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DIGITAL TRANSFORMS PHYSICAL

SPK and Associates

A Comprehensive Guide to

Automotive SPICE

Introduction

The first Ford Model T hit the market over 110 years ago. The classic and hugely successful car was built up of around 1,500, primarily mechanical components. Today, a passenger car with a traditional combustion engine contains about 30,000 parts, while a significantly more simple electric-powered car will have around 10,000 individual components.

Mechanical parts are increasingly replaced by complex embedded systems. A modern high-end car with a variety of advanced systems for safety and convenience contains up to 150 electronic control units (ECUs), and millions of lines of software code. That adds a great deal of complexity – and with it, an ever-growing chance of failures. A number of technical standards and frameworks help automotive product developers ensure the quality of their innovation processes and eventually, the safety and reliability of their products amidst that rising complexity.

As the automotive adaptation of ISO/IEC 15504, Automotive Software Performance Improvement and Capability dEtermination (commonly referred to as ASPICE) provides a framework for defining, implementing, and evaluating the processes used in the development of automotive software and systems.

Managing defects: confidence levels

In the development of any complex system, human error is inevitable, difficult to control, and can lead to a number of defects. To what extent a certain design (be it a circuit diagram for a hardware component or a piece of software) contains faults may not be determined in an exact and quantifiable manner. Instead, we use confidence levels to describe the level of risk associated with a certain component or (sub)system.

This approach is reflected in the capability levels of maturity models such as CMMI (Capability Maturity Model Integration) and ASPICE. Confidence levels also appear in ISO 26262 as development methods, approaches, and procedures according to Automotive Safety Integrity Levels (ASIL) in the standard's sections covering both hardware and software development.

ASPICE & ISO 26262: Standardization environment in the automotive industry

The standardization environment governing the development of electronic/electrical automotive systems is defined by ISO 26262 for functional safety (as the automotive adaptation of the general safety standard IEC 61508), and ASPICE for process assessment & capability maturity determination.

While ISO 26262 focuses on the product's functional safety aspects, ASPICE provides general guidance on the process-centric development of automotive hardware and software systems. Simply put, ASPICE focuses on product and process quality, while ISO 26262 emphasizes product safety and related processes. These standards are complementary to each other: their combined use offers valuable help for automotive companies (OEMs or suppliers) to build out and manage reliable E/E development procedures.

In addition to these most important standards, there are further elements of the regulatory environment covering, for instance, the environmental conditions of E/E systems (ISO 16750), or those supporting Advanced Driver Assistance Systems (ADAS) such as ISO/PAS 21448, ISO 11270, ISO 15622, ISO 17387, UL 4600, and others.

ASPICE in the automotive supply chain

In the automotive Tier structure, multiple companies may contribute to the delivery of a complex embedded control system for mobility applications. Some suppliers are involved in designing the ECU(s), others may work on delivering hardware PCB (printed circuit board) designs, yet other suppliers will be developing embedded software.

As the primary standards, ISO 26262 and ASPICE help these various suppliers collaborate by providing shared syntax and semantics for the delivery of design contents. In other words, these documents provide the standardized interfaces that enable collaboration in the automotive supply chain.

The practical aspects of this collaboration, however, can be infinitely more challenging. Differing company cultures, multi-layered program and project management, and a need for unified development processes (and the process automation solutions that support it) all add to the complexity.

In this multi-layered environment, quality control across the multitude of developers and suppliers along the value chain is a challenge. **ASPICE helps ensure consistent product quality across all the different layers in the process of product delivery.**

Introduction to ASPICE (Automotive Software Process Improvement and Capability dEtermination)

Automotive SPICE is a domain-specific derivative of the ISO/IEC 15504 standard (SPICE), which sets out a framework for process assessment. SPICE helps evaluate development factors that allow assessors to determine an organization's capacity for effectively and reliably delivering software products. ASPICE applies that framework to the automotive industry.

Fundamentally, ASPICE defines best practices for embedded software in automotive development. It allows teams to organize their projects and approaches to ensure manageability, reliability, and deliverables. While ASPICE has not been conclusively mandated, every automotive supplier could at some point be assessed for ASPICE compliance.

All about ASPICE: goals, requirements, and traceability

ASPICE builds on the V-Model, also known as the Verification and Validation model, which requires a testing phase corresponding to each stage of development. It is a disciplined model that requires rigorous evaluation to ensure continuous assessment and development.

This approach benefits both providers, who can eliminate potential problems in initial stages, and clients, who can assume a meticulous approach to both ideation and development. An additional goal of ASPICE is to ensure continuous innovation and product development at every stage.

The ASPICE process is best understood visually as a "V" shape, with two prongs illustrating the complete and continuous development process. ▶

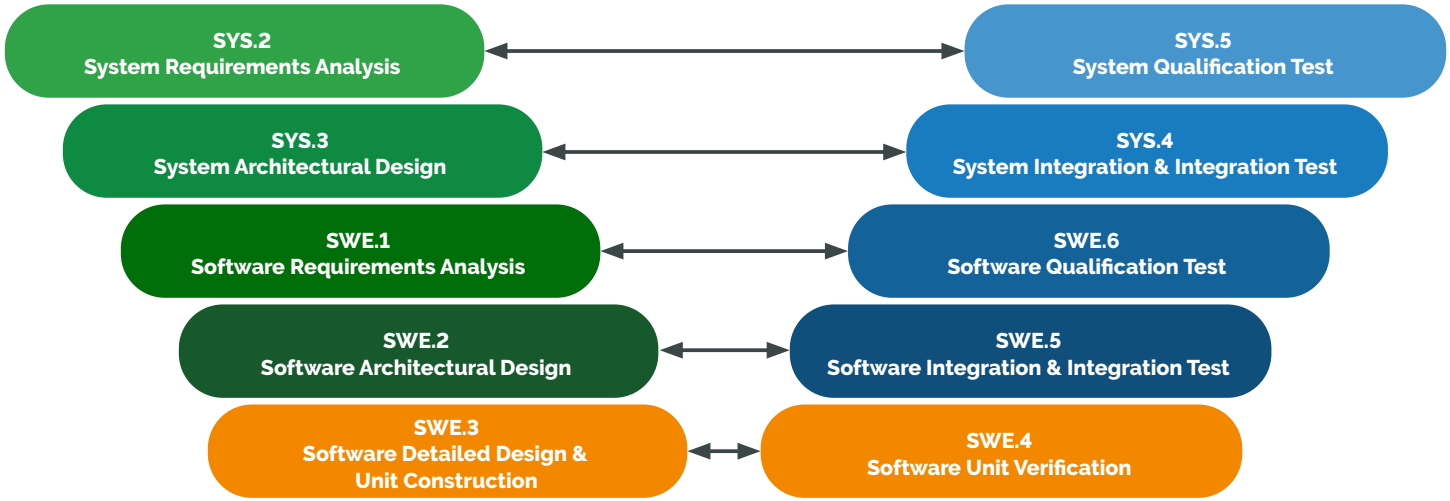
The initial phases, or the left side of the V, include:

- **Requirement Analysis**, or ascertaining and organizing your client's requirements.
- **System Design,** or mapping your client's and stakeholders' needs to restructure them into a viable work process.
- **Architecture Design,** or organizing these requirements into logical operations encapsulating hardware, software, and communication.
- **Module Design,** or the creation of software requirements to match the system requirements and the development of service units.
- **Coding,** the point of the V, wherein the design and implementation of the units take place.

The secondary phases, or the right side of the V, include:

- **Unit Testing,** or ascertaining if the code matches the design and if basic standards and requirements have been met.
- **Integration Testing,** or the evaluation of software architecture and whether the service units are still functional.
- **System Testing,** or integrating all of the services into the full system and testing for functionality and requirement achievement.
- **Acceptance Testing,** or the final tests performed by the client.

Each of these points includes a corresponding testing phase, plus additional traceability and management processes. Suppliers can earn an ASPICE certification based on these standardized achievement phases, and their assessment will result in specific ASPICE levels that their clients take into account.



Source: Automotive SPICE® Process Reference Model Process Assessment Model Version 3.0

Levels of ASPICE capability

ASPICE's guidelines differentiate between 5 levels of process capability. Ranging from 0 (not achieved) to 5 (fully achieved), these capability levels provide different levels of confidence about the performance of your automotive product development processes.

Level 0

ASPICE's Level 0 assessment means that activities in the organization are carried out in an ad hoc manner. Some basic ASPICE practices may be adhered to, but not as a direct result of an organized and purposeful ASPICE initiative. Therefore, Level 0 means that you'll achieve the work products defined by ASPICE at most partially.

Level 1

ASPICE's Level 1 is characterized by the existence of work products to prove that a certain process is in place. Examples of such work products include requirements specifications, a test plan or strategy, a supplier assessment report, or other artifacts. Coverage may not be complete (e.g. you may largely produce the work products specified by ASPICE, but there may be gaps in coverage), but it does span the entire V-shaped lifecycle.

At Level 1, there is no assessment of how much a specific work product is a full and integrated part of your operations. Organizations aiming for Level 1 can use preconfigured tooling that contains fundamental ISO 26262 and ASPICE work products for a successful process assessment.

Level 2

Level 2 in ASPICE means you're able to set goals, manage processes, monitor progress, and respond accordingly. At Level 2, processes plans are laid out, resources are planned and monitored, and all related activities are goal-oriented. Work products are expanded to contain management information on topics such as reviews or change management.

At Level 2, it's entirely possible that projects relating to similar development areas have significant differences in execution. In other words, knowledge and processes may not be simply transferred across projects, limiting organizational learning.

Similarly to Level 1, Level 2 can benefit a lot from relying on adequate process automation tooling. ►

Level 3

Focusing on organizational learning, Level 3 is the first established or stable level of ASPICE. Level 3 essentially means that centralized standards inform how your organization carries out certain processes, and those process definitions are actually followed in practice as processes are executed. At Level 3, you have established and set the performance standards for the organization and continuously evaluate and learn from them. Level 3 requires the existence of a general process framework that may be customized for each project.

Level 4

Level 4 means a high level of capability maturity that enables the organization to use predictable processes. At Level 4, process performance indicators are measured, and the organization is able to monitor trends and implement process corrections to ensure that goals are achieved.

Level 5

Level 5 is all about process innovation that enables the organization to continuously respond to changes and emerging challenges. In essence, organizations at Level 5 maturity are able to optimize their processes to deliver similar results even as circumstances (resources, deadlines) change.

Collecting and evaluating statistical data about processes is inevitable for levels 4 and 5. To enable this, it is crucial to use a process automation system that provides up-to-date data about processes across the organization to fuel continuous improvement.

Reaching Automotive SPICE® Level 3 and Beyond with ALM

Automotive developers can save a lot of resources using Codebeamer's project inheritance feature with the Automotive template. This enables your team to set up a general project configuration for Level 3 assessment – future projects will be based on this fundamental model which may be adapted to project-specific requirements as needed.

Using a controlled process, these project-level changes may then be merged back to the general automated framework to make them available for further projects. That's how organizational process improvement is supported by the Automotive ISO 26262:2018 & ASPICE Template.

Read more

How ASPICE affects automotive development

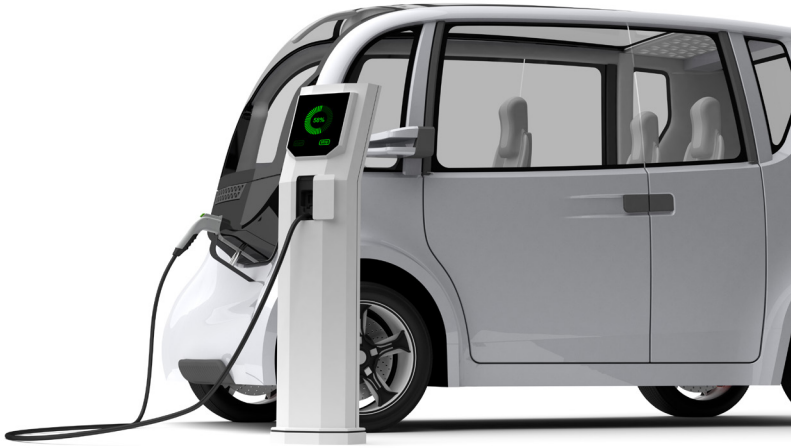
While the framework may seem daunting, ASPICE is actually largely generic. It does not dictate specific tools or techniques, but rather your approach to the internally selected development methods.

Many companies accept ASPICE Level 2, and Level 3 is the universal standard for excellence. Levels 4 and 5 are aspirational achievements usually attempted by large corporations.

Organizations can only learn by attempting to improve their standards. Without a standard for achievement, it would be challenging to determine structured goals within the industry. ASPICE standards provide a benchmark for suppliers to ensure the stability of their processes and products, leading to an overall improvement in an industry where any mistake could cost you dearly.

Automotive SPICE certification requires both suppliers and clients to be rigorous about the products they put on the road, and that alone will improve the automotive product quality standard. But ASPICE steps beyond that by validating feedback and innovation. It recognizes that improved standards can support continuous innovation in the automotive industry, and the resulting process improvement would positively impact not only developers but consumers en masse.

ASPICE standards also have the potential to reduce labor time and costs by integrating the testing process throughout production, limiting dangerous missteps and reducing product recalls. If every organization followed these standards, suppliers could identify problems and manage risks before a vehicle goes to market. ASPICE also improves client-facing processes, allowing suppliers to avoid miscommunication and provide greater transparency from the get-go. Wide-scale adoption could optimize the automotive industry at a pace that has not been witnessed since the advent of the assembly line.



Reaching ASPICE compliance

For each ASPICE process on the V's two prongs, there is a set of base practices defined. It is by following and implementing these practices, and providing evidence thereof, that your organization can achieve compliance with Automotive SPICE.

Your process capability level as per ASPICE will be determined by the following process attributes outlined by the ISO 15504 (SPICE) standard:

- **Process performance**
- **Performance management**
- **Work product management**
- **Process definition**
- **Process deployment**
- **Process measurement**
- **Process control**
- **Process innovation**
- **Process optimization**

To judge the degree of achievement, all these attributes will be evaluated using the following rating scale (as defined by ISO/IEC 33020):

N	**Not** achieved	There is **little or no evidence of achievement** of the defined process attribute in the assessed process.
P	**Partially** achieved	There is **some evidence of an approach to, and some achievement of**, the defined process attribute in the assessed process. Some aspects of achievement of the process attribute may be unpredictable.
L	**Largely** achieved	There is **evidence of a systematic approach to, and significant achievement of**, the defined process attribute in the assessed process. Some weaknesses related to this process attribute may exist in the assessed process.
F	**Fully** achieved	There is **evidence of a complete and systematic approach to, and full achievement of**, the defined process attribute in the assessed process. No significant weaknesses related to this process attribute exist in the assessed process.

Source: **ISO/IEC 33020** – Information technology

Automotive SPICE in your organization

ASPICE is not a concrete set of systems and processes. It is a rough guideline to help suppliers develop a set of best practices that work for them. You can – and should – incorporate ASPICE standards at every level of production. The most important task is to understand the phases and certification levels. Then follow a few easy steps to assess whether your team is ASPICE-compliant:

- **Use gap analysis to assess your current level of ASPICE compliance.** Draw up a draft of your existing processes to visualize how they fit into the ASPICE V-Model.
- **Introduce the missing steps.** If you lack a clear differentiation between two phases, create a plan to separate those two steps.
- **Include stakeholders and team members.** Ensure awareness of the reasons for and guidelines of ASPICE standards. This will help you allocate the resources to begin operating under the new best practices.
- **Incorporate a testing phase at each step of production.** This is the most important – and most challenging – phase of ASPICE compliance. Take the time to build a rigorous testing phase into each step of your new process!

Motivation for ASPICE implementation

Organizations are mainly motivated (or pressured) by OEMs or Tier1 suppliers to implement ASPICE. This often means a required CL (mainly CL3) in selected processes – and of course the continuous implementation of these processes.

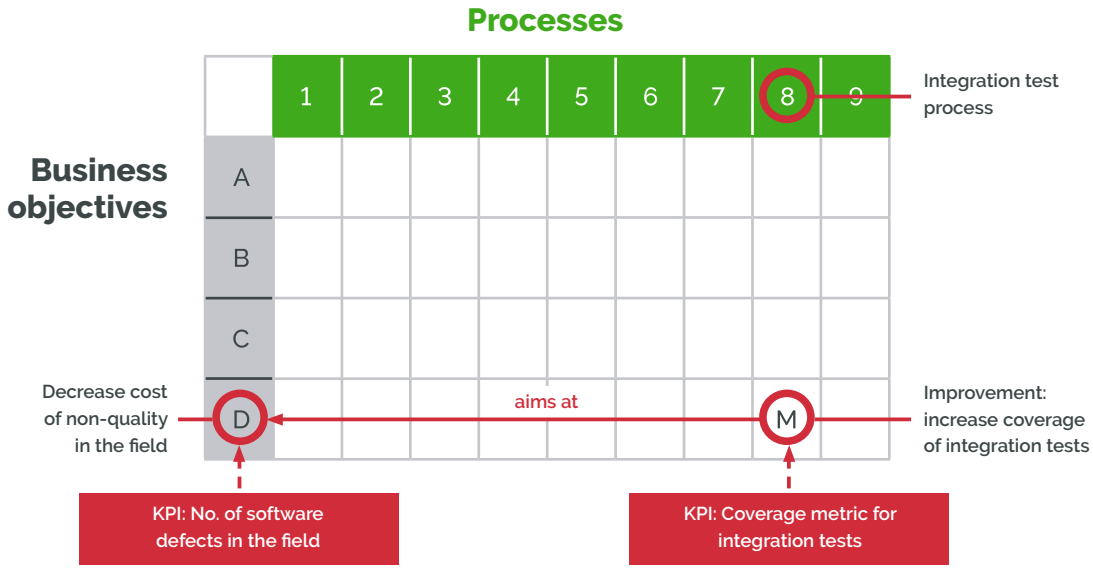
However, this motivation that comes from an external source often leads to resistance against changes. This can result in higher costs and difficulties of maintaining process maturity for future projects.

Process development vs business objectives

Business objectives and process development improvements aren't always linked to each other. Even though people don't always realize it, this relationship does in fact exist: the way teams work always impacts business goals. Streamlined processes can shorten development cycles, leading to reduced costs or improved quality. In addition to these, improved processes might also lead to more satisfied employees. As a general framework to help process improvement, ASPICE can positively impact both.

How processes can make a measurable contribution to business goals

An effective approach is to gather management and the process team in the same room to discuss potential improvements that will contribute to business objectives. These improvements must be measurable and trackable through KPIs.



Source: Automotive SPICE Essentials (Abowd, Hoermann, Vanamali, Wall, 2020)

ASPICE implementation strategies

While ASPICE is not a process assessment model of the organization but of the individual project, in order to achieve CL3+ we need to think in terms of establishing processes on the organizational level. The key to achieving the desired capability level is to first define a strategy for achieving it, then carefully implementing that plan. The most commonly required – and therefore often the ultimate – goal of most organizations is to achieve (pursue) Capability Level 3 for all processes as this provides the best cost-benefit ratio.

According to 'Automotive SPICE Essentials' (Abowd, Hoermann, Vanamali, Wall, 2020) there are three potential strategies:

Strategy 1: The sort of naive approach. Three levels, three phases. This takes the longest time and comes with the highest associated costs. The longer the project takes, the more opportunities there are to fail.

Strategy 2: Combining CL1 and CL2. This offers advantages as there actually is an overlap between CL1 and CL2. The three key processes of Project Management, Configuration Management, and QA support the implementation of CL2. If these processes are implemented in a comprehensive way, CL2 is 90% implemented already. Most organizations fail to take advantage of this.

Strategy 3: It may be initially more expensive, but is more efficient overall to implement all 3 levels in one go. The gain in efficiency can best be compared with Strategy 1, where you would need to enhance all process designs while transitioning to the next level. While with Strategy 3, all processes and all three levels are designed in one go.

Since CL3 deals with process standardization and requires significant organizational commitments and support, it is clear that all three strategies will require plenty of work – both at the project and the organizational level.

Strategy 1

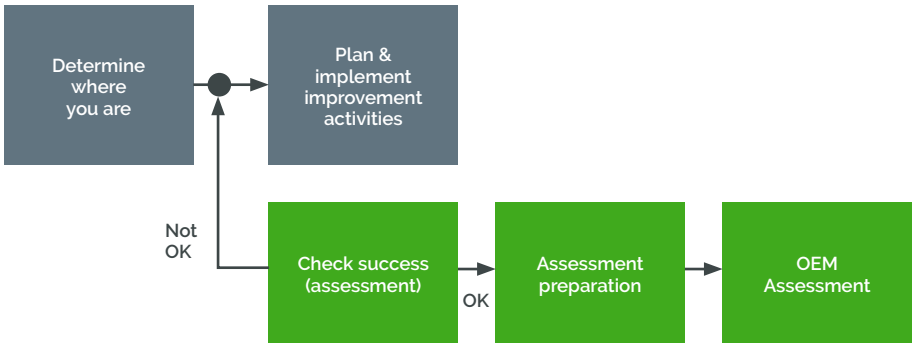
Strategy 2

Strategy 3

Best practices for project-level ASPICE implementation

Many companies try to meet OEM requirements related to ASPICE by introducing it through a specific project instead of a large-scale initiative that would affect the entire development organization. A proven way to do this is to:

- **Start with determining where the organization is at (perform a gap assessment as outlined above)**
- **Plan and implement improvement activities**
- **Assess the success of the implementation:**
  - Not OK: re-execute the planning and implementation of improvement activities
  - OK: Assessment preparation, then OEM assessment.



Best practices for organizational-level implementation

The disadvantage of the above, project-specific implementation is that it is difficult to apply these achievements to another project. Since projects may be slightly (or vastly) different, this approach leads to project-specific ASPICE implementations. The cost of project-specific implementations can be much higher than the cost of an organizational-level implementation.

Taking that latter approach, of course, is more complex and comes with its own pitfalls. However, in the case of CL3, project-level implementations aren't viable since CL3 talks about established processes on the organizational level.

To successfully implement changes on the organization level, you'll need to consider the following success factors:

Source: Automotive SPICE Essentials (Abowd, Hoermann, Vanamali, Wall, 2020)

In general, it is important to break down such organizational-level changes to phases, similarly to the model outlined below in this illustration representing the key phases of an organizational change process:

1 Initial phase

- Create awareness
- Assessing the status quo
- Objectives
- Strategy
- Planning - commitments
- Staffing
- Organization
- Change management concept

2 Delta phase

- Changing and supplementing processes

3 Piloting phase

- Validate processes in practice
- Make processes fit for rollout

4 Rollout phase

- Rollout of processes
- Train, coach, and motivate staff
- Enhance processes based on feedback from practitioners
- Start systematic assessment preparation

5 Institutionalization phase

- Processes are becoming part of the organization's culture
- Assessment for checking success

Interested in a real-life use case?

Download our case study to find out how this UK-based electromotor technology company tackles ASPICE & ISO 26262 requirements in an Agile environment!

Source: Automotive SPICE Essentials (Abowd, Hoermann, Vanamali, Wall, 2020)

Introduction to Agile

A hasty start can ruin everything

If the initial phase is neglected, you may start out with an immature concept and/or an unprepared organization. This could lead to an underestimation of effort, leaving out the right people, wrong objectives, inaccurate know-how, or a lack of motivation. In the initial phase, it is crucial to involve management.
Risk: Major implementation problems or even a complete failure of the implementation project.

Not linking to business objectives

Without the appropriate linking to business objectives, one cannot communicate a clear business motivation. This may lead to lack of motivation among stakeholders and difficulties of managing change in the business. As the definition of success is missing, you may not be able to show proof of success.
Risk: The project has a low priority and doesn't get enough management attention or resources.

Trying to win a race

Sustainable changes on the organizational level simply take time. Unrealistic time pressure (e.g. CL3 in one year) doesn't make sense – but may still be set as a goal by top management.
Risk: Overloaded team, constantly corrected schedules, widespread disappointment regarding the implementation.

Overengineered processes

Good processes are built based on practical solutions that work and are improved iteratively with feedback from the actual practitioners.
Risk: Processes designed in an ivory tower. Unrealistic or way too detailed processes that simply don't work out in practice.

Half-hearted investment

Objectives and resources of the project are often disproportionate: there is a budget, but it's not sufficient. The result is that the company ends up burning a lot of money without real achievements.
Risk: Unsuccessful implementation or a suboptimal cost/benefit ratio.

> **Overall, not only is it possible to reach compliance with the necessary levels of Automotive SPICE, but it can also be greatly beneficial for your organization. By ensuring the maturity of processes, ASPICE helps developers of automotive products reduce the costs of risks, wasted resources, builds confidence in the quality of the company's products – which in turn could positively impact market performance. While compliance with the requirements of ASPICE isn't easy, careful planning and the use of adequate tools to support the transition go a long way in reducing associated costs.**

Sources: 'Automotive SPICE Essentials' (Abowd, Hoermann, Vanamali, Wall, 2020) / Automotive SPICE® Process Reference Model Process Assessment / Model Version 3.0 / What is ASPICE? by Andreas Zwinkau / An ASPICE Overview by Michael Knop

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