Technology integration maturity assessment for aircraft development programs

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Abstract

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Technology integration maturity assessment for aircraft development programs

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Abstract

Technology Readiness Levels are the industry standard to assess technology maturity. New technology is often developed in separated technology bricks. The presentation addresses an approach to define operationally and assess the maturity of the integration of these technology bricks into an aircraft platform, for the example of more electric aircraft technologies.

Introduction

The assessment of technology maturity regarding its readiness for implementation into a new or derivative aircraft development program is central to technology development initiatives and a key activity in aircraft conceptual design phase. Technology maturity is most widely assessed via the Technology Readiness Levels (TRL) scale defined in [1]. The interpretation of TRL can be ambiguous, especially when it comes to the important aspect of technology integration. Whereas, mastering the technology integration is a key success factor in order to develop new aircraft while respecting schedules and delivering the expected benefits. For large scale technology development and insertion projects, also when dealing with multiple new technologies in multiple domains (e.g. not only systems, but also structures, etc.) the technology development is performed in a non-integrated manner, in terms of “technology bricks”. For the example of the More Electric Aircraft demonstrator project at Bombardier Aerospace several subproject are performed involving numerous external partners. The aircraft manufacturer as integrator has to ensure the maturity of the integrated technology is properly understood in order to be confident in its benefits and associated risks. Two key elements have to be addressed in this regard: first, the harmonization of TRL across multiple technology bricks and the consideration of the “integration” aspects. This paper applies a methodology proposed in [2] to the example of the MEA technology development. Moreover, it presents the alignment of the technology development and the aircraft product development at Bombardier Aerospace.

The TRL Quality Gates process at Bombardier Aerospace

The TRL Quality Gates process is used within Bombardier Aerospace to provide an unbiased perspective on technical maturity and alignment with business needs in technology development projects. Technology development at Bombardier Aerospace uses a TRL quality gate process that includes the following key aspects: - Technology maturity plan: list of deliverables to substantiate each TRL, developed by a project’s technical lead. - TRL roadmap (TRL progression time-line) - Peer reviews - Benefits and schedule alignment with business needs

This paper mostly focuses...
on the first two aspects. TRL including the integration aspect Academia has published papers on how to include the “integration” aspect into the technology maturity assessment. The paper [2] provides a comprehensive review of the state of the art and provides a notional graphic depiction summarizing the key aspects of systems integration of the TRL levels 3 to 7. This graphic depiction was found as helpful to communicate and assess the understanding of the integration aspects for single technology bricks and for architectures of technology bricks at the same time. Therefore, the graphical depiction, along with the definitions provided in [2] has been a starting point to develop a guideline for maturity plans on system level (single or a few technology bricks) and at aircraft level (architectures of new technology bricks). Requirements for demonstrator & test environment as well as for the analytical model and performance prediction can be derived. Fig. 1 shows as an example the adaptation of TRL 5 graphical description. In addition to the graphical depiction, a list of typical deliverables for pertinent categories covering “demonstrator & test environment” and “analytical model & performance prediction”. In the case of aircraft system integration, the categories such as "testing", "system definition", "system performance", "safety and certification", "system installation", etc. are proposed to assure a harmonized approach between technology bricks. Technology integration maturity and new product development In order to minimize technology insertion risks for new program development, the technology maturity should be as high as possible at the time of insertion. At the same time, TRL higher than 5 can be difficult to reach without considering at least a conceptual definition of the targeted aircraft platform. Considering the integration aspects and the guidelines from [2], the target platform (aircraft) needs to be considered while progressing towards TRL5. This can be done in two ways: 1) Considering an existing aircraft as reference platform and assessing the technology form, fit, function and benefits. If the “fit” and the benefits can be observed as positive at TRL 5, the technology is suitable as a retrofit. 2) Considering a so-called virtual aircraft as target. This virtual aircraft is a conceptually defined platform with sufficient definition to assess the technology form, fit, function and benefits. The virtual aircraft is ideally developed ahead of a target aircraft product development program and allows iterations between the technology development and the aircraft platform development in order to maximize the mutual benefits and minimize integration risks. The use of a virtual aircraft has the advantage to analyse the integration of multiple new technologies and combination of technologies in a so-called set- based design approach. Regarding the required maturity for critical technology insertion into new development programs with minimal risk the following approach is considered: TRL6 need to be achieved prior to the Joint Conceptual Design phase (this design phase is performed together with development partners) for clean-sheet development programs. TRL7 needs to be achieved in line with the aircraft flight testing program. For retrofit into existing platforms the TRL progression is decoupled. Fig. 2 shows schematically the relation between critical technology development (TRL progression), the host system development and the aircraft product development. Application to the more electric aircraft technology development project In the frame of the More Electric Aircraft project at Bombardier [3] the following technology bricks are developed: Electric ECS (E-ECS), Electric Ice Protection System (E-IPS), Electric APU (E-APU), electric main engine start, optimized hydraulic system (OHS), amongst others. In terms of technology insertion into a future platform many scenarios are possible and there is a need to assess which technology bricks are ready to be integrated, and, are all integration aspects understood and covered by the technology development. In order to answer these questions, an aircraft-level maturity plan has to be developed for each specific scope or architecture of technology bricks, such as bleed-less aircraft with federated power electronics. A key element for integration at TRL 3 is to well define the technology scope in a way to define less coupled technology packages. For example, one package can be technologies enabling a bleed-less aircraft (E- ECS, E-IPS, E-APU, E-MES) and another can be focused on the less-hydraulic aircraft (E-actuation, optimized hydraulic system), or, alternative battery technologies. Each technology brick maturity plan should address as many integration aspects as possible (following the adapted guideline [2]) and follow the standard list of deliverables for the categories “test environment” and “analytical prediction”. The presentation will provide two example applications of this methodology: 1) One example covering the aircraft-level: the bleed-less aircraft 2) One example covering system level: Optimized Hydraulic System. For both cases the graphical depiction of TRL3 to TRL6 are presented, along with the holistic maturity roadmap. Conclusion Technology readiness assessment including the integration aspects is a key element for risk management for a new aircraft development. The paper presented the application of an academic approach to an industry context. For the example of the More Electric Aircraft project a more harmonized and holistic maturity plan could be developed. It is planned to expand the approach to other technology development project at Bombardier aerospace. In addition, the formalization of expected deliverables in terms of testing and also in terms of analytical models is catalyst to develop long term modelling and simulation strategies to support the maturation of technologies. References [1] “Appendix G—Technology Assessment/Insertion,” NASA Systems Engineering Handbook, NASA SP- 2007-6105, Rev. 1, 2007. [2] Jimenez, H., Mavris, D., “Characterization of Technology Integration Based on Technology Readiness Levels,” Journal of Aircraft, (2014), Vol. 51, No. 1, pp. 291-302 [3] A. Ardman, “More Electric Demonstrator Project Update”, SAE AeroTech Conference, Sep 2013, Montreal, Canada . Fig. 1: Example TRL 5 graphical depiction adapted from [2] Fig. 2: Alignment of TRL progression and product development

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