

SKILL SET | PRACTITIONER

MEASUREMENT SYSTEM ANALYSIS

SUPPLY CHAIN

CONTROLLING SUPPLIERS

A-SPICE

NORMS AND STANDARDS

MULTIDISCIPLINARY

FUNCTIONAL SAFETY

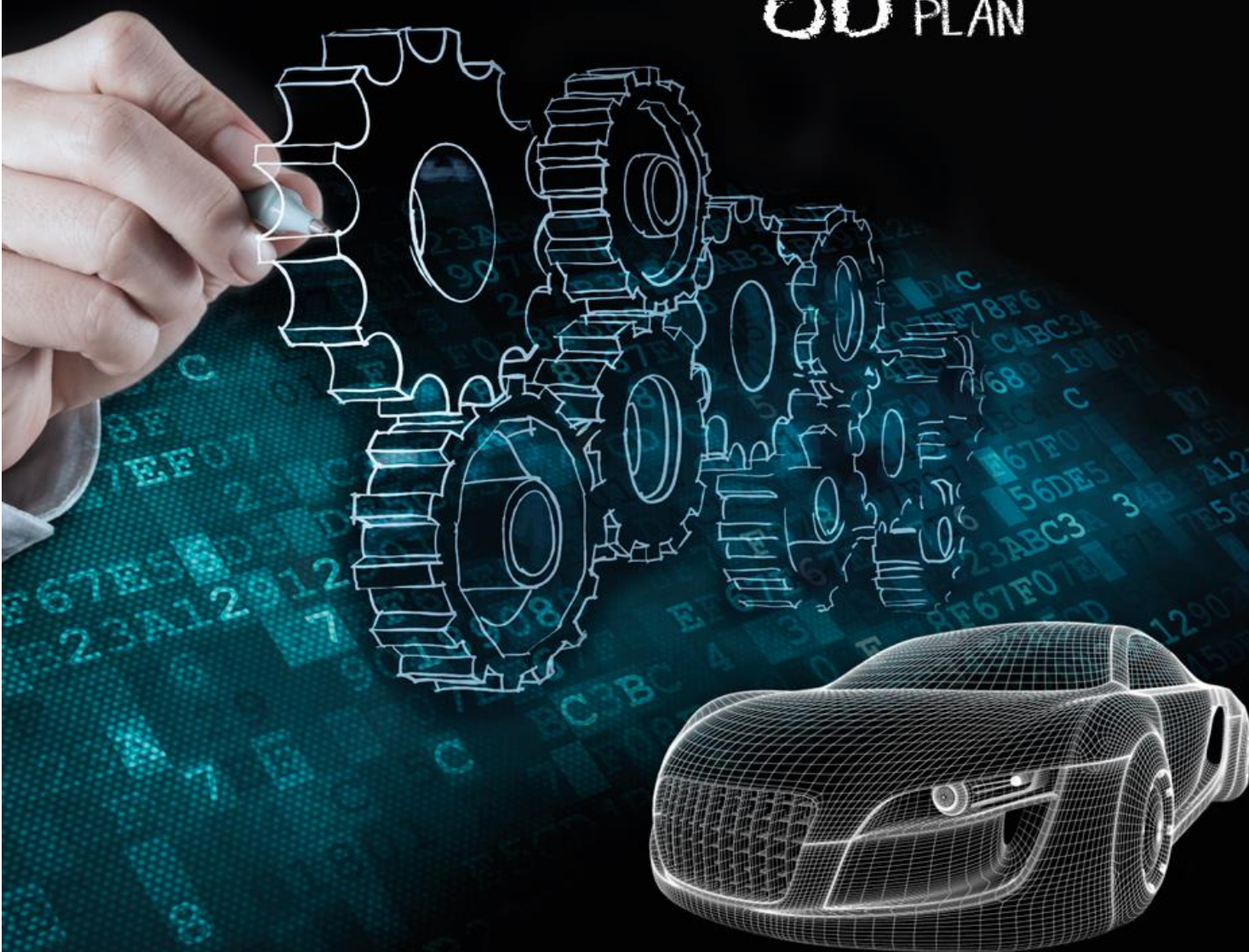
PPAP AND EMPB

APPROACH

SIMULTANEOUS

8D

CONTROL PLAN



AUTOMOTIVE
ENGINEER

WORKING IN THE AUTOMOTIVE INDUSTRY SKILL SET | PRACTITIONER

A GUIDELINE FOR AUTOMOTIVE
TRAINING AND CERTIFICATION
AT PRACTITIONER LEVEL

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FIRST EDITION

FIRST EDITION

Lean Six Sigma Academy[®]

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Amstelveen

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Version 1.0, January 2017

Co-funded by the
Erasmus+ Programme
of the European Union



The "Automotive Engineer" project is financially supported by the European Commission in the Erasmus+ Lifelong Learning Program under the project number 2014-1-NL01-KA200-001189. This project's website and publications reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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INTRODUCTION

The automotive industry is a sector that is growing on a worldwide level at different paces. While markets in Europe are stagnating, those of the BRICS countries (Brazil, Russia, India, China and South Africa) are almost exploding and opening up a huge economic potential. However, it is important to keep in mind the countries' differences in culture, infrastructure, legislation, economy and environment. International vehicle manufacturers like Renault, Toyota, BMW or VW should be aware of the impact of these differences when establishing a factory, dealer network, or releasing a new type of vehicle in a new local market.

The automotive industry is changing more rapidly than ever. The first company dedicated to producing vehicles was the French company French Panhard et Levassor, in 1889. Peugeot followed only two years later. Since then, vehicles have changed significantly. This is a result of increasingly stricter legislation and regulation, as well as changing customer demands (behavior). Safety comes first. In the past, a vehicle used to be delivered with a tool case to be used in case of a breakdown. Nowadays, every vehicle released on the market has to be well developed and thoroughly tested during the construction process. This is executed using different methods and analyses. Clearly, this also means that the education of mechanics and engineers needs adaptation. As the automotive industry will continuously innovate, the technical schools are to anticipate on these changes. Self-driving cars and alternative fuel systems influence the way a vehicle is designed and produced. These changes will also affect the infrastructure. For example, think of all the necessary charging stations at parking lots, businesses, homes, etc. Moreover, how will a self-driving vehicle know where it is when it is in a tunnel?

AUTOMOTIVE ENGINEER SKILL SETS

The two released skill sets, one at Practitioner level (VET) and one at practitioner level (higher education), are the fundamental basis of all the training materials developed. They comprise the basic knowledge and the skills required in the modern automotive development and manufacturing processes, including the different sustainability dimensions.

The structure of the skill set is based and on the ECQA skill set definitions. The structure consists of a number of 'Units', 'Elements' and 'Performance Criteria'.

- **Unit:** The syllabus is presented by syllabus areas; each called a 'Unit'. The chapters in the book reflect the 'Units' described in this syllabus.
- **Element:** Each 'Unit' consists of a number of 'Elements'. Each element is described in a separate chapter in the book.
- **Performance Criteria:** Each 'Element' consists of a number of 'Performance Criteria' and each 'Performance Criteria' has an explanation. These describe the tools, techniques and competencies that are required by an Automotive Engineer.
- **Level of Cognition:** A 'Cognitive Level' has been assigned to each 'Performance Criteria'-description according to Bloom's Taxonomy [5.]. This defines at which level it is expected to apply the respective tool, technique or skill.

This modular structure is reflected in the hierarchical numbering system used throughout this document, whereby each sub-component of the Domain (Unit > Element > Performance Criteria) is represented by its initial letter and listed sequentially, as in the example "U1.E2.PC3", which indicates 'the third Performance Criteria of the second Element in the first Unit'.

EXAMINATION AND CERTIFICATION

Examinations are provided through a number of 'Examination Institutes' (EIs), which use the skill set to develop exams. The exams are open to all. Individuals can apply directly to the EIs or sign up via one of the training organizations. It is recommended that candidates receive training to prepare for certification. Alternatively, candidates who wish to self-study have the option to apply directly for certification. For further information about examination please visit the ECQA webpage (www.ecqa.org) or the LSSA webpage (www.lssa.eu).

U1.INTRODUCTION

This unit is an introduction to the automotive sector in terms of its history, evolution and future, as well as key terms and key challenges. Characteristics of the sector are discussed, in particular the supplier structure, product and releases, and the importance of customer focus. Typical automotive engineering job roles are introduced to help learners orient themselves towards specific fields of interest.

A learning element giving an overview of a small selection of the most important legal documents, regulations and standards relevant for the sector.

The importance and essence of processes and process thinking in the automotive sector is also elaborated in this introductory module. The increasing dominance of mechatronic subsystems in modern vehicles implies an outstanding of the role of multidisciplinary challenges in engineering organizations and processes. This is also discussed in this introductory module, as is the important concept of simultaneous engineering.

E1. AUTOMOTIVE INDUSTRY

The Learning Element 'Automotive industry' explains the most important moments in the history and evolution of the automotive as well as the future and key challenges. Also the structure of the supply chain and the most important differences to other branches will be discussed.

U1.E1.PC1	History and Evolution Recall the history and developments within the automotive industry.	Remember
U1.E1.PC2	Definitions, Terms, and Abbreviations Recall automotive definitions, terms, and abbreviations.	Remember
U1.E1.PC3	Supply Chain Describe the supplier structure of the automotive industry.	Understand
U1.E1.PC4	Key Challenges Understand the key challenges of the automotive industry.	Understand
U1.E1.PC5	Automotive Industry versus other Branches Understand the differences with others branches (e.g. aerospace, medical, defense, consumer electronics, etc.).	Understand
U1.E1.PC6	Evolution and Future Understand what the future of the automotive industry could be like (e.g. electric, hydrogen, self-driving car).	Understand

E2. CHARACTERISTICS IN THE AUTOMOTIVE

The Learning Element ‘Characteristics in the Automotive’ explains the customer focus and the formal procedures like product and process releases and change notifications.

U1.E2.PC1	Product and Process Release Understand the product and process release and change notifications within the automotive industry.	Understand
U1.E2.PC2	Customer Focus Recall the role of customers' expectations and specifications.	Understand
U1.E2.PC3	Job Roles Understand the engineering job roles in the automotive industry and their differences.	Understand
U1.E2.PC4	Specification Documents Identify specification documents (e.g. customers' specifications, software requirements, etc.).	Understand

E3. LEGISLATION, REGULATIONS, AND STANDARDS

The Learning Element ‘legislation, regulations, and standards’ introduces the most relevant regulations, laws and directives for the automotive industry. It introduces the product liability and safety law and the homologation process and continues with the description of several international standards, starting with the most well-known and widely recognized ISO/TS 16949.

U1.E3.PC1	Legislation and Regulations Identify and apply the legislation and regulations there are in the automotive industry.	Apply
U1.E3.PC2	Standards Identify and apply the existing norms and standards (e.g. ISO/TS 16949, ISO 26262, APQP, VDA, ISO/IEC 15504, etc.). Understand the key objectives and concepts underlying the several norms and standards, its complexity, and the relations between them.	Apply

E4. PROCESS THINKING

The Learning Element ‘Process Thinking’ explains the different processes within automotive companies and the multidisciplinary approach.

U1.E4.PC1	Primary Process Understand the primary process of a company.	Understand
U1.E4.PC2	Automotive Process Landscape Understand the automotive process landscape.	Understand
U1.E4.PC3	Changes on Product and Process Understand the consequence(s) of changes on product and process	Understand
U1.E4.PC4	Multidisciplinary Approach & Simultaneous Engineering	Understand

Understand the multidisciplinary and simultaneous engineering approaches.

U2.PRODUCT AND PROCESS DEVELOPMENT

This unit focusses on selected engineering aspects of product and process development in the automotive sector. Departing from the explanation of the notion of the product life cycle and sustainability, a closer look is taken at the development phase of the product life cycle by discussing the development process, as well as the typical activities carried out in the context of this process. The notion of systems engineering is explained, as it is of particular importance in modern vehicles where system-level functions are implemented by numerous cooperating subsystems. The explanation of the V-cycle establishes the link between system-level and component-level development activities.

Functional safety, i.e., the safe behavior of subsystems in case of failure, is discussed in the context of a module on risk management. This module also contains an introduction to FMEA, i.e., Failure Mode and Effect Analysis, which is one of the most important methods of risk management on both product and process levels in automotive.

E1. PRODUCT LIFECYCLE MANAGEMENT

The Learning Element 'Product Lifecycle Management' explains the significance of the product life cycle and its management for the product creation and support process. The relationship between product life cycle management and environmental sustainability is pointed out. A particular focus is directed on the engineering for the end-of-life as a key lever to increase sustainability.

U2.E1.PC1	Different Levels	Understand
	Understand the life cycle at different levels (e.g. software, hardware, system, product, service, infrastructure, safety, security).	
U2.E1.PC2	Designing for End-of life	Understand
	Understand the complexity from designing until End-of-life (EOL) of a vehicle.	

E2. ADVANCED PRODUCT QUALITY PLANNING

The Learning Element 'Advanced Product Quality Planning' (APQP) explains the different phases within product and process development and their most important activities and tools used in these phases.

U2.E2.PC1	Objectives	Understand
	Understand the objectives of APQP, why and when it's used.	
U2.E2.PC2	Phases	Understand
	Identify the different phases of APQP.	

E3. SYSTEMS ENGINEERING

The Learning Element ‘Systems Engineering’ explains the essential automotive engineering principles, starting from a system level down to component level. It introduces the automotive development process and the most important related activities and concepts. A particular focus is made on the development of automotive subsystems containing electrics/electronics and software.

U2.E3.PC1	Breakdown Structure of a Vehicle Understand the complexity of a vehicle and its systems.	Understand
U2.E3.PC2	System Level Development Understand Product Development Process, and V-Model.	Understand
U2.E3.PC3	Component Level Understand the development lifecycle.	Understand

E4. RISK MANAGEMENT

The Learning Element ‘Risk Management ’ describes risk management and risk management tools like functional safety hazard and risk analysis and FMEA. The element describes how to apply the FMEA and how to perform a functional safety hazard and risk analysis.

U2.E4.PC1	Risk Management Process Understand the purpose of risk management.	Understand
U2.E4.PC2	Failure Mode and Effect Analysis Motivate the risks and safety issues, taking in consideration the several systems in a vehicle and their interference. Understand the process FMEA and recall the process risks.	Apply
U2.E4.PC3	Functional Safety Review Failure Mode Effects Analyses and diagnostic analysis. Review the hazard and risk analyses based on ISO 26262 and IEC 61508.	Apply

U3.PRODUCTION

The third training unit deals with the automotive production process, with a particular focus on the quality assurance measures based on Six Sigma principles. The key topics here include the Process Capability (a measure for the variation in the process) and Process Control, mainly based on statistical tools applied to data measured in the process.

Since the suppliers have a key role in the automotive development and production process, the assurance of the quality they deliver is essential to the total quality management of the product creation process. This training element therefore discusses supplier control and assessment schemes, in particular Automotive SPICE®, which is used by automotive OEMs to assess their suppliers' mechatronics development process quality worldwide.

Change management is an important activity throughout the entire product creation process, because changes can happen at every moment.

E1. PROCESS CAPABILITY

The Learning Element 'Process Capability' describes how to calculate the process capability and performance in relation to specification limits.

U3.E1.PC1	Variation Understand the difference between special cause and common cause variation.	Understand
U3.E1.PC2	Process Capability Indices Calculate and interpret process capability indices, Cp and Cpk, to assess process capability.	Apply
U3.E1.PC3	Process Performance Indices Calculate and interpret process performance indices, Pp and Ppk., to assess process performance. Interpret the relationship between capability and performance indices.	Apply

E2. PROCESS CONTROL

The Learning Element 'Process Control' describes different tools used for controlling processes, it explains how to perform measurement systems analyses and their control methods in order to identify out-of-control situations and deviations over time.

U3.E2.PC1	Measurement System Analysis Analyze measurement system analyses. Basics of Measurement System Analysis: calculate and interpret measurements and analyses (e.g. Gage R&R, Attribute Agreement Analysis report).	Analyze
U3.E2.PC2	Controlling Processes Describe how and why processes are controlled during production.	Understand

U3.E2.PC3	Statistical Process Control Describe the objectives of SPC, including monitoring and controlling process performance and tracking trends. Apply SPC for reducing variation in a process.	Analyze
U3.E2.PC4	Control Plan Prepare a control plan to document and hold gains. Define controls and monitoring systems. Transfer of responsibility from the project team to the process owner.	Analyze
U3.E2.PC5	Gage R&R study Understand the difference between repeatability and reproducibility (R&R) and the meaning of the number of distinct categories.	Understand

E3. SUPPLIER QUALITY ASSURANCE

The Learning Element ‘Supplier Quality Assurance’ describes the significance of supplier quality assurance process and their tools to evaluate and control the suppliers. The element describes how to collect and analyze documents for the PPAP and EMPB and perform supplier audits according to the VDA 6.3 standard.

U3.E3.PC1	Controlling Suppliers Identify the risks of a supplier and can take the needed action by using PPAP, EMPB, and VDA 6.3.	Apply
U3.E3.PC2	PPAP and EMPB Use PPAP and EMPB.	Apply
U3.E3.PC3	Auditing Suppliers Prepare a supplier audit (VDA 6.3).	Apply
U3.E3.PC4	Automotive Spice Assessment Understand Automotive SPICE® and why and how Automotive SPICE® Assessments are performed.	Understand

E4. MANAGEMENT OF CHANGE

The Element ‘Management of Change’ explains the importance of a change management process in product and process development as well as in released processes with the focus on evaluating the impact of the risk in terms of costs, timing, quality and prepare a change notification to the customer.

U3.E4.PC1	Risk of Changes Calculate and review the risks when changes are being proposed/made. Is able to fill out a Change notification.	Apply
U3.E4.PC2	Change Notifications	Apply

Define change notification, PPAP, and EMPB.

U3.E4.PC3

Changes during Design and Development

Understand

Understand the interface with change management in design and development.

U4.CONTINUOUS IMPROVEMENT

This fourth and last unit deals with continuous improvement as an intrinsic element of successful automotive development and production processes. The key elements are tools and methods for problem finding, analyzing, and solving, lean manufacturing (i.e., the minimization of non-value-adding activities in the manufacturing process), quality awareness, as well as approaches to sustaining improvements.

E1. PROBLEM SOLVING

The Learning Element ‘Problem Solving’ describes how to apply the ‘Eight Steps Problem Solving Method’ used to approach and resolve problems.

U4.E1.PC1	8D Apply the eight disciplines problem solving process which is used to approach and resolve problems.	Apply
U4.E1.PC2	Problem solving techniques Define and apply root cause analysis, recognize the issues involved in identifying a root cause. Apply problem solving process and tools.	Apply
U4.E1.PC3	Kaizen events Setup and lead Kaizen events.	Apply

E2. LEAN MANUFACTURING

The Learning Element ‘Lean Manufacturing’ describes the values and principles of Lean Manufacturing and its role in the automotive industry. The element describes also how the most common tools are applied.

U4.E2.PC1	Lean Manufacturing in the Automotive Industry Describe Lean Manufacturing and interpret Lean Manufacturing in the automotive chain.	Understand
U4.E2.PC2	Applying Lean Manufacturing Apply Lean Manufacturing tools such as process mapping, value stream mapping, 5S, Kanban, flow, and pull.	Apply

E3. QUALITY AWARENESS

The Learning Element 'Quality Awareness' is about the most important factors influencing the quality awareness in the organizational culture. It investigates leadership and commitment, team formation and teamwork, as well as cultural diversity and their influences on quality culture. A quality culture in automotive organizations is the necessary requirement for providing a high-quality product to customers.

U4.E3.PC1	Leadership and Commitment Describe the type of leadership needed in the automotive industry. Describe what commitment is and its importance.	Understand
U4.E3.PC2	Interdisciplinary Nature of Quality Understand that the interdisciplinary expertise is fundamental for tackling complexity in innovation cycles.	Understand
U4.E3.PC3	Cultural Diversity and its Influence Understand cultural diversity (not only nationalities but also between job roles).	Understand

E4. SUSTAIN IMPROVEMENTS

The Learning Element 'Sustain Improvements' describes the methods for sustaining improvements and how to apply them in order to prevent mistake, avoiding problems in the future and optimize processes.

U4.E4.PC1	Sustaining Improvements and Changes Define and apply methods for maintaining improvements to become a learning organization (standardization and documentation). Standardize and review lessons learned.	Apply
U4.E4.PC2	Quality Management Propagate the quality management system and procedures. Identify opportunities for improvement.	Apply
U4.E4.PC3	Standardized Work Standardize tasks and processes to establish the foundation for continuous improvement and employee empowerment. Prepare documents, standard operating procedures (SOPs) and one-point-lessons to ensure that the improvements are sustained over time.	Apply
U4.E4.PC4	Lessons Learned Identify and document lessons learned from all phases of a project. Identify possible improvements and ownership.	Apply

U4.E4.PC5	Ongoing monitoring, evaluation and auditing	Apply
	Apply tools for the ongoing evaluation of the improved process, including auditing (internal / external), monitoring for new constraints and identification of additional opportunities for improvement.	

APPENDIX A – BLOOM'S TAXONOMY FOR PERFORMANCE CRITERIA

In addition to specifying content, each performance criteria in this skill set also indicates the intended complexity level of the test questions for each topic. These levels are based on 'Levels of Cognition' (from Bloom's Taxonomy – Revised, 2001), and can be used to create learning outcomes for students [6.].

The Taxonomy of Educational Objectives, often called Bloom's Taxonomy, is a classification of the different objectives that educators set for students (learning objectives). The taxonomy was proposed in 1956 by Benjamin Bloom, an educational psychologist at the University of Chicago. During the nineties, Lorin Anderson a former student of Bloom revisited the cognitive domain in the learning taxonomy [5.]. Bloom's Taxonomy divides educational objectives into three 'domains': Affective, Psychomotor and Cognitive. This Skill set only notices the Cognitive domain. The 'Levels of Cognition' are in rank order - from least complex to most complex. The Black Belt skill set only uses the levels 'Understand', 'Apply' and 'Analyze'.

Remember

Recall or recognize terms, definitions, facts, ideas, materials, patterns, sequences, methods, principles, etc.

Understand

Read and understand descriptions, communications, reports, tables, diagrams, directions, regulations, etc. In the skill set the following verbs were used at this level: Describe, Follow, Identify, Interpret, Participate, Understand.

Apply

Know when and how to use ideas, procedures, methods, formulas, principles, theories, etc. In the skill set the following verbs were used at this level: Apply, Assure, Calculate, Define, Demonstrate, Divide, Eliminate, Empower, Facilitate, Implement, Motivate, Organize, Plan, Prepare, Present, Promote, Propagate, Review, Select, Standardize, Support, Use.

Analyze

Break down information into its constituent parts and recognize their relationship to one another and how they are organized; identify sublevel factors or salient data from a complex scenario. In the skill set the following verbs were used at this level: Analyze, Construct, Design, Develop, Distinguish, Evaluate, Lead, Manage, Translate.

Evaluate

Make judgments about the value of proposed ideas, solutions, etc., by comparing the proposal to specific criteria or standards. This level is not used in the skill set.

Create

Put parts or elements together in such a way as to reveal a pattern or structure not clearly there before; identify which data or information from a complex set is appropriate to examine further or from which supported conclusions can be drawn. This level is not used in the skill set.

APPENDIX B – REFERENCES

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