

Assurance of Model-Based Fault Diagnosis Techniques

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 Program: Strategic Initiative

Project Objective:

Verification and Validation (V&V) of Model-based fault diagnosis (MBFD) is the necessary first step in enabling other autonomy capabilities. MBFD determines the health state of the components of a system by comparing a model of how those components are expected to function against multiple sources of information (e.g., sensors, commands and relationships to other components). This effort develops V&V approaches for MBFD that will:

- Develop and demonstrate the techniques for **checking the correctness and coverage/completeness of MBFD.**
- Develop and demonstrate the techniques for **analyzing the performance characteristics of MBFD** such as speed, memory usage, and false-positive and false-negative diagnosis rates.

FY19 Results:

In the third year, we focused on the following areas:

- Developing Infusion Pathways for Ongoing and Future Missions
 - Adapt earlier ACS models. Modify earlier models of SMAP ACS for ASTERIA/SSDT.
 - Develop assurance checklist for future missions to guide model assurance activities by mission phase.
- MBFD Diagnostic Performance Analysis
 - Developed experiments for broad performance metrics gathering (e.g., true and false positive diagnosis rates).

This year's effort capitalized on earlier work by developing a pathway for infusing AMBFD into ongoing and future missions. We have been working with the ASTERIA mission to prepare for hosting MONSID and an ACS diagnostic model on the spacecraft to assess their performance and utility during ASTERIA's post-prime mission period. We anticipate two main results:

- Observing the performance of MONSID and diagnostic models for real mission, especially during the time that ASTERIA de-orbits and the ACS fails.
- Incorporating lessons from working with ASTERIA into the infusion pathways developed this year.

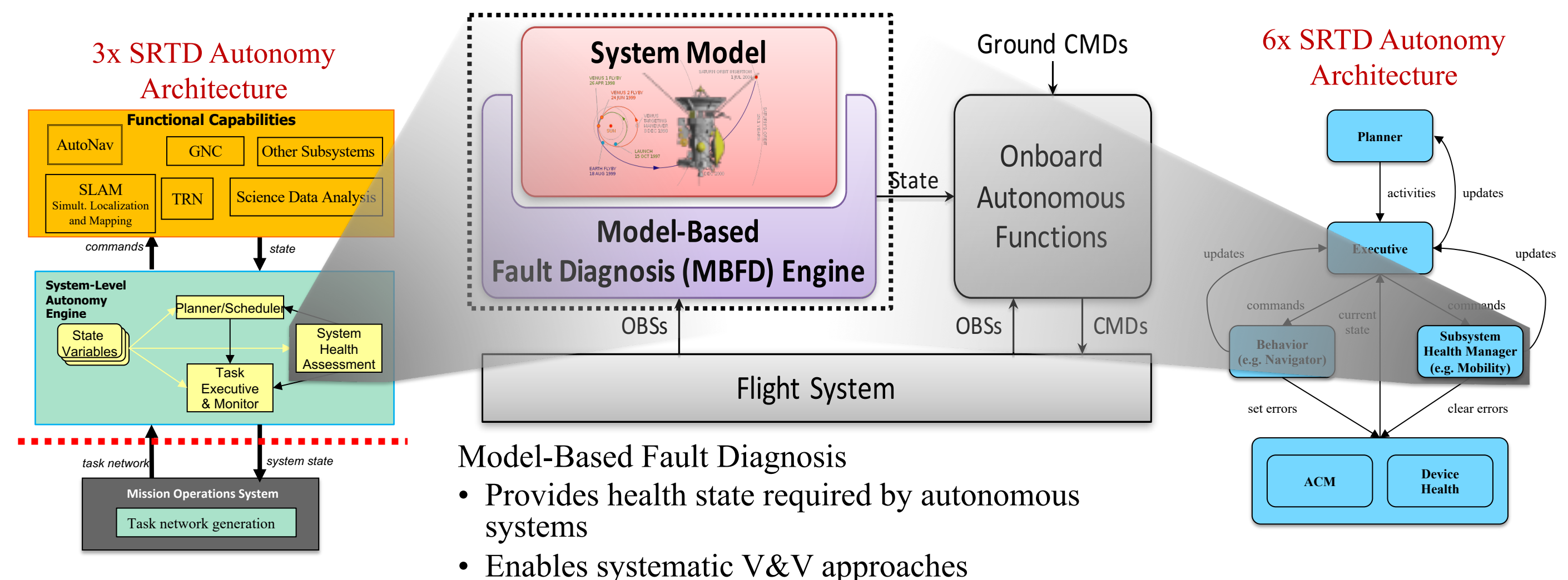
Benefits to NASA and JPL:

While MBFD has been developed through decades of research, the techniques for adequately verifying and validating MBFD technologies are not well understood. Without proper V&V of MBFD:

- The estimated health state produced by MBFD may be incorrect or vague, or MBFD may cause unacceptable delays or excessive use of on-board computing resources.
- The decisions made by other autonomous systems based on the MBFD's estimated health state will be held in low confidence, often necessitating review by spacecraft operators, and thus diminishing their value.

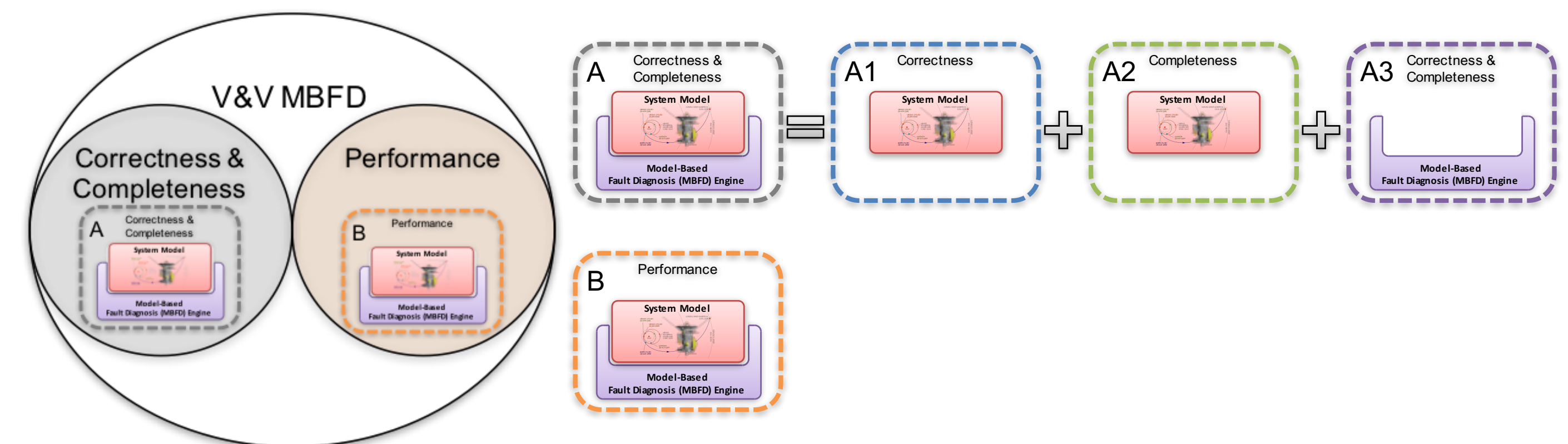
Thus, **assurance of MBFD confirms that it will correctly determine the state of spacecraft hardware, knowledge of which is required for other on-board autonomy capabilities such as planning and scheduling.**

Role of Model-Based Fault Diagnosis in On-board Autonomy

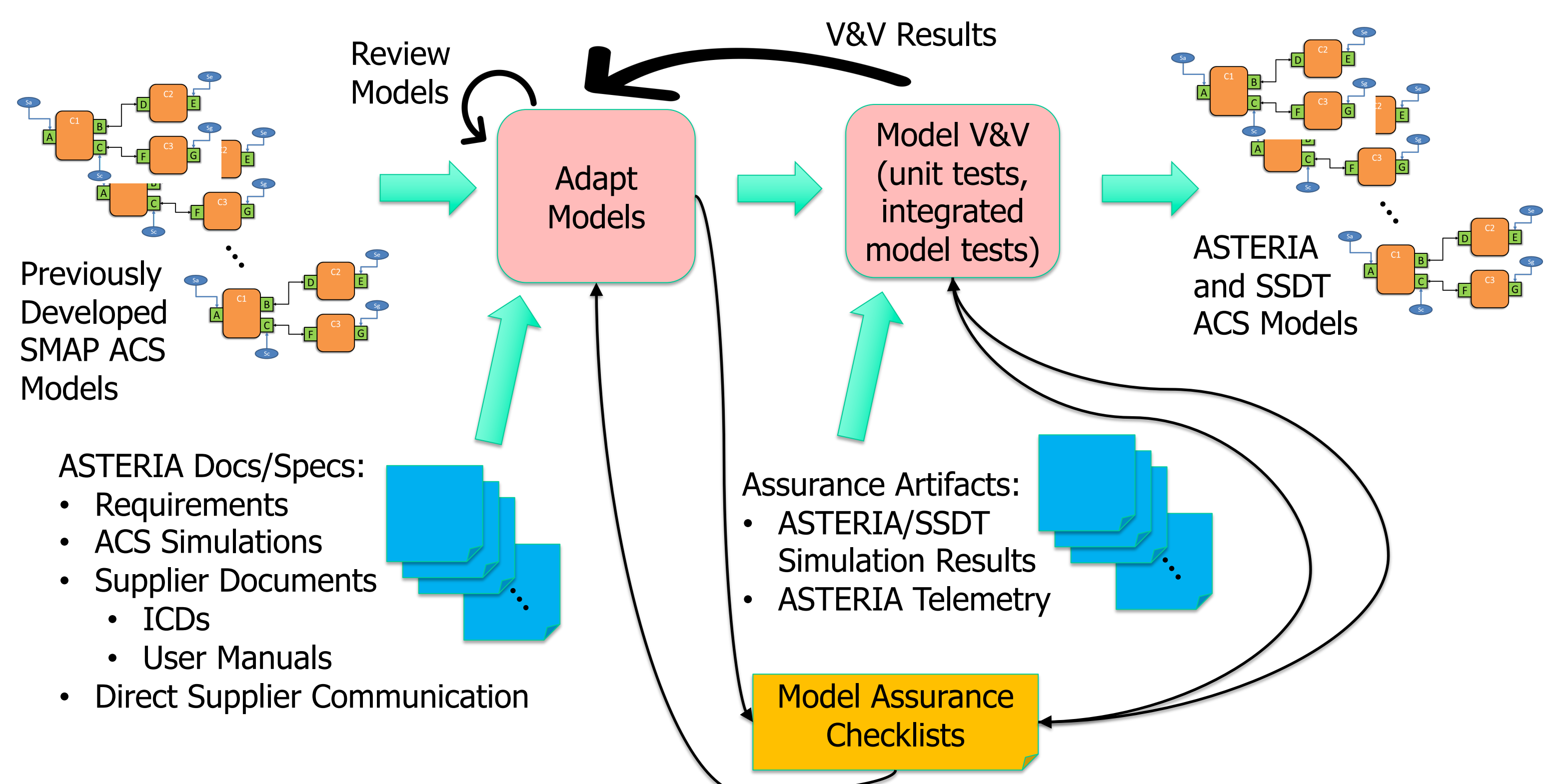


- Model-Based Fault Diagnosis
- Provides health state required by autonomous systems
 - Enables systematic V&V approaches

Objective: Developing the V&V Method for Model-Based Fault Diagnosis

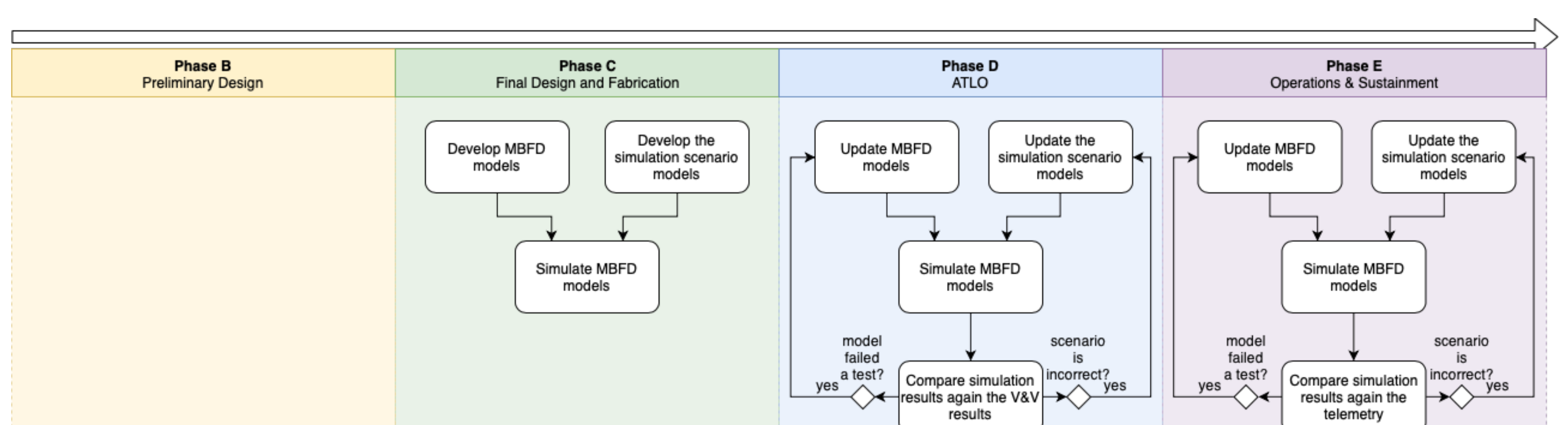


Approach for Year 3: Developing Infusion Pathways, Assessing Model Diagnostic Performance



Adapt SMAP MONSID ACS Models to ASTERIA/SSDT

Results:



Publications:

- Nikora, A., Srivastava, P., Fesq, L., Chung, S. and Kolcio, K., "Assurance of Model-Based Fault Diagnosis," *Proc IEEE Aerospace Conference*, 2018 IEEE, Big Sky, Montana, March 3 – 10, 2018.
- Nikora, A., Srivastava, P., Fesq, L., Chung, S. Kolcio, K., and Prather, M., "Assuring Correctness, Completeness, and Performance for Model-Based Fault Diagnosis Systems", *Proc IEEE Aerospace Conference*, 2018 IEEE, Big Sky, Montana, March 2 – 9, 2019.
- Nikora, A., Fesq, L., Chung, S. Kolcio, K., and Prather, M., "Demonstrating Assurance of Model-Based Fault Diagnosis Systems on an Operational Mission", submitted to IEEE Aerospace Conference, 2020.