

> Is there any dedicated Tool / Methodology training(s) internal to ESA (or external to industry that wishes) being provided? What is the expected Knowledge ramp-up time to move from classic paper-centric to Model-centric approach?

The MBSE Space team (within the Systems Engineering Division in ESA) currently delivers training to projects and to system engineers learning model-based approaches. No external training is currently provided.

The "Knowledge ramp-up" is difficult to estimate or give a good indication of, as the use cases are defined mission-by-mission and vary the scope of implementation greatly. Generally our training sessions are accompanied by on-hand support from our MBSE Space team for minimum of a year.

> In Galileo G2G we actually cover all aspects including launch and operations, not just Space and Ground.

Clarification from Catherine

> As you already mentioned, each mission uses different tool/method/language combination. Is there a target to converge to a certain tool/method/language in the future?

Yes, we are currently developing the next generation of our ESA MBSE approach to start this convergence. This is presented in the "ESA MBSE Evolution: From ESA SysML Toolbox to ESA MBSE Solution" talk from my colleague Alberto.

> In general, how are you measuring the benefits of adopting MBSE? (versus traditional document based approaches)

At present it is a qualitative approach, based on the expert opinion of the system engineers and stakeholders on each mission. Some of these benefits will only be observed and judged in later phases. However we have a desire to begin quantifying the benefits, and we will sponsor a PhD idea originating from the OSIP MBSE campaign to provide robust methods to quantify the benefits of MBSE.

> We see most projects using MBSE for the left hand-side of the V-cycle, except PLATO and MSR-ERO that has some usage for AIT. Any expectations to see MBSE more used between qualification and validation? Any additional feature to be developed in MBSE to make it more friendly for steps between qualification and validation?

Yes we do envisage extending MBSE implementations to include qualification and validation domains for future projects. There is an ITT currently released, "MBSE for AIT" , which will lay the groundwork for how best to implement model-based approaches within the AIT/AIV domain.

The talk "ESA MBSE Evolution: From ESA SysML Toolbox to ESA MBSE Solution" from my colleague Alberto gives the framework of how we are planning to integrate the subdomains at mission/system level, including AIT/AIV concerns, as part of the ESA MBSE approach.

> Is there any roadmap to introduce MBSE in phase E even to Mission that have not used MBSE in the previous phases ?

At present, there is no interest observed for Phase E implementation as the cost-to-benefit of retrofitting the various subdomain models and generating a system model is seen as unfavourable.

> In the mission you present is MBSE applied to both Space and Ground Segment or mainly Space Segment ?

The implementation of model-based approaches to Ground Segment development depends on the mission. Some missions are indeed looking into this - the Paperless Ground Segment Engineering tool from the Operations Directorate will use Euclid as its test case. Its successor will be provided by the Advanced Digital Ground Segment Engineering activity, which will be presented during the MBSE2021 conference.