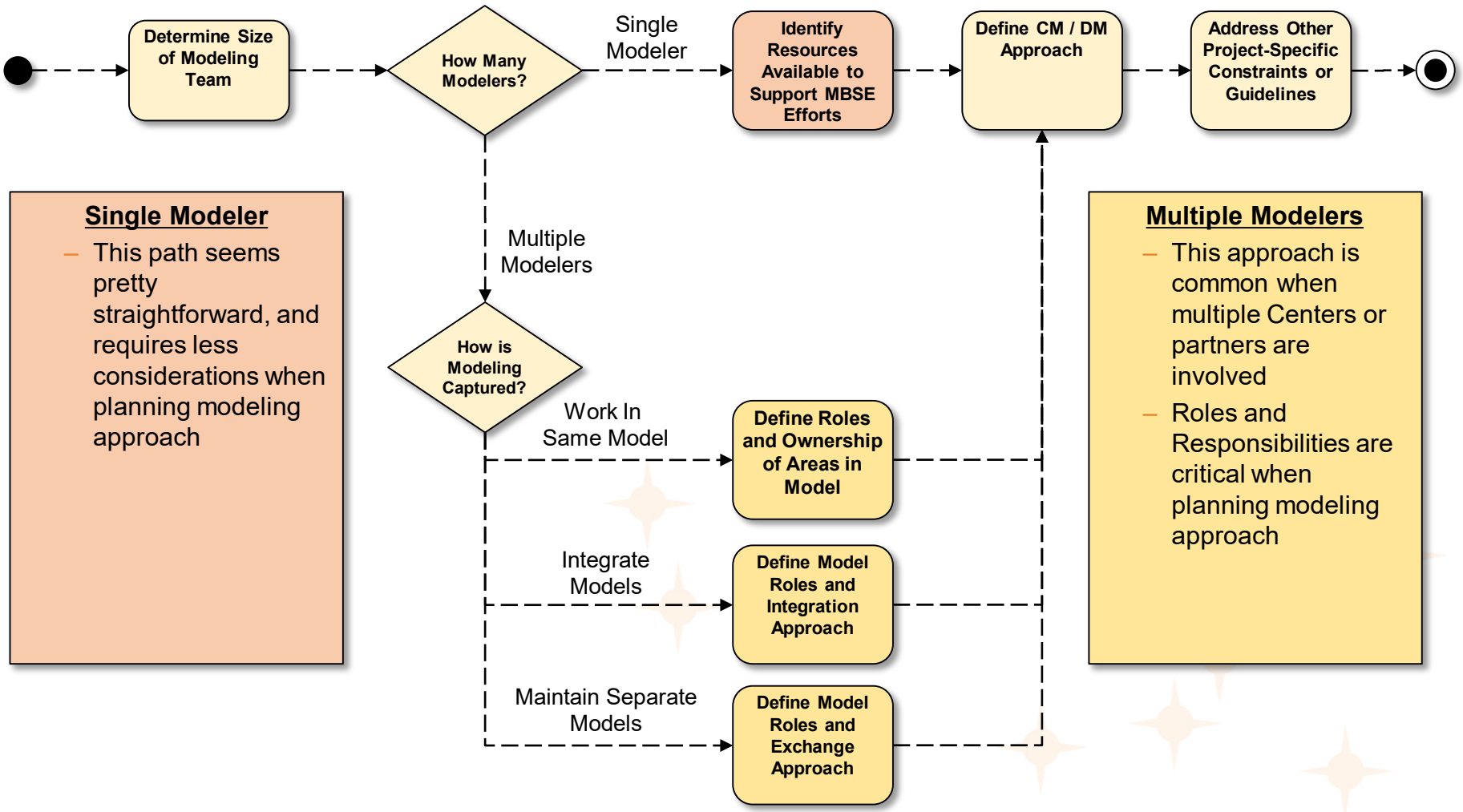


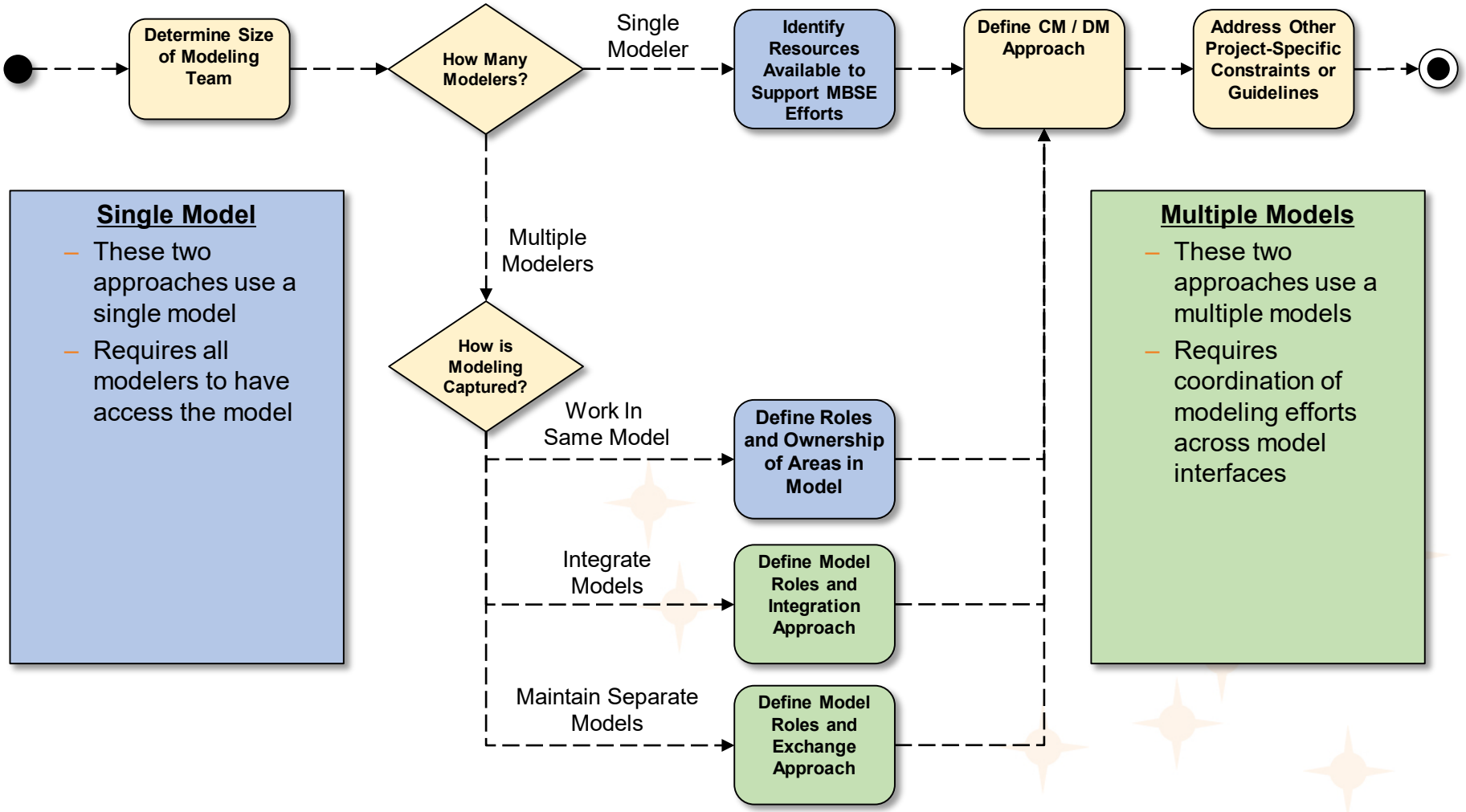
Single Modeler

- This path seems pretty straightforward, and requires less considerations when planning modeling approach

Multiple Modelers

- This approach is common when multiple Centers or partners are involved
- Roles and Responsibilities are critical when planning modeling approach

Step 4: Define Modeling Approach



Single Model

- These two approaches use a single model
- Requires all modelers to have access the model

Multiple Models

- These two approaches use a multiple models
- Requires coordination of modeling efforts across model interfaces

Step 5: Capture in a Modeling Plan

- Much like any other technical plan for engineering work, it is time to capture agreements and points of order about using models to do the SE work
- Captures the results of the assessment and details for how the project will operate with respect to MBSE
- Clarifies how MBSE will adhere with existing practices within the project
  - Configuration Management
  - Model Reviews
- Defines the purpose of the model, and how it will be used to support project goals
- Example Plan structure is shown to the right
  - **Modeling Plan Example Link (NASA Only)**

Example Modeling Plan:

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Final Thoughts

- **MBSE is relatively new to NASA, but not to private industry**
  - We must get more fluent with MBSE and how to use it effectively
- **MBSE provides many benefits that can support existing SE processes**
  - Provides deeper insight, quicker assessment of impacts, and a central point for SE documentation and product generation
- **Understand the purpose of your modeling effort: this critical to effective MBSE implementation**
  - Don't boil the ocean, or model for modeling's sake
  - Purpose-driven modeling leads to cleaner models and makes reuse for later projects much easier
- **Make sure you have the team and the resources in place to support the scope of the MBSE effort you define**
  - This will help justify training and staffing requests, and to assess descope impacts
- **More materials related to this talk can be found at the MBSE CoP on the Nasa Engineering Network website:**
  - https://nen.nasa.gov/web/mbse

QUESTIONS?