

# Strategies and Best Practices for Model-based Systems Engineering Adoption in Embedded Systems Industry

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Model-based Systems Engineering (MBSE) is the formalized application of modeling to support system requirements, design, analysis, verification and validation activities. Specialized tools automate much of the non-creative work (which translates to gains in productivity and quality) and generate code based on the models. MBSE foster artifact reuse, improves product quality, and shortens time to market [Bö14]. Despite the aforementioned benefits, adopting MBSE is a complex task, especially for larger and established companies [Vo17]. Process changes are required in all system life-cycle phases as well as a shift in the development paradigm (i.e., abstract thinking) and application of new tools. Projects are not likely to meet their cost and delivery target when adoption is carried out poorly. Our goal was to find out what was tried, what worked, what did not work, how the problems were solved, what can be recommended, and what should be avoided when adopting MBSE in organizations that develop embedded systems. For this purpose, we devised an inductive-deductive research approach in a triangulation fashion. We conducted 14 semi-structured interviews with experts from embedded systems organizations. From these interviews, we extracted 18 best practices fitted for tackling MBSE adoption challenges. Sequentially, we validated and prioritized the best practices with the help of an on-line questionnaire which was answered by MBSE practitioners. Our findings provide input for planning MBSE adoption based on the knowledge of practitioners that went through the experience of implementing MBSE in already established embedded systems development organizations.

*Results:* The best practices are listed in the following: **BP01:** The organization should start adopting MBSE with new projects. **BP02:** The pilot project should create real value for the organization (i.e., no didactic project). **BP03:** The pilot project should have enough budget and time allocated to bear the overhead of adoption. **BP04:** No translation of old artifacts, exception is when considering reusable artifacts. **BP05:** Start small in terms of project and team size in order to acquire some experience. **BP06:** Tools with open interfaces and homogeneous work-flow are preferred. **BP07:** All engineers should have access to the tools. **BP08:** Tool acquisition is very costly therefore should be thoroughly planned. **BP09:** Have

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the new MBSE processes well documented so you better understand what tool you will need. **BP10:** All engineers should get, at least, basic training in MBSE. **BP11:** Using examples that are familiar to the domain of the organization eases the understanding. Model some existing artifacts for using as examples. **BP12:** Many strategies can be used to build knowledge of an organization, the context should be taken into consideration. **BP13:** There should be a planned form of later evaluation to fill eventual gaps. **BP14:** Make the advantages of MBSE clear. **BP15:** Have technically prepared people to support your engineers (i.e., not sales personnel). **BP16:** Bring everyone to adoption (i.e., avoid creating castes). **BP17:** If you have good engineers let them do the work for you, it is cheaper and they will engage more (i.e., empowering). **BP18:** Management should unify all employees towards adoption.

*Most important best practices:* We used a questionnaire to discover which best practices (BP) are considered the most important. The BPs are discussed in the following under this light: **BP14** Engineers are less likely to withstand the hurdles of adoption if they cannot perceive its benefits [Vo17]. **BP05** Through experimenting, managers can understand which tools, languages, and styles are best fitted for the organization and its respective domains and current processes. **BP02** By working into something that will be used in production setting, the employees have to learn and employ MBSE. If it is something that is just for learning, there are no consequences if the project is incomplete or not well done thus making the learning also incomplete. It also gives room for procrastination (i.e., learning later when it is necessary). **BP03** Learning-curve costs as well as the delivery dates should be planned accordingly. Time-critical projects should be avoided. Engineers will drop the MBSE techniques in favor of already established development methods in order to achieve celerity gains and meet deadlines. **BP10** Although not all engineers require deep modeling skills, everyone should be able to, at least, read and understand the models.

*Conclusion:* The complexity of MBSE and its pervasiveness creates challenges that could jeopardize its implementation in an organization. In the long run, benefits outweigh the costs and hurdles, however, it is necessary to identify success factors and share best practices enabling efficient and effective MBSE adoption in industry. As future work, we could investigate the best practices that received many disagreement votes to understand whether context plays a role in such phenomenon.

## Literaturverzeichnis

- [Bö14] Böhm, Wolfgang; Junker, Maximilian; Vogelsang, Andreas; Teufl, Sabine; Pinger, Ralf; Rahn, Karsten: A Formal Systems Engineering Approach in Practice: An Experience Report. In: Proceedings of the 1st International Workshop on Software Engineering Research and Industrial Practices. S. 34–41, 2014.
- [Vo17] Vogelsang, Andreas; Amorim, Tiago; Pudlitz, Florian; Gersing, Peter; Philipps, Jan: Should I Stay or Should I Go? On Forces that Drive and Prevent MBSE Adoption in the Embedded Systems Industry. In: PROFES 2017, Innsbruck, Austria, November 29–December 1, 2017, Proceedings. S. 182–198, 2017.