Analysis of Product Development Toolsets for Electrical Distribution Systems in the Automotive Industry
A Study inside an Original Equipment Manufacturer

By

María Gabriela Medrano González

B.S. Mechatronics and Process Control Systems Engineering
Universidad La Salle Cuernavaca, 2008

SUBMITTED TO THE SYSTEMS DESIGN AND MANAGEMENT PROGRAM
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN ENGINEERING AND MANAGEMENT
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
JUNE, 2016

Signature of Author________________________ Signature redacted
María Gabriela Medrano González
System Design and Management Program
May 16, 2016

Certified and Accepted by____________________ Signature redacted
Patrick Hale
Director, System Design and Management Fellows Program
Senior Lecturer in Engineering Systems Division
Massachusetts Institute of Technology - Engineering Systems Division
Thesis Supervisor

Page intentionally left blank.

Analysis of Product Development Toolsets for Electrical Distribution Systems in the Automotive Industry
A Study inside an Original Equipment Manufacturer
By

María Gabriela Medrano González

Submitted to the System Design and Management Program on
May 16, 2016 in partial fulfillment of the requirements for the degree of
Master of Science in Engineering and Management

Abstract

A study was performed to understand the definition and utilization of a key product development enabler, the tools, in the development of Electrical Distribution Systems inside a sample Original Equipment Manufacturer (OEM). The primary purpose of this study was to take in in-depth look at the integration of the system of tools utilized by the commodity department in the development of Electrical Distribution Systems components, and then to identify opportunities for establishing a more efficient system of tools for the compliance of requirements.

The study focused on the deliverables required in the fulfillment of requirements as the element for critical comparison. That comparison consisted of the utilization of the current system of tools versus the desired system of tools—a desire system resulting from the fulfillment of requirements that would constitute a "Utopia System". The mapping of deliverables to requirements, and the processing linkage among them were based in the definition of inputs and outputs already identified by the sample OEM for the development of this specific commodity; and the mapping of deliverables to the utilization of tools was enabled by experiential inputs of the author as well as insights gained from interviews with employees at the sample OEM. Structural representations allowed for a better and thorough comprehension of the mapping of deliverables and provided a foundation for understanding the challenges embedded in the desired objective: clustering existing tools for an improved and more effectual integration. Specifically, the mapping of deliverables to the utilization of the current system of tools, allowed for the analysis of efficiency levels and the identification of opportunities for redundancy avoidance.

Considering the challenges and sudden changes constantly faced by those in the automotive industry, including those of this OEM, the proposal for optimizing the system of tools was based on network metric comparisons between the current system of tools and the desired system of tools. The proposal for integrating a better system of tools then concluded with a step-by-step plan that could be utilized as an approach for continuous improvement of this key enabler of the product development process—the tools. The desire of this "vision" would be that such optimization would then lead to performance metrics improvements for the EDS department and the product development organization as a whole.

Thesis Advisor: Patrick Hale
Title: Director, System Design and Management Fellows Program
Senior Lecturer in Engineering Systems Division

Acknowledgements

I would like to thank the System Design and Management (SDM) faculty who have taught me so much and inspired me to take initiatives to enhance the future world of all humanity. I would especially like to thank Pat Hale for his enriching insights throughout the development of this study, for sharing with me his experience and knowledge about the systems engineering subject and for assisting me in expressing, in a satisfactory manner, all of the initiatives and ideas that I envisioned for this analysis.

To all the SDM fellows and team members I had the pleasure to work with more closely, thank you for all the sharing during the development of new thinking processes. Eric and Guillermo, I am grateful for having you not only as my SDM fellows and work colleagues, but also as my friends throughout this experience; thank you for your time, your support and your endless cheering.

Professionally, I would like to thank Marcos Perez, Janak Chitalia, and the management team at FoMoCo for allowing me to participate and learn from this once-in-a-lifetime experience through the SDM program at MIT. Also, I would like to thank Lizardo Amador, first for his friendship and second, for making this program known to me and supporting my enrollment in it, solidly believing that this was the right avenue for me to pursue in my career development. Indeed you were correct in your ascertainment!

My sincere thanks to Matt Brabant, for his support during the development of this study and for sharing with me useful insights throughout its progression. Also, I would like to thank the colleagues who willingly participated in the interview process and illustrated me about the processes and activities performed within the Original Equipment Manufacturer (OEM). I thank you all for helping me to remove any biases acquired through my individual experience.

Also, I would like to thank Michelle McKenzie, for her irreplaceable support in proofreading this analysis and for helping me to continuously improve my English language skills.

Personally, I want to thank my beloved husband, who encouraged me to live this enriching experience and for providing me an infinite amount of support and love during the entire length of this program. You were always my light and calm in moments of challenging and stressful times. This achievement is yours as much as mine and I will cherish forever every experience we lived together during this time period.

To my dearest parents, Silvia and José (†), thank you for giving me your life examples, examples of success in every sense. I will always be thankful and proud of being your daughter. To my sisters, thank you for all the energy and support provided back at home so I could remain focus on completing this program. To my brothers and extended family, thank you for your love and for making count every moment of our lives together.

Page intentionally left blank.

Table of Contents

List of Figures

List of acronyms

CAD	Computer Aid Design
DFM	Design for Manufacturing
DI	Digital Innovation
DSM	Design Structure Matrix
EDS	Electrical Distribution System
EESE	Electrical and Electronics Systems Engineering
GPDS	Global Product Development System
I.D.	Informational Deliverable
IT	Information Technology
MDM	Multiple-Domain Matrix
OEM	Original Equipment Manufacturers
OPD	Object-Process Diagram
OPD	Ongoing Product Development
OPM	Object-Process Methodology
PD	Product Development
PDP	Product Development Process
PLM	Product Lifecycle Management
R&R	Roles and Responsibilities
ROI	Return on Investment
SME	Subject Matter Experts

Chapter 1.Introduction

1.1 Thesis Motivation

Throughout the millennium, humanity has made use of transportation to fulfill a myriad of needs. From the time of antiquity, when early nomads were on the move searching for hunting grounds, to the present age in which an asundry of transport modes are utilized for work, recreation, the purchasing of goods, etc., humanity has employed various means of transportation.

Offering both human and goods transit, current ground modes of transportation provide a variety of services. With few exceptions, these modes from shared to private vehicles are primarily manually operated and based in the operation of fuel combustion engines. According to the EPA (Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013), the transportation industry contributed a share of 27% to Greenhouse Gas (GHG) emissions (equivalent to ~1842 million metric tons of Carbon Dioxide CO2) in the US by 2013; within this percentage, Light Duty Vehicles (including passenger cars and light-duty trucks) contributed a significant 60% of GHG emissions, damaging our environment and increasing the risk to the sustainability of our atmosphere.

Focusing directly on the emissions contributed by the passenger vehicles, I have ascertained that this problem is mainly formed by two elements: usage modes and the products themselves. Usage modes are directly tied to social needs and behaviors. Personally, I believe that regulations and self-awareness activities, assist people in altering the way they live, causing then to behave in a more sustainable way. Nevertheless, despite my interest in this subject, I intend to collaborate instead on the portion of products themselves. I believe that both the system thinking skills learned during this program as well as my own personal working experience can contribute much to this collaboration.

With prior observations about pollution in mind, it is exciting to observe how the automotive Original Equipment Manufacturers (OEM) have initiated actions to identify mobility solutions that help solve congestion problems while at the same time maintaining solid core business operations. If we consider that new product designs can potentially form part of this strategy, I think it is imperative that the engineering workforce prepares to break the mold, designing and validating new technologies more robustly, solidifying their empowerment to make decisions more quickly and work more efficiently overall.

More than once, while working in an OEM Product Development (PD) department, I have observed that engineering and management requirements which must be achieved, are being fulfilled multiple times, and thus unnecessarily duplicated. Throughout a multitude of product developments, I have discovered vast opportunities to optimize the day-to-day work activities of engineering by reducing the embedded, complicated usage of systems, tools, and methods. Considering the significant content of electrical components that vehicles of today carry, and the complexity they bring to the development of the electrical design, I will focus on the processes and tools the Electrical Distribution System (EDS) department utilizes to identify meaningful opportunities for improvement.

1.2 Thesis Objective

Through the integral mapping of tools utilized by the Electrical Distribution Systems team in the processing of deliverables for the fulfillment of requirements, an efficiency analysis will identify opportunities for optimization with the EDS components' design and development process in a sample OEM by means of optimizing one of the key product development enablers: the tools.

The primary research objectives this analysis will strive to cover include the following:

- Identify the stakeholders EDS engineers interact with throughout the PD process.
- Identify the requirements placed upon EDS engineers' activities and what the decomposition and classification of those requirements are.
- Identify the processes utilized in the development of EDS components and the tools utilized in these processes as well as the classification of these tools.
- Ascertain how optimum the linkage between inputs and output is across EDS development processes.
- Review the integration level between EDS processes and tools to determine whether opportunities for optimization exist.
- Deduce the efficiency level in the usage of EDS tools and identify any opportunities for redundancy avoidance.
- Identify existing initiatives and draft new ones that can potentially contribute to the optimization of EDS processes and tools' efficiency including the roadmap to implement key recommendations across PD.

Finally, as an indirect objective, the integration analysis of tools usage in the EDS commodity department will provide an initial example of a pathway for performing similar analysis in other vehicular commodity departments.

1.3 Research Methods

The research will feature elements from SDM courses, such as Systems Architecture, Systems Engineering, System Dynamics and Program Management. It is arranged in the following process steps:

a) Compile literature of the Product Development Process (PDP), its phases and enablers with a focus on the automotive industry and its PDP dynamics.
b) Perform interviews with sample OEM EDS engineers to gain fuller perspective of the overall activities performed in the development of EDS components, the processes that currently work well and the areas for improvement already identified by the EDS team.
c) Mapping of the EDS system boundary and stakeholders that interact with the EDS team.

d) Review of the control structure and requirements placed upon EDS engineers.
e) Analysis of the integration of sample OEM tools following the next steps:
    1. Linkage of deliverables (Inputs and Outputs) to EDS requirements.
    2. Interface analysis of informational deliverables that fulfill EDS requirements.
    3. Linkage of deliverables (Inputs and Outputs) to existing OEM tools.
    4. Interface analysis of existing tools that process EDS deliverables (and therefore, fulfill requirements).
f) Review of opportunities for improvement of the existing system of tools in the sample OEM, by the comparison of an interface analysis in the processing of deliverables.
g) Review of aspects to consider in the proposal for optimization of the tools system with the intent of moving toward a platform development.
h) Document key findings and final recommendations.

1.4 Thesis Structure

This thesis is arranged in such a way as to provide the reader with an overview of the product development process, the automotive industry, and the toolsets utilized in the development of new vehicles. With specific interest in the electrical department, it will present an integral mapping of how toolsets are utilized to fulfill different stakeholder requirements. Additionally, this thesis will attempt to identify potential opportunities for improvement that might improve efficiency in daily engineering activities.

Chapter 2. The systems approach: Product Development Process in the Automotive Industry
Chapter 2 will begin providing a quick overview of the dynamics involved in the development of automotive products. The Product Development Process is then introduced, and focusing on the automotive industry, to a more in depth level the phases utilized in the automotive product development and the dynamics of this process will be reviewed. Moreover, this chapter will cover the importance of capabilities, such as those of toolsets, in the development of new products; complexity will be introduced to the reader in order to provide a background from which to understand the need for product and organization partitioning. Finally the selection of the Electrical Distribution System (EDS) department as the system of interest for this study will be explained.

Chapter 3. The Electrical Distribution System (EDS) Department
Once equipped with a brief background of the product development process, its importance, and the partitioning of subsystems within the automotive industry, Chapter 3 will draft the scope limit of this analysis to an EDS system boundary with special focus on understanding the interactions of this department relative to both internal and external stakeholders. Followed by the stakeholder interaction analysis, the reader will find a decomposition of requirements set upon the EDS department and a hierarchical control structure that will aid in the understanding of the roles of representative authorities. Having established an understanding of the primary operational activities of the EDS department, a

discussion will take place regarding how iterations and reworks prevent the EDS team from performing at a utopic level in the product development of EDS components.

Chapter 4. EDS Tools Analysis

Chapter 4 delineates in further detail the processes the EDS team performs in the development of EDS components. It presents a mapping of deliverables to requirements in order to identify the structural integration of a system of tools that would be just adequate enough to process such deliverables. Next, the mapping of currently utilized tools to deliverables enables comprehension of how the current system of tools meets, or exceeds the expectations of the interactions among deliverables. Both systems, the desired system and the current system of tools are then analyzed from a network perspective for comparison purposes. Finally, a step-by-step plan is proposed for a continual and optimal integration of the systems of tools in the sample OEM.

Chapter 5. Conclusion

This final chapter will consolidate the observations and opportunities for improvement uncovered from the process of carrying out the methods of analysis and will conclude with how the objectives of the research can be achieved. Finally, future work recommendations unveiled during and after the completion of the analysis are presented with the intention of identifying further opportunities for improvement in the expansion of this model of analysis to other commodities, and in the modification of the proposed plan for integrating the system of tools of the entire PD organization.

Chapter 2. The systems approach: Product Development Process in the Automotive Industry

As identified in the introductory chapter, the motivation for this work lies in improving product development processes within the automotive industry. In line then with this motivation, Chapter 2 will introduce a systems' thinking methodology which will allow proactive identification of opportunities in the analysis of the product development process. Together with this, and in order to outline key dynamics considered in the automotive industry, an example of this methodology will be illustrated.

2.1 The System Dynamics methodology

System dynamics is an interdisciplinary method that facilitates the learning of complex systems. It utilizes nonlinear and feedback control theory from different science disciplines (Sterman, 2000). Originally developed by Jay W. Forrest at the Massachusetts Institute of Technology (MIT), this method is broadly employed in system thinking applications in order to analyze and capture potential emergences of a system; a *system* is understood as a group of components that interact synergistically to produce results that would not be delivered by the sole operation of a single component. For instance, the wheels of a vehicle are a key component of the vehicle; however, the wheels as a singular component could not transport somebody from one place to another (Ackoff, 2010).

Complex systems are define by the number of components and the interaction between those components. A useful threshold to define whether or not a system is complex can be set considering INCOSE's "rule of thumb", that determines a system should be composed by no more than 7 ± 2 elements to remain in balance (INCOSE, 2011). Considering this amount of elements, a complex system is also understood as any system that cannot be managed, controlled or operated by a single person. For instance, vehicles are considered complex systems due the fact that, although when driven, they are operated by a single individual, the integration of each vehicle is composed of roughly 10,000 parts (Ulrich & Eppinger, 2012) that interact mechanically or electrically among each other.

The system dynamics methodology utilizes variables to represent relevant elements of the system, and arrows to represent causalities among elements. These causalities are also considered feedback loops and can be labeled with positive and negative symbols. Positive symbols represent self-reinforcing feedback, while negative symbols represent self-correcting feedback. Additionally, the interconnection of variables in a closed loop can be labeled as Reinforcing (R) or Balancing (B) loops; and the orientation of the rounding arrow indicates the direction of feedback flow from one element to another. Figure 1 below shows a simple model which includes some of the key elements utilized in this methodology. Observed at the left side of the model is a Reinforcing feedback loop. This first loop involves positive causalities between *Complexity* and *Number of Components in a System* – higher *Complexity* causes a higher *Number of Components in a System*; a higher *Number of Components in a System* causes higher *Complexity*. To the right side a Balancing feedback loop is found. It shows positive and negative causalities throughout the *Complexity-Operators Capacity-Components* flow – higher *Complexity* causes lower *Operators Capacity*; a lower *Operators Capacity* causes higher *Components Deletion*; higher *Components Deletion* causes lower *Complexity*.

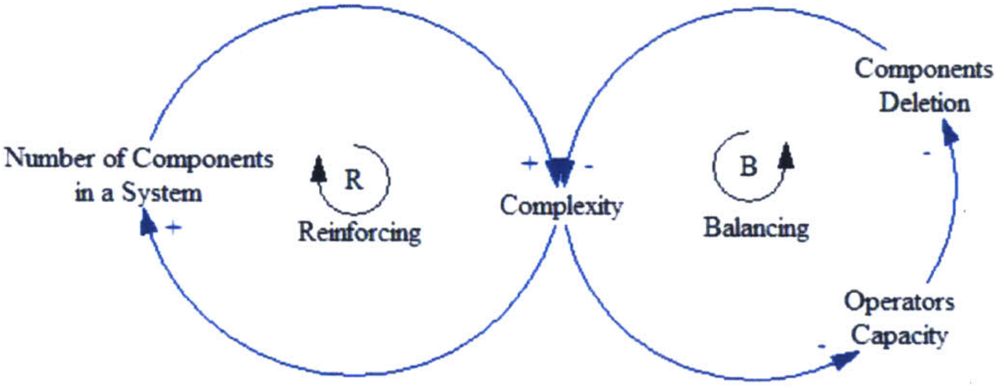


Figure 1. Draft example of key system dynamics methodology elements

2.2 Automotive Product Development dynamics

Within the manufacturing industry, automotive Original Equipment Manufacturers (OEM) source an extensive supply chain to design, develop, test and manufacture original components. These components are then shipped to the final automotive assembly facilities for integration into the final product, automobiles.

The dynamics the automotive industry faces in the development of new automobiles, although interesting, are quite challenging. Considering the focus of this research in the automotive product development department, the following system dynamics causal model will attempt to show some of the dynamics the automotive industry faces in the development of new vehicle products. As illustrated in Figure 2, the dynamics initiate with external *Customer Requirements* (and content desirability) that include vehicle content, optioning and personalization. *Customer Requirements* initialize the need for *New Products*; these then can directly increase the Product Design Complexity. The translation of customer desires into a clear definition of Product Design Complexity dictates how soon a company can launch the product to the market (Time to Market) and how much that launch will cost. Considering competitors' *Time to Market* and *Cost*, a company's *Need for Product Development Management Optimization* increases or decreases creating a direct impact on the company's product development processes. With regard especially to increases, O*EM Capabilities, Communication Frameworks* (that enable *Rework Reductions* and shorter *Testing Times*) are impacted.

These actions, *Rework Reductions* and shorter *Testing Times*, optimize processes to deliver a *Robust Design Integration* that reduces the *Time to Market* and increases the *Profit Margin* by avoiding *Campaign Expenses*. In a way that contributes much, a shorter *Time to Market* is reflected in *Sales* increases which enhance the *Profit Margin*; an increased *Profit Margin* can enable further *Investments in Technology* which find their way to *Technology Availability* which then ignites *Content Desirability*

(/Customer Requirements) and *Market Changes* overall. These dynamics are enclosed in two main loops: A Complexity Impact reinforcement loop and a Design Optimization balancing loop.

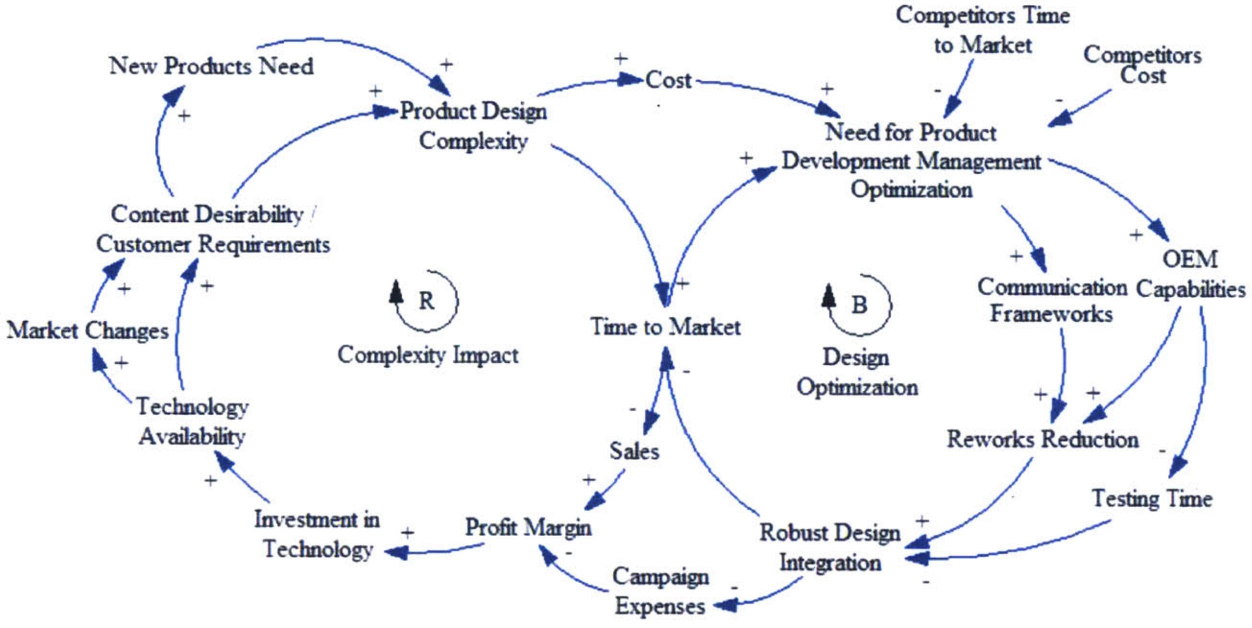


Figure 2. Dynamics in the Automotive Industry

2.3 Enablers for success: the Product Development Process

Inferred from the automotive model above, the success of one company relative to another lies significantly in its flexibility and ability to launch new products – products that satisfy the requirements of the market as well as fulfilling customer needs and desires – more quickly and efficiently than their competitors. (Though unrelated to the automotive industry, two concrete examples would include: 1) the successful launch of VHS over Beta video players, and 2) the rise of the 3½ disk over the 5¼ floppy disk (Christensen, 1997). Often in spite of their arduous efforts to maintain their pinnacle positions at the top of their respective markets, companies sill struggle and lose market share with the entrance of new competitors.

During the past century, the US manufacturing industry has seen significant peaks of competitors' entry into and exit from the market for products such as the Television, Transistors, Electronic Calculators, Disk Drives, Super computers and Automobiles (Utterback, 1996). From this market entry and exit dynamic, it is interesting to observe how some companies have remained in a positive position if not at the top, for over a century. Looking at examples from different industries, companies like GE, Clorox, 3M, and P&G have remained successful in the market thanks to their capability to innovate, process and launch new dominant product designs that excite customers as they express new requirements (Chesbrough, 2012; 3M, 2012; Brown & Anthony, 2011). Also, beyond just meeting customer expectations, these large corporations continue to invest in technological developments resulting in innovative products that surprise and exceed customer expectations.

A clear metric that reflects whether or not a product has met or exceeded customer expectations, is sales. However, in order to improve or maintain sales volumes for incremental or disruptive products, organizations need a standardization of processes. Such a standardization aids these organizations in continuing to transform customer wants and organizational investments. In addition, this standardization process makes it much easier for organizations to classify, rate and compare varying projects with similar metrics; facilitating the targeting of cost, timing and scope; the planning of human resources and manufacturing facilities, and in general, any process requiring decision-making.

Within the company internally, a clear and standard development process helps the product development team to clearly identify the steps required to achieve the project goals, goals that include the timing to develop the product and the deliverables to be delivered throughout that timing to launch. Also, it is beneficial to draft a clear distribution of responsibilities so that everyone in the organization (the company or the team) understands the boundaries of their individual responsibilities and personal accountability. Establishing a standard distribution of team *Roles and Responsibilities (R&R)* optimizes the time necessary to launch a product, given that every time team members are assigned to new projects, they can focus on understanding the requirements of the given deliverable and push to meet those requirements in the most efficient and timely manner, rather than losing any time trying to understand their roles and responsibilities for each new product launch. A clear understanding of R&R further demands comprehension of the exact inputs required of each team member as well as the specific processes required to transform those inputs into final deliverables.

The standardization and beneficial aspects of having clear R&Rs mentioned above, together with some other elements to be described in this chapter are encompassed in what is called and recognized as the *Product Development Process (PDP)*.

2.4 Phases in the Product Development Process (PDP)

Not only will differences between service and product development industries be identified so too will be the differences in the PDP instituted by each company, specifically in the partitioning of phases required to accommodate the tracking, design and development of the peculiarities of each product. Eppinger and Ulrich (2012) have divided the PDP into six generic phases that can be adjusted as required to different industries including key activities performed by functional groups (Figure 3).

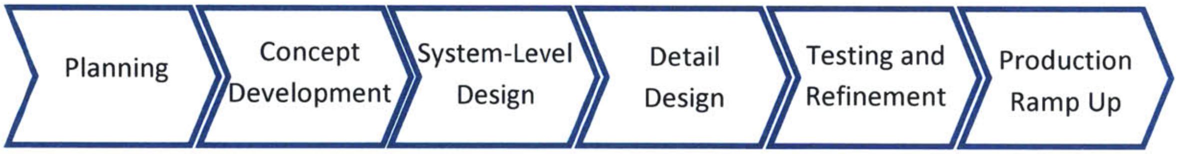


Figure 3. The Product Development Process (PDP) phases

In the automotive industry, the product development process provides OEMs with a standard management for the design and development of new vehicles. As of an example, the Global Product Development System (GPDS) is the standard stage-gate process Ford Motor Company utilizes for planning, tracking and managing the launch of new products. It holds different stage levels including financial and design integration milestones, and it adapts to life cycle variability depending on the change scalability program management and marketing assigns to every project. The average life cycle of a new project development in the automotive industry from inception to launch ranges from 3 to 4.5 years. However, and as previously emphasized, the optimization of timing to launch is critical to OEMs and is arduously pursued so that they may retain their competitive positions within the market.

For the purpose of this analysis, in order to breakdown the GPDS into relevant phases (while at the same time maintaining confidential protected information), a sample of Eppinger's and Ulrich's generic PDP phases will be mapped. This mapping of some key corporate milestones (Figure 4) will be followed by a descriptive overview of each phase.

Figure 4. Automotive PDP phases.

Planning

During this initial phase, market requirements and the availability of technology availability are assessed. These are assessed with respect to current production models in order to make decisions about whether the existing production of vehicle models satisfies present and future customer wants and desires. The findings of such assessments may very well result in extensions, mid-cycle modifications, replacement or even elimination of current vehicle models. Marketing assessments that result in modifications to current models or the development of brand new models.

Concept Development

Following the initial planning of a new project, marketing defines the scalability coding that will allow program managers to establish the appropriate amount of new resources necessary, depending on system level changes, to support the project. At the same time, design studio teams create complete vehicle sketch concepts and 1:1 (scale) clay models are built; customer clinics and management reviews are held to obtain feedback on design concept; and finally, program content, optioning, target market, production volume target, and time to launch are released internally. Benchmarking analysis continue to be developed, and between engineering and marketing attribute targets such as cost and weight are decided upon. Return on Investment (ROI) analysis are performed followed by the definition of the vehicle electrical architecture together with the overall partitioning of subsystems. Utilizing this information, subsystem design concepts are developed to enable the bringing on board of manufacturing suppliers. Stamping and manufacturing strategies are defined and modifications to the generic prototyping and production build plans are communicated.

System-Level Design

Engineering concepts continue to be developed while warranty information is reviewed for failure mode avoidance. Designs in 3-Dimensional Computer Aid Design (CAD) are developed and continuous modifications take place in order to integrate all systems. Specification requirements are assessed utilizing virtual data; once compliant, designs are frozen to initiate the creation of manufacturing drawings. Electrical connectivity information is added in wiring harness manufacturing drawings and compatibility reviews are run for robustness checks. Once completed, manufacturing drawings are released to suppliers, purchasing orders are set and procurement of parts are reviewed to ensure parts availability in prototyping builds. Critical items to be controlled by manufacturing are identified, also, design for manufacturing concerns requiring support at supplier facilities are solved.

Validation and Testing

Later on, the team focuses on reviewing the validation of components that will support the prototype build of subsystems. This support must include, additionally to complete vehicle prototyping build phases, the report of compliance to functional requirements. Documentation of compliance to manufacturing complexity, cost, weight, and other performance attributes targets are archived. Design iterations are run as needed to meet external regulations, and internal requirements and specifications are adhered to, and accurate tracking of status versus targets is also maintained. Afterwards, deviations required are identified and sign-offs are documented.

Launch

Finally, manufacturing and assembly trials of production parts start. Manufacturing, design and assembly issues from build phases are archived, as well as resolution plans. Designs get adjusted as required with accurate approvals of cost and functional attributes. Owner manuals are signed off. Tracking of production readiness from supplier is maintained and compliance to OEM requirements are ensured. Following, the finance department runs design and manufacturing costs analysis of status vs. target. Lastly, the shipment of parts to dealers initiates and new models are available for selling to the market.

2.5 Iterations in the Automotive PD process

From a systems perspective, although interesting, the planning, concept development, system-level design, validation and testing, and launch of automobiles is also quite complex. Much of this complexity is related to the amount of iterations required in the finalization of a product and the numerous inputs; Marketing, Manufacturing and Product Development departments can modify, changing the scope, cost or schedule of the project at any given time. Marketing, as previously indicated, reacts to the market trends and has authority to call for modification approvals to the project whenever determined to be necessary. Manufacturing, as the key production enabler of a product launch, demands compliance to ergonomic assembly standards that are adjustable to the sociotechnical environment. Finally, Product Development play the key role in assuring that designs are integrated and that they comply with design specifications, validations, and testing requirements. The following System Dynamics causal model (Figure 5) provides a broad overview of three primary OEM departments relative to the key functions they perform in some high-level stages of the product development process.

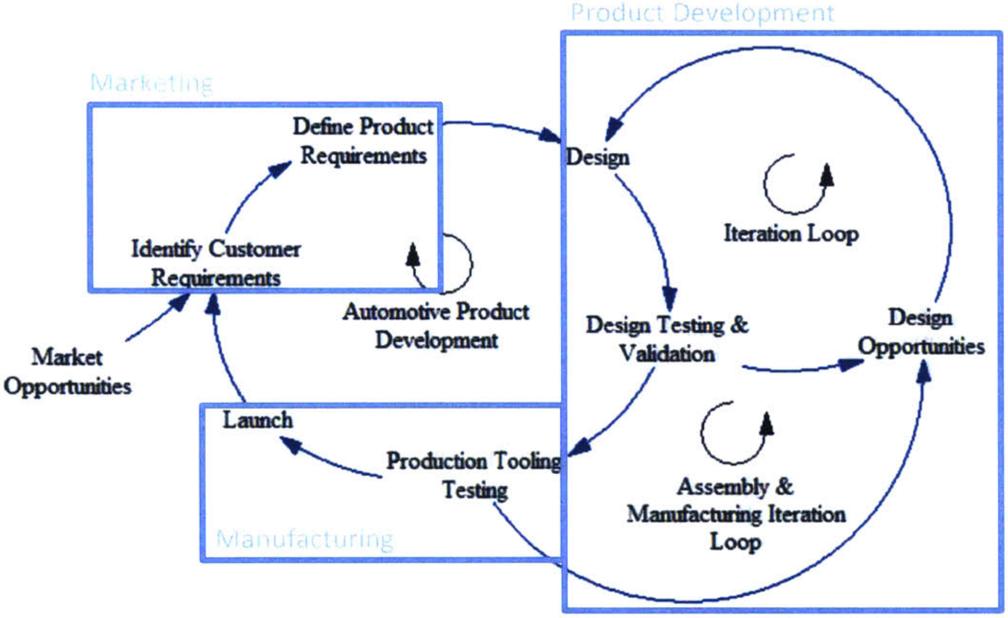


Figure 5. Marketing, Product Development and Manufacturing in PDP stages

As noted above, the actions taken by Marketing, Product Development and Manufacturing departments align with the need of growing companies to attain competitive positions. As might be expected these actions often result in project modifications which in turn affect the scope, cost and schedule of the project to varying levels of severity level. To what degree each of these is affected depends upon just what stage the project is at. The following model (Figure 6) reflects Incremental/Linear and Evolutionary Development (Forsberg, Mooz, & Cotterman, 2005) of requirements and identifies how the increase of such requirements require evolutionary development for final design integration. As previously mentioned, this increase of requirements is very common in the automotive industry at any PDP phase, however when comparing this incremental/Linear and Evolutionary Development Model to the PDP map of phases previously mentioned, it is clear reworks will further affect the PD process and therefore delay deliverables and increase cost.

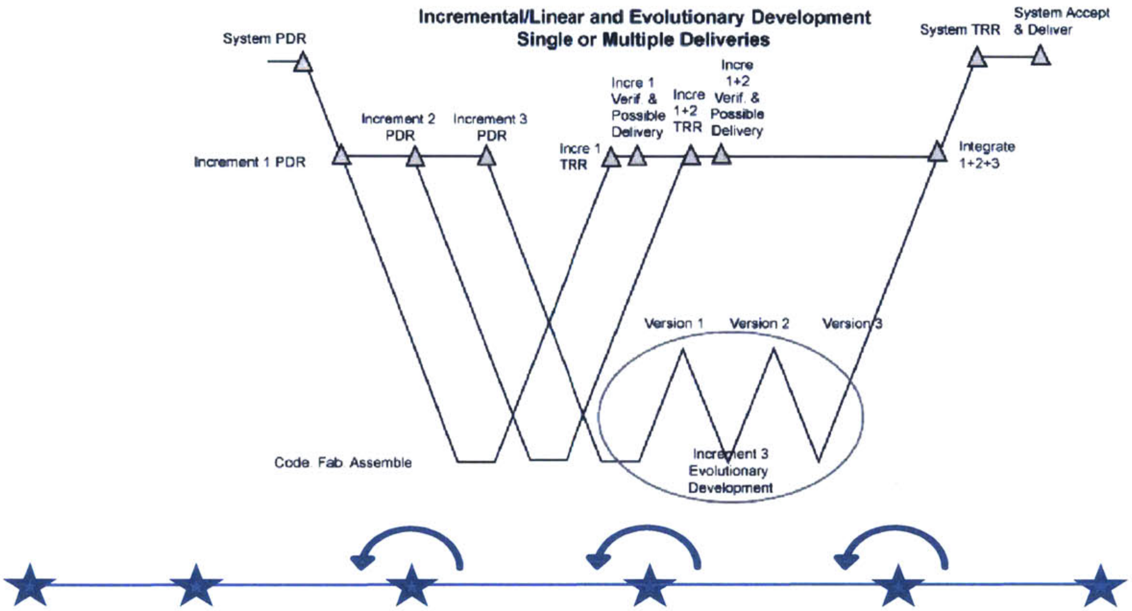


Figure 6. Incremental/Linear and Evolutionary Development and OEM PDP phases

Keeping in mind iterations and reworks have a cost, it is important to remember the further along the project is when design changes are identified and implemented, the more costly they become (Defense Acquisition University, 1993; INCOSE 2011). In the automotive industry it is not unusual to observe a constant trade-off between scope and cost; this trade-off however does not include timing. While keeping in mind that the project schedule is fixed, management in the sample OEM can utilize the management "Iron Triangle" (Figure 7) to determine further opportunities in regard to scope and cost. Often, companies within the automotive industry do not have the flexibility to adjust scope targets given the competitiveness involved in the industry; consequently, additional cost enablers must be established in order for projects to be completed within their defined timing schedules.

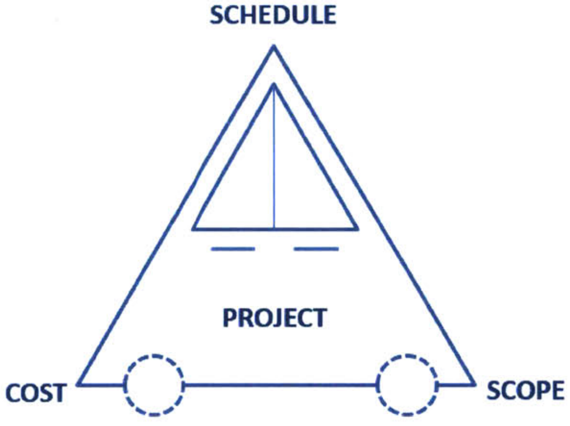


Figure 7. Iron Triangle[1]

---

[1] (Modified from ESD.411_PM_Introduction-2014 Lecture slides)

Within some internal company enablers related to cost we can find the cost of resources. As would be evident, the higher the number of resources allocated to a project, the higher its cost; none the less, it also provides a solution for delivery within the specified time Schedule. Additionally, the decomposition of products in system and subsystem design developments can enable a proper repartition of responsibilities which then result in a more expeditious integration of the final product.

2.6 Partitioning of responsibilities and global teams

The partitioning of systems – also, in automotive practice, called commodities – by functionality is a common practice in OEMs. It would be fair to say that this partitioning is aligned with a cost strategy, given that the more teams focused on single task, the greater the expertise and the fewer errors, thereby producing cost savings. In order to illustrate the partitioning of automobile commodities by the processes and functionality they perform, an Object-Process Diagram (OPD) is presented below in Figure 8. The OPD diagrams are part of the Object-Process Methodology (OPM) framework for modeling systems in a form and function decomposition, where objects and processes are treated as equally important (Dori 2002; Soderborg, Crawley & Dori 2003). In the OPM, Object is considered as a thing that exists or might exist physically or in the form of information; it is visually represented by a rectangle or a square. Process is then considered as a thing that transforms one or more objects; it is visually represented by ovals and circles. The connection symbols (e.g. arrows) between objects and processes represent the linkage between them, and the variance of symbols is then utilized in the definition of influencing, transformation, consumption, etc., between these two elements.

In the OPM Process-Operand diagram of automobile commodities' functionality provided below, a list of level 2 objects (or operands) – considering a structural decomposition where level 1 is an automobile system – are shown at the right for reference to the objects utilized in the development of each functionality process. In the middle, examples of processes required in the development and operation of a final vehicle are listed in a column-fashion position to signify whether a given process requires Aerodynamics, Mechanical, Electrical, or multiple functionalities. At the right, a list of level 1 objects – again, considering a structural decomposition – is also provided along with its classification in the automobile commodities previously mentioned and enlisted in: Powertrain, Chassis, Body, and Electrical.

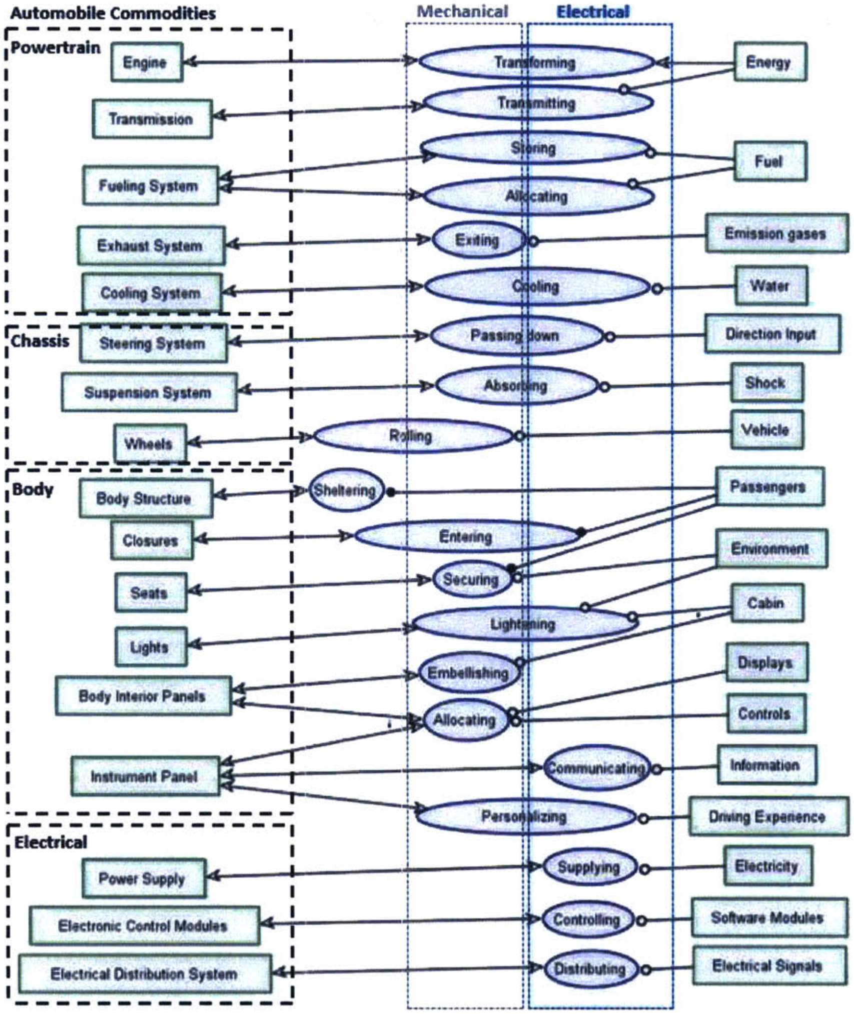


Figure 8. OPM Process-Operand diagram of automobile commodities' functionality.

As evidenced, due to the fact that it is responsible for providing electrical signals to all the systems and sub-systems having electrical functionalities, the Electrical Distribution System (EDS) is one of the systems that interacts more highly with other systems.

2.7 Complexity management

It is clear that the managing of complexity is highly relevant to the Electrical Distribution System (EDS). From its earliest models, when automobiles became available to the population at large, to the present, the number of features a vehicle offers has always been a drawing factor for the customer. These features have continually evolved—features such as safety, security, performance, and even now, entertainment, etc. With each added feature comes the need for added electrical connectivity. Affecting to an even greater degree the complexity of electrical content in vehicles, present and forthcoming sustainability and automatization challenges will further add performance and usability requirements.

The complexity of vehicles is made up of two main elements: 1) the application of science for the development of new materials and technology; and 2) as just mentioned, the integration management of features to be included in a design. This analysis will focus on providing solutions to manage the complexity embedded in the second element—that is, the complexity embedded in the integration of a large number of features in complex vehicles.

In regard to flexibility, Rich Morris, Vice-president for BMW Manufacturing Co, has defined flexibility as "the ability to make any model, in any plant, anywhere in the world to meet the shifting demand in any global market" (BMW group). This definition set high standards for the operational plans of OEMs, including product development departments, enforcing an expeditious delivery process to both internal and external customers. In the meantime while full flexibility is being achieved by OEMs, the appropriate optioning of features will facilitate the obtaining of flexibility improvements through the maintenance of a manageable level of complexity for design and development teams.

In order to continue to gain a more meaningful understanding about this management of complexity in the arena of product development, it is important to review the PD processes and their main elements. The International Council on Systems Engineering (INCOSE)'s Context Diagram for Process (INCOSE, 2011), identifies key factors involved in the design and development of products, and are perfectly applicable to the design and development of EDS components as well. This process includes:

- Inputs such as data and material
- Controls like directives and constrains
- Activities including processes (per INCOSE, "A process is an integrated set of activities that transforms inputs into desired outputs" (INCOSE, 2011)).
- Enablers such as resources which include infrastructure, workforce, tools and technologies
- Outputs that can be processed data, products or services.

Chapter 3 will detail each of the elements involved in the process of designing EDS components:
1) A review of the requirements identified as inputs to the design and development activities; 2) the limitations and approvals required as part of the controls in such a process; 3) the outputs delivered by the EDS department; and 4) the toolset enablers that facilitate this process.

Chapter 3. The Electrical Distribution System (EDS) Department

As mentioned in Chapter 2, the Electrical Distribution System (EDS) is responsible for providing electrical signals to all the systems and sub-systems with electrical functionalities. Because of this, it is highly complex, given its direct and indirect interaction with components from all different subsystems of the vehicle. For this reason, and acknowledging other product development areas are also potentially important for study, the forthcoming analysis will focus on the EDS department.

3.1 The Electrical Distribution System

The Electrical Distribution System (EDS) is formed by wiring harnesses that connect power supply and ground signals to all the different components requiring electrical connectivity. Figure 9 shows key inputs, activities, controls, and enablers that the EDS department follows in the transformation of product requirements into physical parts delivered to OEM plants for final assembly of the vehicle. In summation, the EDS team is responsible for designing, releasing, and supervising the manufacturing and assembling of wiring harnesses that provide electrical connectivity to vehicular components, while, at the same time, assuring a robust routing and protection of wires to meet the life cycle requirements of each product.

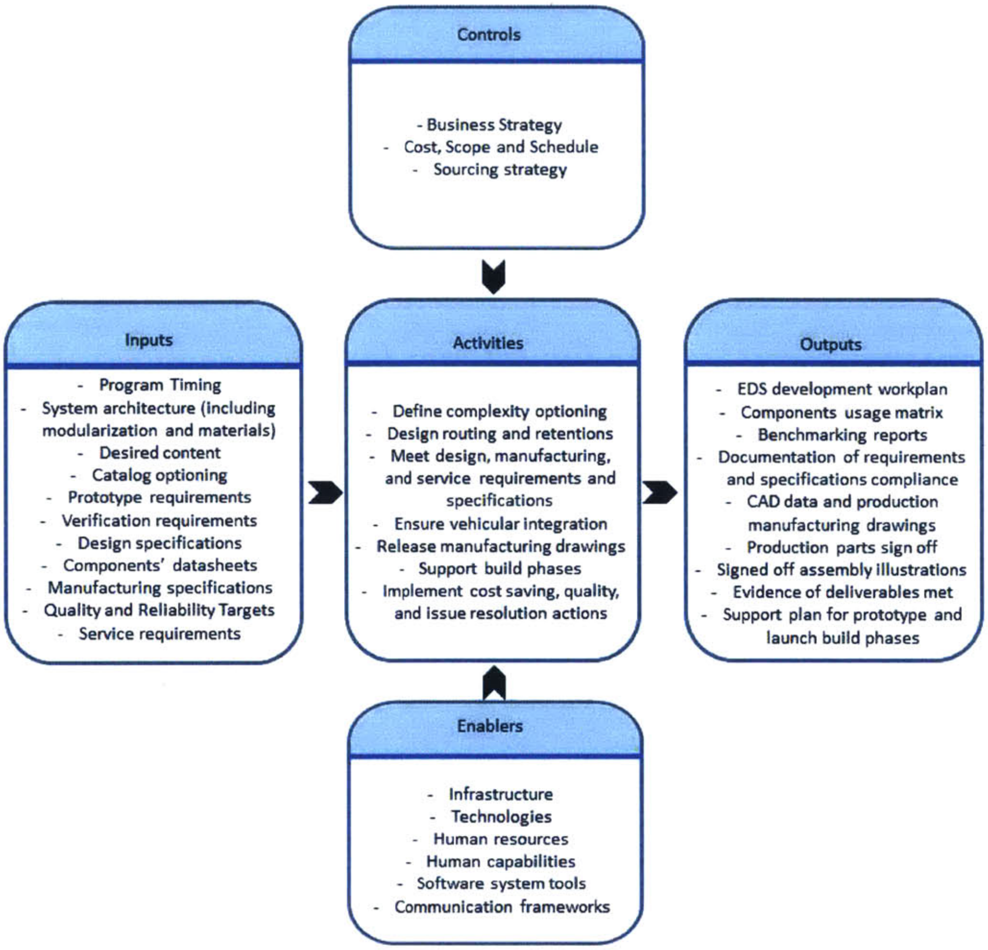


Figure 9. EDS Process Diagram (adapted from INCOSE's Context Diagram for Process)

The activities an EDS team performs for every product design, development, and launch are enclosed in the forgoing diagram; however, it must be noted that the way in which every process activity takes place can vary from one OEM to another. Furthermore, the activity processes presented in Figure 9 may contain additional levels of decomposition that are not represented (due to limited space in the diagram). As a case in point: the activity of meeting design requirements and specifications encompasses multiple steps such as those of reviewing the historical data in specification compliance from the OEM and competitors, identifying root causes for historical issues, filling-out robustness documents, performing several checks on design requirements and rules compliance, identifying design deviations, and approving mitigation plans.

Another example (of process detail not included in the diagram) is found in ensuring vehicular integration, which can be achieved through physical builds, but which also requires several virtual design checks to capture interferences, modify designs, and ensure integration feasibility. For this process step, it must be disclosed that EDS teams are not responsible for the integration of the entire interfacing commodities; other system(s) departments – Power-Train, Chassis, and Body – collaborate to make the routing of wiring harnesses feasible. Still, given the fact that it is of interest to the EDS team to integrate and solve incompatibilities, this team frequently becomes the lead for incompatibility resolution activities.

A third example (of process detail not included in the diagram) is that of the testing of production tooling; this testing requires engineers to support build phases. In order to support build phases, EDS engineers need to determine which wiring harnesses must first be manufactured according to and up to the manufacturing specifications delineated by the OEM. This mandatory step (ensuring parts are built up to mandated specifications), necessitates that the EDS team works out the resolution of Design For Manufacturing (DFM) items discovered during the suppliers' manufacturing process. Such resolution then entails that the EDS team visits the manufacturing site to sign-off on the manufacturing processes, once having ensured that the physical parts compare exactly to the drawings for (their) manufacturing, and therefore, that they met the sample OEM manufacturing requirements. At the same time, the EDS team needs to work closely with purchasing to ensure purchase orders are sent out to the suppliers and parts are subsequently manufactured in a timely fashion. Finally, the EDS engineers must follow-up with procurement and logistics departments of both the OEM and suppliers to ensure parts are shipped and arrive at the assembly plants for the build phase kick-off.

In more expanded detail (from the Process Diagram previously shown), the list of activities performed by the EDS team includes:

- EDS processes vehicle specifications, content optioning plan and electrical component datasheets (DT) into electrical connectivity schematics.
- EDS team defines the partitioning of the EDS wiring harnesses for manufacturing and assembly feasibility ensuring OEM global strategies for modularization and assembly are met.

- EDS designs the routing of wiring harnesses and requests retentions to make routing robust and feasible. Interfacing systems (like power-train, chassis and body) departments collaborate with EDS to make this routing of wiring harnesses feasible.
- EDS systems, along with other systems' engineers run computerized analyses to ensure conductivity requirements are met by the design.
- EDS CAD designers run further computerized checks to confirm the geometric integration of all subsystems and identifies ergonomic assembly issues.
- EDS documents evidence of compliance to design, manufacturing, and service specifications and requirements.
- EDS then freezes designs up to production intent and 2D drawings are created to be sent to manufacturing suppliers.
- Suppliers test wiring harnesses for connectivity (checks). Once delivered to OEMs, these are tested at a subsystem level with all the electrical components in a breadboard. Later, EDS supports the resolution of issues when wiring harnesses are assembled and tested in prototype vehicles.
- EDS updates wiring harnesses designs to meet production intent specifications based on outputs from assembly trials and testing.
- EDS supports the launch events and final production of vehicles prior to production and tooling testing sign-off.
- Finally, EDS hands over commodity ownership to the Ongoing Product Development (OPD) team.

In order to proceed with a discussion about EDS processes and understand the nature of the system discussed, the system boundary of EDS must be defined. That definition (Figure 10) includes its possible partitioning into internal wiring harness boundaries; although this partitioning of EDS wiring harnesses varies across OEMs, it is commonly utilized for similar reasons: to facilitate the assembly of parts in the vehicle; to reduce the cost of repairs or replacements when required; and to assist in managing the complexity of features. Furthermore, within the automobile boundary, the remaining Electrical Components, though they do not form part of the EDS boundary, directly interface with the Wiring Harnesses, as well as other primary commodities – Body, Chassis and Power-Train. Additionally, Tooling, People, and Environment interact physically and intermittently with the automobile and its components during its overall lifecycle, from its manufacturing and assembly to its maintenance; it can therefore be said, that these external elements interacts with the entirety of the automobile system boundary.

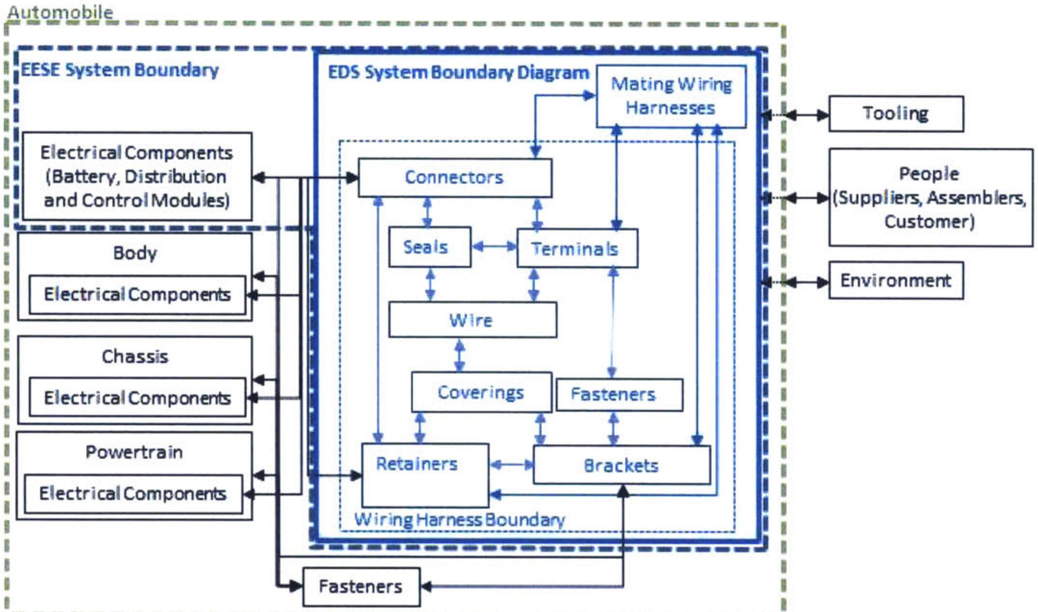


Figure 10. Electrical Distribution System (EDS) Boundary

As can be observed from Figure 10 above, the Electrical Distribution System (EDS) is considered part of the Electrical and Electronics Systems Engineering (EESE) department. As well, Figure 10 illustrates that the wiring harness boundary consists of: 1) the assembly of all wires that carry and distribute electricity; 2) the interface of terminals, seals and connectors, that together ensure a proper connection interface from wire to wire or from wire to component devices; 3) coverings that bundle wiring branches that include more than one wire (providing protection for them); and 4) fasteners and retainers that secure the entire assembly of all components to other commodity components and brackets. Note that the fasteners and retainers of #4 provide retention to wiring harnesses whenever retention from other commodity components is not feasible.

The boundary of the tangible automobile itself is thus isolated from other "automobile factors"—from the tooling utilized to assemble all vehicular components; from the people that come in physical contact with the automobile during its lifecycle; and from the environments in which the automobile is placed throughout its lifecycle.

3.2 Stakeholder interaction analysis

As briefly described in Chapter 2, the formation of individual product development teams correlates to the functional boundaries of systems. In contrast to how teams are designated at the product development level (according to commodity departments), EDS teams themselves are formed differently. Figure 9 displays that all commodities have electrical components that directly interface with the EDS and that those components – components of the Body, Chassis and Power-Train commodities – physically interface with the EDS components themselves. All components inside the EDS boundary diagram form part of single wiring harnesses; therefore, the design and development of individual wiring harnesses is managed by specific employees who are responsible for the internal integration of EDS components, failure mode avoidance, and cross functional requirements compliance.

Furthermore, the sample OEM holds roles for component Subject Matter Experts (SME) who seek out the most advanced technologies and materials applicable to the industry. These experts (SMEs) also facilitate the release of new components within the OEM system, support design reviews, and provide their input for decisions requiring SME judgment.

The design and development of EDS components is quite extensive and complex; consequently, the partitioning of responsibilities requires assistance from internal resources in order to contain workload, meet, and at times, exceed the deliverables requested. The following EDS Team Interaction Mapping (Figure 11) "maps" the partitioning the sample OEM holds for EDS Teams: 1) EDS Engineers are responsible for designing and releasing the overall design deliverables as well as for compiling the evidence documentation of compliance to fit and functional requirements; 2) EDS Systems' Engineers are responsible for defining the wiring specifications that meet the electrical component requirements and ensuring the compatibility of wiring harnesses designs; and 3) EDS CAD designers are responsible for creating and releasing 3D CAD models and 2D manufacturing drawings. At the same time, Figure 11 shows some of the key interactions between internal PD teams and other OEM departmental teams.

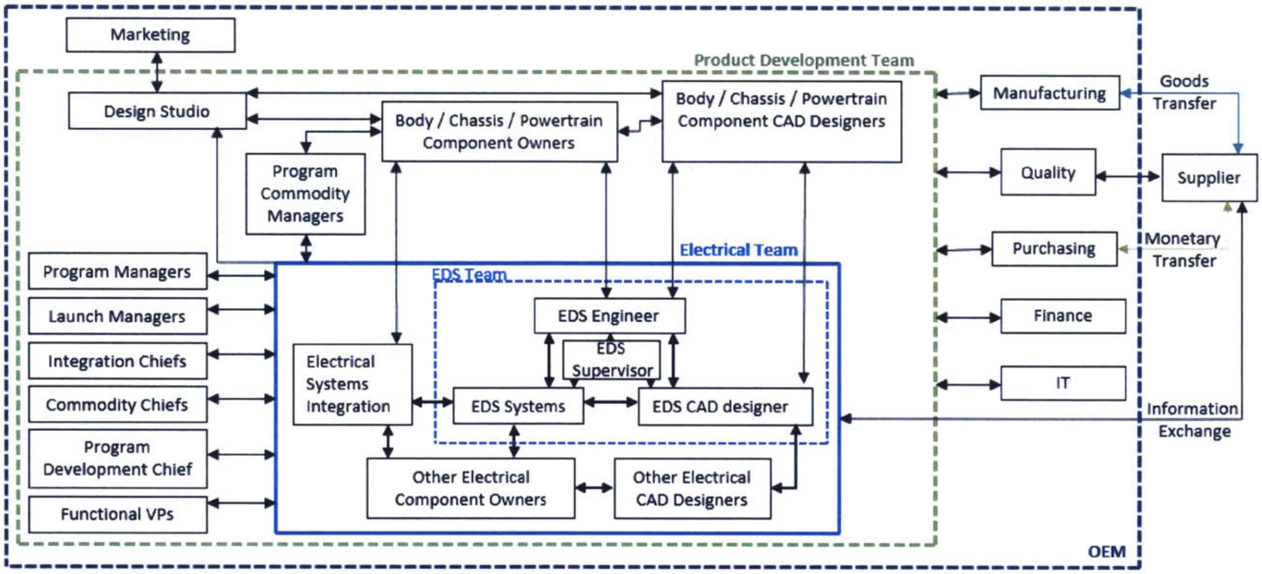


Figure 11. Electrical Distribution System (EDS) Interaction Mapping[2]

As evidenced, the EDS team holds direct interactions with other product development stakeholders: Body, Chassis and Power-Train commodity owners/designers, design studio engineers, and program management entities such as program commodity managers, launch managers, integration chiefs,

---

[2] Interactions between two stakeholders denote sole interaction between those two stakeholders; interactions between a stakeholder and a team boundary denote interactions from that specific stakeholder to any stakeholder included in the team boundary.

commodity chiefs, PD chiefs and functional VPs. All of them, in turn, hold interactions with non-product development entities such as marketing, manufacturing, quality, purchasing, finance and information technology departments.

Given that information is the key element required in the elaboration of the PDP process, the establishment of whether or not an internal entity has had an interaction with the EDS team is based on the interaction of information among stakeholders: information regarding general requirements, design specifications, design rules, design compliance relative to regulations, project status, design status, integration status, and so forth. Beyond informational exchange, the interface with the supplier, an external stakeholder that continuously interact with the EDS team, also includes monetary and goods' transfers, which are usually directly handled with the supplier by the Purchasing department, or the Manufacturing department respectively.

For the clarity of the EDS Team Interaction Mapping, as well as the confidentiality embedded in the roles and responsibilities of the sample OEM, specific requirements from one stakeholder to another were not detailed in Figure 11. However, it is clear that all interfaces occur for one sole purpose – to deliver the required outputs in a manner that is exactly aligned with the design and development of EDS components. Several of these outputs were previously included in Figure 9:

- EDS development work plan
- Components usage matrix
- Benchmarking reports
- Documentation of requirements and specifications compliance
- CAD data and production manufacturing drawings
- Production parts sign-off
- Signed off assembly illustrations
- Evidence of deliverables met
- Support plan for prototype and launch build phases
- Etcetera.

3.3 The EDS requirements

Of course the development of such complex product cannot be limited to a list of 9 outcomes/deliverables, indeed ensuring all the ilities demanded from the automotive industry, or even the top three classical ilities of engineering: safety, quality, and reliability (De Weck, Ross and Rhodes 2012), might require a much more extensive and detailed list of deliverables from each product development department, including the EESE EDS. Inside the sample OEM, requirements from the EDS team have been clearly defined in a list of 92 requirements with detailed inputs/outputs, and classified in 7 main areas as follows (Sample OEM Proprietary document – EDS eSOW) [3]:

---

[3] The list of EDS requirements from the sample OEM was reviewed and consolidated from a list of 275 observations, from which only 125 had specific, detailed inputs and outputs. Furthermore, the list was updated to remove the identification of tools and specific files already elaborated, and were replaced with the functional

1. Program Management: 17 requirement items
2. Market Research: 1 requirement item
3. Design and Engineering : 33 requirement items
4. Manufacturing: 17 requirement items
5. Testing: 13 requirement items
6. Build phases support: 6 requirement items
7. Ongoing Product Development (OPD): 5 requirement items

From this list, it is clear that that which is required of Design and Engineering is the greatest; Manufacturing possesses the second largest portion along with Program Management; Testing follows with 13 requirements; and finally, the remaining areas are relatively minimal in comparison with a 14% of total requirements.

Necessary to keep in mind is that classification of these requirements does not translate to a direct relationship of effects between them and the ilities mentioned. Nevertheless, it is the intention of the author to bring them to light as, at the end of the day, compliance to these requirements results in an extremely effectual impact on system lifecycle properties, and this impact impacts the success of not only the department but also the entire company. The detail of correlation between ilities and requirements in the automotive industry is key to understanding the focus OEMs must place on their PDP deliverables. However, in addition to the difficulty of the task—given the huge amount of potential externalities embedded in the environment that effect customer wants—difficulty also lies in trying to render accurate forecasting approaches, forecasting approaches that continuously evolve from day to day. It is though, absolutely essential that OEMs place great interest on Big-Data analysis in order to make effectual attempts at comprehending the relationship between sales success and product deliveries, among others. (The Hansen Report 2014).

Placing aside a more in-depth analysis of the effect of the requirement(s') compliance for the final market sales metrics, the focus (of this present word) returns to the analysis of this (present) research in which the author attempts to begin measuring the efficiency of the process that enables the fulfilling of requirements delineated by the OEM. Having presented the generic classification of requirements and those that drive a large number of requirements, it must be noted that, in keeping with corporate mandates and policies, 40% of the requirements require approval from various stakeholder authorities. This leads to making the other 60% of requirements a sole responsibility of the EDS team to review, manage, and approve the deliverables that fulfill this portion of requirements. Nevertheless, it can be the case that 60% of these last requirements are actually required as inputs for the requirements that

---

requirement intent those tools previously identified. Additionally, in order to maintain focus on sole PD EDS deliverables the list of requirements from the Facilities and Personnel area were not considered as part of the requirements embedded in the Product Development activities. Also kept aside were those requirements of the HR and facilities enablers.

need corporate approval. Intriguing is that the EDS has more than 50% autonomy in the approval control process of PD EDS components.

3.4 The role of the authority chairs

Referring back to the intention of the PDP in the automotive industry to be linear – with few exceptions during prototyping – it is important to remark, as well, that linear PDPs require approvals by each stage-gate. These approvals enforce the review of deliverables according to project phases and enable the escalation of roadblocks if necessary, aid in the identification of lessons learned, and determine whether or not teams have achieved targets, so that approvals can be granted. Stage deliverables vary from phase-to-phase and from OEM to OEM; metrics utilized to assess each stage generally include: 1) incurred costs; 2) forecasted expenses and budget status; 3) readiness, availability and integration of design; and 4) definition and implementation of the manufacturing strategy.

Additionally, many day-to-day approvals must take place in order to complete stage deliverables, and it is imperative to identify the control structure the EDS team employs in order to later understand some of the key opportunities embedded in the approval process. (These will be covered in Chapter 4 during the analysis of toolsets utilized in the reporting and approval processes). The following EDS Hierarchical Control Structure Sample (Figure 12) illustrates a sampling of these control structures. Hierarchy of organizational control is diagrammed in a top-down fashion – the higher the placement in the structure, the greater the control/authority held by those in that organizational position

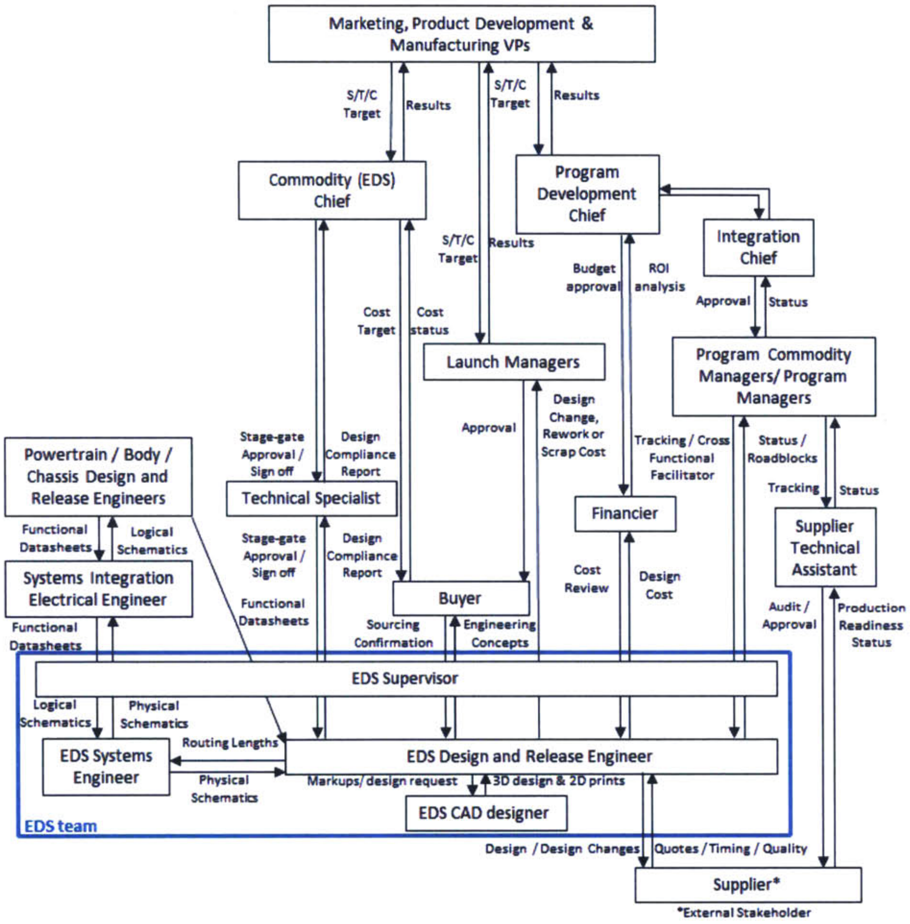


Figure 12. EDS Hierarchical Control Structure Sample

Figure 12 depicts only a sample of various stakeholders control elements relative to their interaction with the EDS team. It additionally depicts a basic control from the EDS team to the supplier, an external stakeholder. Keeping in mind the previous control structure, and considering all requirement deliverables require EDS audit and approval before corporate approval, an analysis of EDS requirements is thought provoking—66% of the requirements are sole deliverables requiring EDS upper management approval, the other 16% of controls are shared with the program commodity managers, and finally, the remaining 17% of requirements require creation, auditing or tracking of EDS in spite of the fact that the final approver withholds a title outside the EDS organization (Figure 13).

Department to be submitted for approval	Percentage
EDS team, EDS Technical Specialist, EDS Chief	66.3%
Program Commodity Managers	16.3%
Supplier Technical Assistant	6.5%
Program Managers	5.4%
Buyers / Financier	3.3%
Manufacturing and Launch Managers	2.2%

Figure 13. Authorizing Stakeholders

Figure 13. Authorizing Stakeholders

The identification of authorizing stakeholders is compelling in that it gives an understanding of how the majority of team work requirements for deliverables are required to meet EDS objectives as assigned by the OEM. This is significant because members of the EDS team quite often are under the impression that most of the work to be done is requisite of a different commodity or a different department, and this naturals leads to complaints/complaining. (authors' impression from Interviews with internal EDS engineers of sample OEM). After this quick-count overview, determining that only 17% of deliverables are approved by stakeholder in another department, beyond EDS prior approval, EDS engineers must possess a great sense of ownership and accountability. Just as a knowledge note, that 17% of deliverables outside the commodity department of EESE, consequently requires tracking, approval, and documentation from a myriad of departments for final integration into the product development.

3.5 Reworks in the EDS PDP process

Furthermore and as previously discussed, the PDP is sensitive to design iterations; consequently, many of the approvals and controls exerted by different authorities occur more than once throughout the program. Additionally, these approvals might occur more than once considering the complexity embedded in the design iterations driven by the integration of different components that integrate EDS commodity parts. Of course, a product development utopia in the EDS department would approximate the ability to perform the list of activities mentioned in the forgoing EDS PDP process and hold the interfacing interactions with the rest of the functional teams inside and outside the product development department without major problem. As well, such a utopia would provide response, feedback and status to every authority responsible for controlling specific processes or stages and would do this in a prompt manner, regardless of the product complexity level.

Underscoring the definition of a product development "utopia" in the EDS department, that utopia begins with the assignment and understanding of responsibilities, permitting all parties involved to be proactively accountable for the completion of every deliverable. Once a project initiates and the team is gathered, roles and responsibilities must be clearly stated for each engineer. This also applies for any additions or replacements to the engineering team. Based on my experience, while working in a product launch oriented environment, it is extremely beneficial to have constant guidance regarding the deliverables required throughout the project schedule, and to maintain automated tracking of one's status against the plan; this enables the team to be focused on upcoming deliveries and reduces time wasted during present stages.

Once deliverables are clearly delineated, revision and approvals required for each phase are set, and then all deliverables required for such approval can be prepared in timely manner. As previously mentioned in chapter 2, the EDS development in the automotive industry is susceptible to multiple requirement increases or modifications by Marketing, Manufacturing and Product Development. Thus, the performance assessment regarding the evaluation of how healthy a project made it to the approved phase can vary.

In addition to design and integration iterations, reworks and late deliverables are principle detriments to PD management and in spite of their efforts to solve the continuous appearance of root causes across the PD projects, they still continue to arise. In order to facilitate the assessment and optimization of any project, it is imperative to differentiate reworks from iterations, such that on the one hand, personnel can be evaluated based on their performance relative to objectives, and on the other hand, project management can evaluate the impact of allowing late changes to the project. Focusing on personnel performance, and strictly discussing the portion of reworks, the reader must keep in mind that reworks often are not strictly related to personal performance errors; rather, reworks in performing activities can occur as a result of human errors that are not contained by automated standard design checks (e.g. the duplication of completing manual checklists). Additionally, the need for reworks may also be due to a lack of integral communication (e.g. duplicating inputs to disconnected software systems) and bureaucracy (e.g. duplicating reports, approvals and archiving). Unfortunately, these scenarios are often recognized as required iterations rather than reworks – reworks that can be significantly reduced, if not completely eliminated. Engineering best practices should then include the continuous optimization of processes such as those that provide for more rapid and efficient performance of the employee.

It must be clarified that reworks can result from any PDP phase; however, depending on the stage of the program, the impact on the previous deliverables varies. The Vee Model illustrates the verification and validation plan utilized in the development of manufactured products (INCOSE 2012), including vehicles. The Vee Model is broadly utilized in the automotive industry and the sample OEM. The model in Figure 14 below has been adapted from an ESD.411 Systems Engineering Lecture slide (Hommes Q. V., 2014) to enable the identification of some of the reworks mentioned above. Although it does not reflect the detail of requirements the sample OEM demands of its PDP, it provides for improved understanding of the fact that every step in the development of the product (Left side of the Vee Model) is susceptible to reworks, which generate a greater impact on the validation and verification steps of the PDP (Right side of the Vee Model).

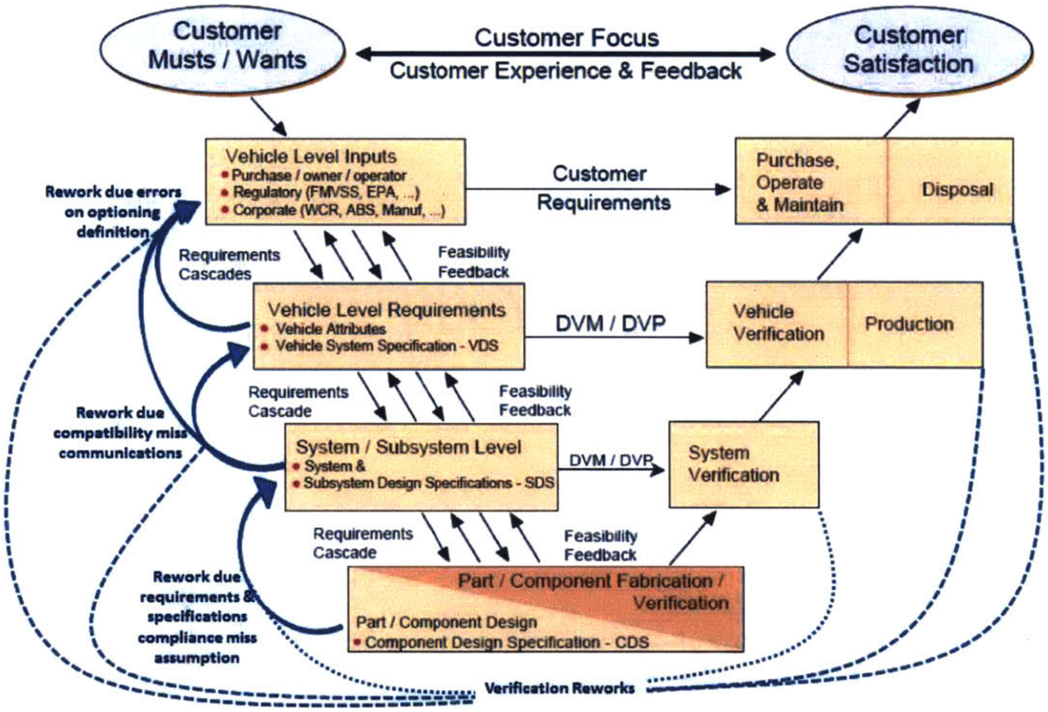


Figure 14. Sampling of EDS reworks in the Vee Model[4]

The above model does not include all the EDS requested performance activities and re-dos; however it provides for a better understanding of how reworks affect activities performed during previous stages of the verification PDP. Since iterations and reworks can take place at different points during the processes performed in the development of PDP, it is necessary to review the enablers that allow for faster iterations and faster solutions to reworks as well as to analyze how efficient these enablers are to the product development EDS team.

From the enablers described in the EDS Process Diagram (Figure 9), all of its elements play a role into how the PDP is performed. For example, appropriate human resources provide for the positive tracking and completion of design activities, which include those catalogued as design robustness checks. Human capabilities and personnel's level of experience can improve error avoidance rates, and increase PD departments' ability to forecast future roadblocks. Communication frameworks can help clarify what processes indeed require iterations, which ones create communicational reworks, and how teams can come together to collaborate for more expeditious integrations of designs. Finally, many of these enablers, require solid software tools that provide for simplification and clarification of their purpose for existence while avoiding replications; however, as already mentioned, duplication in the compliance of requirements during development of EDS components has often been discerned in a number of different projects. The analysis of how toolsets might be prioritized, relative to their usability rates and impact on delivery results, can define the way EDS design and development are carried out; this coupled with the analysis of duplication in the fulfillment of requirements through the replicated usage of tools will be the subject of analysis in Chapter 4.

---

[4] (Adapted from ESD.411 Systems Engineering Lecture 3)

Chapter 4.EDS Tools Analysis

In a seemingly reciprocal way, tools utilized in the process of transforming inputs into outputs modify the process itself while attempting to accommodate the capabilities and limitations of those same tools. In order to begin an analysis of the efficiency of the processes established in the sample OEM and the toolsets that enable such processes, the internal activities performed versus the tools utilized to perform those processes must be first mapped. The PDP overview presented in chapter 2 provided an understanding of all the activities to be performed during the development of a new product, or during the mid-cycle modifications of an existing one. Later, chapter 3 detailed the activities involved in the development of EDS components. Taking into consideration this initial overview of activities, this analysis will now be expanded with a more intent look at the interaction and exchange of information between systems and subsystems which will provide a deeper understanding of how requirements are fulfilled by different software tools.

4.1 Processes and tools

"Tools without processes are nothing, processes without tools are not good enough." (Ebert 2013)

The EDS PDP, from concept definition to final production of new products, is a challenging process that as previously mentioned requires inputs from different cross-functional departments, as well as the integration of stakeholder requirements, not to mention, strict control in the approval of phase-stages. Without a particular focus on the automotive industry, some authors have recognized similar challenges – such as those of setting, integrating, and tracking the requirements of customers, organizations, and design itself – faced by all product industries, contributing significantly to the defining of a strategy of information system management that facilitates the management of product related data throughout its lifecycle, Product Lifecycle Management (PLM) (Stark 2004; Grieves 2006; Saaksvuori and Immonen 2008).

The sample OEM recognizes Engineering Data Management (EDM), Product Data Management (PDM), and recently much more – Product Lifecycle Management (PLM) systems. PLM systems are quite useful to OEM product design and development traceability. During recent decades, they have assigned the Information Technology (IT) department the responsibility of providing software tools that facilitate the PDP for new and exciting products. Together with the PD department of Digital Innovation (DI), IT has developed a variety of strategies that bring the OEM closer to achieving this objective. However, as with any corporate entrepreneurship initiative, the development, integration and implementation of new software systems requires the support and full engagement of top management in order for any initiative to be successful and function in parallel to core business operations (Morris, Kuratko and Covin 2010). Despite this challenge, a couple of initiatives are already ongoing to identify opportunities for improvement in the design and development of tools utilized in the overall PDP. One initiative includes the integration of assorted software platforms into Siemens Teamcenter® PLM tool.

Quite amazing is the visualization of a future PDP in which every decision made can be directly linked to not only its impact on scope, cost, and schedule, but also its impact on market position, best in class ranking, market share and first to market. Reaching a maximum and full optimization of the connectivity and usage of tools that documents and facilitates this decision-making process vision, however, requires extensive investments of both time and the resources necessary to analyze, capture, and evolve in a manner consistent with the changing of requirements of all the involved stakeholders. Of course, due to the fast pace of change in the automotive industry, PD departments must fall in line to facilitate the process of rapidly identifying opportunities for improvement. To succeed, they must also possess other characteristics – namely, a high-level of collaboration to pilot initiatives; full engagement in the utilization of processes; and open flexibility toward continuous improvements.

Why are product development tools created and implemented in the first place? The majority of the time for the most basic, but essential of reasons: to fulfill a need. Many times, though, these needs are isolated; engineering teams do not have prolonged time periods to consider whether these needs apply to global teams or may have relevance to varying PDP stages. Some of the challenges automotive OEMs face are related to global development of designs, engineering processes, and tools. The challenges lie in working against the framework of a global PDP, while remaining flexible and able to deliver regional or particular work requests. Consider, for example, special tracking and approvals variances by cultural regions, or by manufacturing facilities (e.g. prototype plants, production facilities, and warehouses). Companies can benefit if they prepare for this challenge by holistically planning for further toolset platforms that contain integral development, piloting, implementation, and deployment of tools. As a bi-directional action, key findings in the integration of tools and the development of a potential toolset platform in the EDS department could provide the impetus to further draft opportunities in the design and development process itself.

Planning for implementation and optimization of such toolset platforms requires an understanding of the differences between tools along with a potential classification that facilitates the mapping of those tools relative to the established processes in a company. Research conducted regarding tools and techniques to be utilized for product design, drafts key characterization differences in an attempt to define a classification of tools according to: 1) their position in the design cycle; 2) the type of effect they produce; 3) the characteristics of the operators; 4) the scopes, targets and goals to be achieved. This classification of tools should also be according to: 5) how each tool interfaces – directly or indirectly – with the design process; and finally, according to: 6) a tools' universal characteristics (e.g. its mode of communication or level of detail) (Lutters, Van Houten, Bernard, Mermoz, and Schutte 2014).

A robust classification of tools in the development of EDS components should be driven by the value a tool provides – first, to the enterprise as a whole and then relative to the value stream it provides internally to given teams, given the better functional interaction between teams, the more expeditious and the more robust integration of the design. Thus, a tool's value to the enterprise is generated from the ground level. A survey recently performed in the product development department of the sample OEM demonstrates a broad variance in the value of tools utilized in the design and development process

(Time-to-engineer, 2016). Many of these generic tools are utilized by EDS teams, and furthermore, complemented by a series of tools that directly and indirectly enable the completion of tasks performed with them. Here, again, a synergism can be seen – that is a synergism of the value of tools; every tool utilized produces a synergistic effect which results then in the outputs and deliverables that are required throughout the PDP process of Concept Development, System-Level Design, Detail Design, Testing and Refinement, and Production Ramp-up. So that the analysis of EDS tools may be aligned with the definition of requirements by area already assigned by the sample OEM, this study will now narrow in on the breakdown of key deliverables resulting from processing individual and collective activities as follows:

- Among design and engineering deliverables resulting from processing thought, the list includes architecture partitioning layout, complexity charts, owner information, CAD data, design attributes such as weight, design requirements compliance, robustness checks reports, issue management for resolution, release of components, piece cost and tooling cost estimations and design change traceability reports.

- Inside manufacturing deliverables, the EDS team delivers resolution to vehicular integration virtual checks documenting evidence and also delivers signed-off assembly illustrations and manufacturing control plans that identify critical characteristics of the design and the manufacturing control methods that facilitate the compliance of such requirements.

- Informative inputs to the EDS engineering team are also communicated by project management teams in distinct tools, specifying the deliverable formats requiring engineering information management. Complementary to these and to the direct deliverables mentioned above, project management mandates that EDS properly archives deliverables for traceability and further analysis of the project. Deliverables within this area include the Bill of Material (BOM), the validation and procurement of the EDS parts, cost traceability reports, reports including status of production readiness metrics, and status versus quality and reliability targets.

- Following, deliverables for testing include another BOM list, the list of design methods that validates design requirements, and a plan to progress according to the program timing among others.

- The area of build phases support requires plans supporting parts' schedule and deliveries; travel plans for EDS engineers to support build events at the manufacturing facilities and the support contact list; and evidence of compliance to prototype quality inspections.

- To a lesser degree, considering the total amount of deliverables across areas, the area of market research includes benchmarking analysis deliverables; facilities and personnel as related to the licenses of software that enable the PD deliverables overall, training and on-site support plans; and OPD again requires that training plans, quality and warranty continue analysis;

documentation for control and corrective actions performed while in production, and evidence to service requirements compliance.

4.2 The requirement deliverables: Inputs, Outputs and overall interactions

The efficiency of tools usage versus the deliverables afore mentioned will be dictated by the interaction of informative inputs and outputs between tools, the time required in the utilization of such tools, by the identification of replicate processes, and finally and more importantly, by their utilization in the compliance to PD EDS requirements. Once this information (information regarding the efficiency of tools usage relative to produced deliverables) becomes available, each tools' value to the PD office can be assessed, in that a further evaluation of the tools' attributes – or potential attributes – and shortcomings can be determined, and as result, improvements can be made.

As a first step, the list of requirements has been collated. This list entails a total of 92 requirements and has been assigned with names related to the area classification already identified by the sample OEM. The following EDS Inputs-Outputs matrix (Informational Deliverables to requirements) (Figure 15) is the first step in creating a Multiple-Domain Matrix (MDM) that maps informational deliveries to the EDS requirements; total informational deliverables equals 82, with a representative name linked to PDP phases such as Concept Development, System-Level Design, Detail Design, Testing and Refinement and Production Ramp-up (as the top of the matrix illustrates). The Multiple-Domain Matrix allows for the analysis of a system's elements' dependency, in this case EDS tools, from different domains, such as the utilized informational deliverables (Eppinger and Browning 2012). The MDM methodology requires the matrix to identify interactions across domains with the character "X". However, for clarity in differentiating inputs (I) from outputs (O) in the first run, such symbols as "I" and "O" have been utilized instead. The symbol "I/O" depicts Input-Output co-creation between elements from the two domains of analysis.

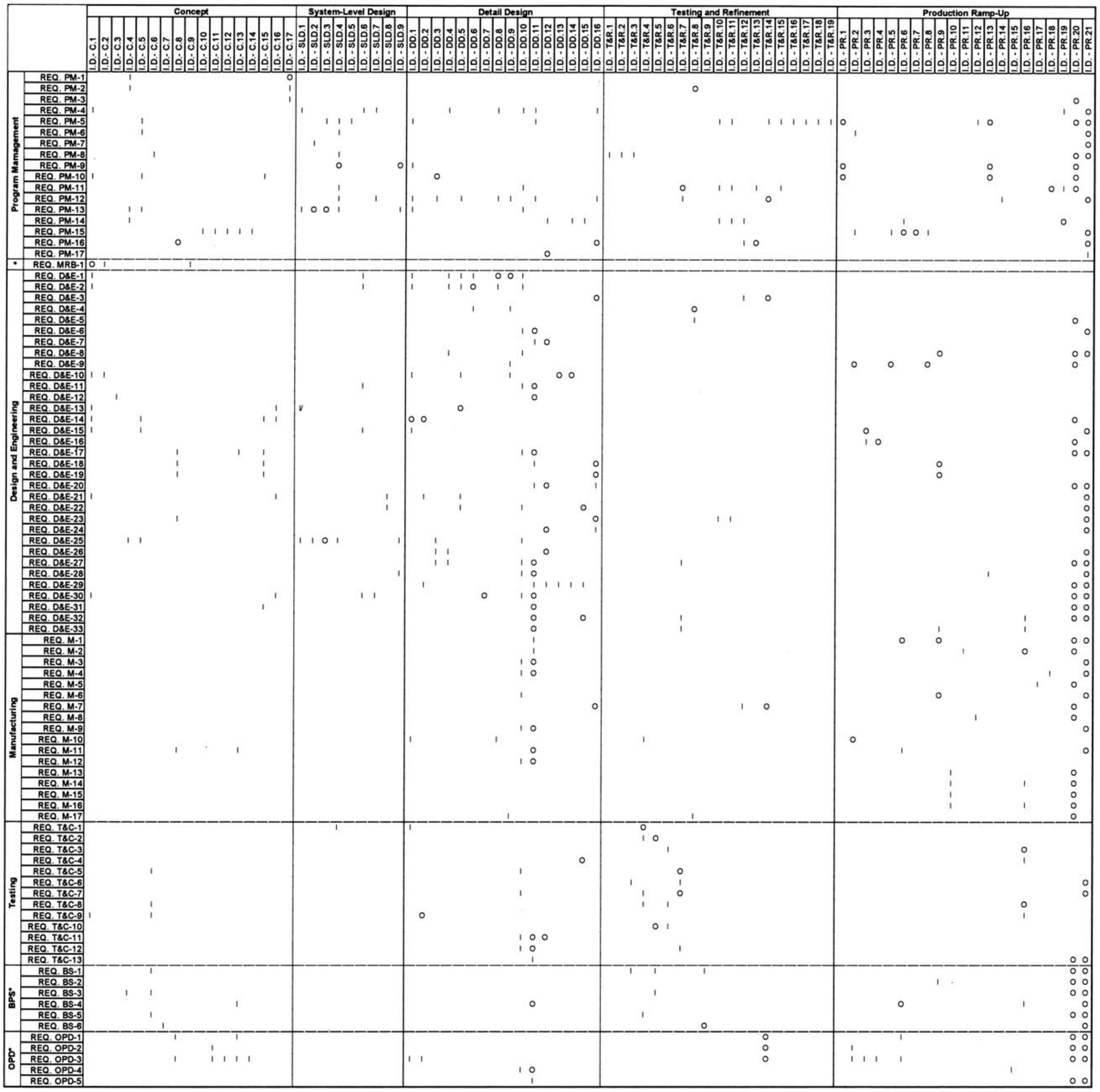


Figure 15. EDS Inputs-Outputs matrix (Informational Deliverables to requirements)[5]

From the mapping of the above EDS Inputs-Outputs matrix, it was distinguished that a few of deliverables did not end in strictly informational deliveries (e.g. assembly illustration sheets and owners' manuals), but in physical deliverables themselves, like physical parts; however, they were retained as part of this matrix considering the near past and present mode of how the sample OEM fulfills such requirements. Additionally, these deliverables are also processed by software tools at certain points in the PDP and therefore worth analysis. Further, as it is the intent of this study to provide opportunity scenarios that would facilitate the usage of tools to the PDP engineers and, as well if possible, to the vehicles owners themselves, none of the previously mentioned deliverables were yet strictly tied to

---

[5] *=Market Research; BPS*= Build Phase Support; OPD*=Ongoing Product Development

certain software tools or deliverables. (As examples of scenarios that would facilitate and make improvements in the usage of tools for vehicle owners, the printing of assembly illustrations sheets could be discontinued and, in the near future, replaced by augmented reality glasses, and owners' manuals could potentially be replaced with fixed or mobile applications loaded onto the vehicle screen for overall information review and/or warranty tracking).

Two other deliverables not quite clear in regard to their position allocation within the PDP phases for naming purposes, were those resulting from approval and archiving requirements; these two elements were also reserved as individual deliveries and included at end of the PDP. They shall be the subject of assessment in the mapping of tools versus deliverables as these deliverables are processed by a software system or systems at differentiated PDP phases.

With an observation of deliverables mapped to requirements, it becomes apparent that: 1) deliverables that fulfill a requirement can be utilized as Input in the process of fulfilling another requirement; 2) all deliverables are equally distributed throughout the PDP phases relative to their title classification (with the exception of Production Ramp-Up which contains the archiving and approval of deliverables; 3) the total quantity of deliverable interactions in the fulfillment of requirements total a sum of 441, that is the sum of 266 Inputs and 175 Outputs; 4) together, archiving and approval deliverables equate to 18% of the total Input-Output interactions, followed by the ~7% related to the evidence of compliance to specifications and requirements, the 5% related to the communication of design specifications and requirements; and finally, 5) the average ratio of Outputs to Inputs (Outputs/Inputs) equals 1.08, meaning that the average number of Outputs equals or exceeds the average number of Inputs required in the fulfillment of requirements

The average ratio of Outputs to Inputs in mentioned in order to provide a comparison to that which would constitute an ideal state of fulfilling requirements—in ideal state in which independent deliverables would be used to fulfill requirements and have the least possible interaction. This "Ideal" is drafted from the understanding and application of the Independence Axiom and the Information Axiom contained in the axiomatic design methodology in the aid of evaluations and selection for a robust production of design solutions (Hommes, 2008; Suh, 2001): the Independence Axiom aims to define a good design solution that which satisfies two or more functional requirements without affecting others. The Information Axiom states that the best design is that design solution which can fulfill a functional requirement with the least amount of information.

In order to have a better understanding of how interconnected all the deliverables are from this initial mapping exercise and in order to assess the level of interaction of the tools that process such deliverables, it is necessary to transform the Input-Output matrix (Figure 15) into a Multiple-Domain Matrix (MDM) format and then to further transform it into a Design Structure Matrix (DSM). The Design Structure Matrix (DSM) is a systems tool utilized in the representation and analysis of task dependencies. It was initially developed for the analysis of designs by Steward (1981) and more recently utilized in the analysis of different domain aspects of the PDP: design oriented, task-oriented, function-oriented, process- oriented, etc. The DSM matrix requires a square distribution of the elements to be analyzed (deliverables in this case study), where names are positioned equally in rows and columns into the desired sequence. Elements that provide inputs to another element are marked in a top-down fashion with a "1" or "X" symbol. The goal is that once this step is completed, an element in any row can be read with the understanding that all marks in that row reflect steps that are required before the completion of the element in question occurs. Overall, the marks in the DSM represent dependencies between elements. In order to facilitate the analysis of dependencies, it is recommended the crossing cells are filled with the element name (from that same row, and column) instead of marks. So, whenever marks are observed only in the lower part of the diagonal, the system elements are sequenced. If system elements are only observed in the upper part of the diagonal, the sequence of elements might be backward and consequently need to be rearranged. This rearrangement, or repositioning of elements, is called sequencing or partitioning the DSM. The main objective in performing a partitioning of the DSM is to order the elements as much as possible considering their sequential dependencies to other elements. Elements providing inputs to lower-positioned elements in the DSM are called sequential elements. Elements that do not provide Inputs to the next proximate element, but together receive Inputs from other previous elements, represent simultaneity iteration; these elements are called parallel elements. Finally, the elements that receive inputs from elements above the diagonal matrix are called coupled tasks; these must be partitioned in order to bring, as much as possible, upper diagonal dependencies closer to the diagonal since these represent iterations to those elements coupled with the elements under observation. (Eppinger and Browning 2012)

The process to create a DSM from an MDM (deliverables vs. requirements) requires the creation of an MDM' prime (requirements vs. deliverables); both of them can then be multiplied to result in a DSM that includes the interaction frequency among deliverables. With the utilization of Matlab®, the previous EDS Inputs-Outputs matrix was multiplied to its matrix' prime in order to obtain the following EDS DSM: Deliverables' Interaction (Figure 16).

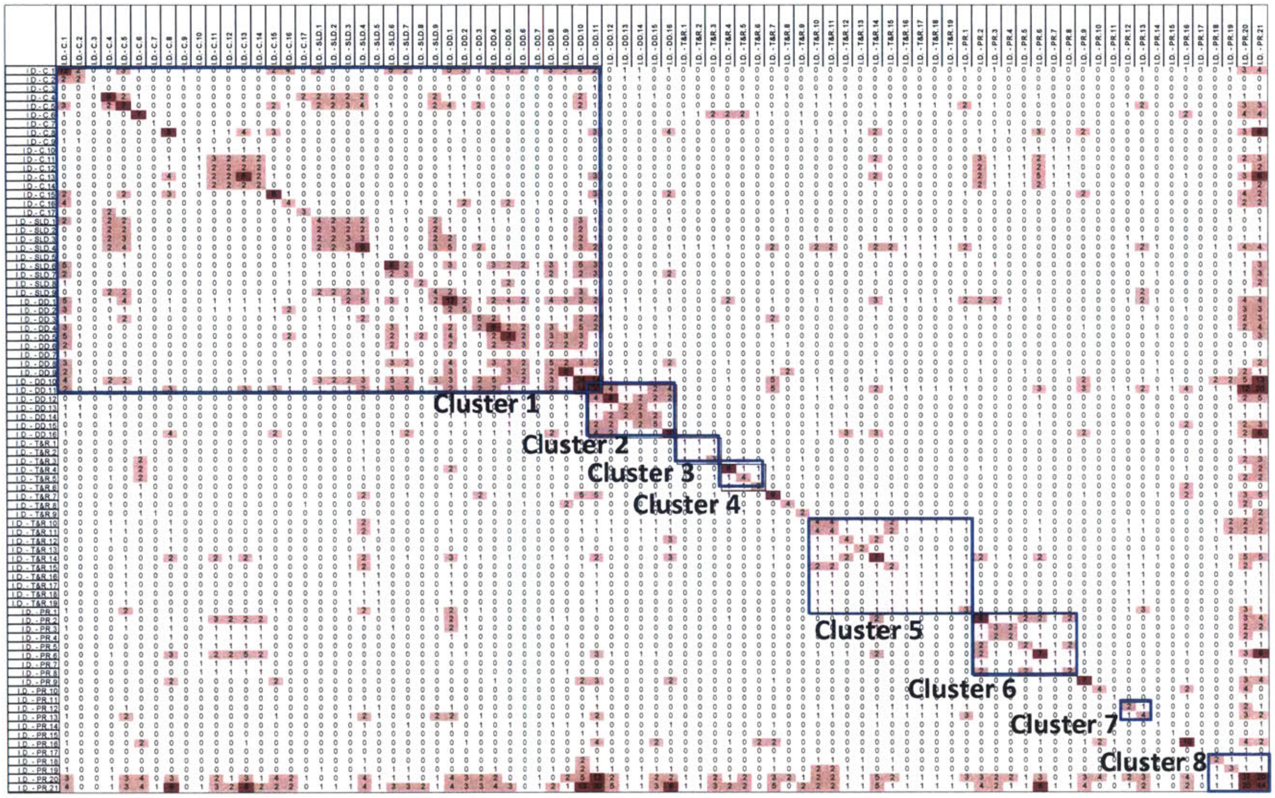


Figure 16. EDS DSM(1): Deliverable Interaction by the compliance of requirements

DSM(1) above depicts how deliverables are interconnected. It is, however, important to mention that for the purposes of this analysis, all interaction types (Inputs and Outputs) were treated equally. The matrix then shows direct interactions frequencies from a minimum value of 0 to a maximum value of 20. In order to facilitate the overview of where the most frequent iterations reside among deliverables, color coding was added to the matrix. Light red references frequencies that equal 1; medium red references frequencies between 1 and 4—the next-up proximate integer from the average of maximum interactions per deliverable; dark red references any frequencies above 4.

It is insightful to also observe how small clusters of deliverables are arranged throughout the interacting DSM(1) axle, and how these clusters already include a significant amount of interactions between deliverables. In this initial manual clustering of the initial deliverables arrangement, two overlapping clusters can be identified—Cluster 1 which includes 37 deliverables and 793 total interactions and Cluster 2 which contains 6 deliverables and 54 interactions. These are followed by five non-overlapping clusters. Cluster 3 and Cluster 4 contain 3 deliverables, 9 interactions each. Cluster 6 includes 11 deliverables and 109 interactions. Cluster 6 has 7 deliverables and 47 interactions. Cluster 7 is made up of 2 deliverables and 4 interactions. Finally, Cluster 8 contains 4 deliverables and 54 interactions. Left out from the clustering proposed above are 10 additional deliverables.

This clustering resulted from a predefined arrangement of deliverables throughout the PDP process. Still, this initial clustering of deliverables (by default) might still bring to light opportunities for improvement in the inclusion of frequency interactions per cluster, especially if it is considered that cluster1 includes many deliverables that are indirectly connected and many other deliverables are not among the main clusters. Nevertheless, since the purpose of this initial analysis is to recommend tools for the managing of the deliverables needed to meet the EDS requirements, it was discovered that the compliance of all EDS requirements could potentially be met by the utilization of 18 tools: 16 non-overlapping sets of tools and 2 other overlapping, though main tools. Without question, it is greatly challenging to accommodate a tool that includes the managing of 37 deliverables, especially when the risk is recognized that this inclusive tool might have to deal with non-highly integrated and only indirectly connected elements (Thebeau 2001). However, the study must be left open for opportunities and not limitations; therefore, a more robust definition of clusters considering the frequency of iterations, previously mentioned, is needed.

Upon the completion of several trials—manually and then by utilizing the Thebeau algorithm (dsmweb.org and Thebeau 2001)—a new DSM was identified as a second option for the rearrangement of deliverables and clusters. It is essential to mention, that for better results in the rearrangement of deliverables for the trial run using the Thebeau algorithm, frequency ranges were utilized. These ranges match the color coding classification previously mentioned as follows: value of 0.5 was assigned to frequencies equal to 1; value of 1 was then assigned to frequency ranges between 1 and 4; and finally, a value of 2 was assigned to any frequencies above 4. This new DSM is then integrated by 12 non-overlapping clusters as shown below (Figure 17).

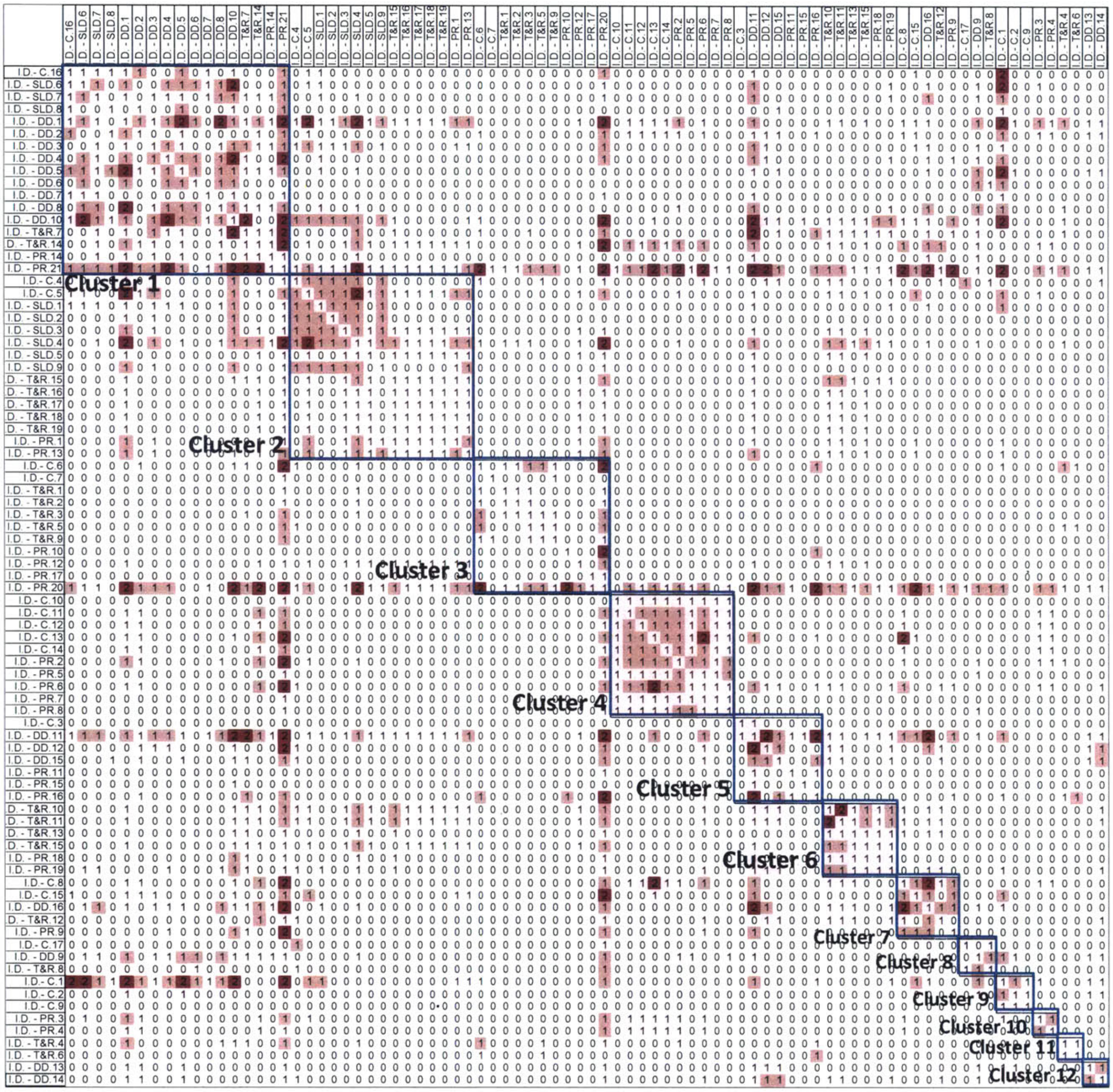


Figure 17. Rearranged EDS DSM(2): Deliverable Interaction by the analysis of requirements[6]

Some of the observations from the above re-arranged DSM(2) are the following: The first cluster includes only 17 deliverables as opposed to the 37 identified in the original DSM(1), and it also encompasses some deliverables that are generic to any commodity department (e.g. to Body, Power—Train, and Chassis) such as the definition of the architecture partitioning for the program, other

---

[6] Cells with a shown value of 1 with light red color actually represent a value of 0.5. However, due to size, modifications for figure representation cells were adjusted to be reduced and numbers were automatically adjusted to the next higher integer

commodities' 3D models, records for the compliance of specifications and requirements, tooling cost of design changes, ID assignment to manufacturing and quality issues, and the record of evidence documentation, including documentation from physical part reviews as well as several other EDS specific deliverables like complexity definition and usage, connectivity information, functional schematics, and CAD files.

The second cluster also includes a significant quantity of 15 deliverables and contains deliverables like PDP key dates, assembly requirements, design owner and supplier IDs, commercial agreements, components ID and its assembly classification, the Bill of Material (BOM), piece-cost and weight information, as well as records for purchase orders. Thus far, between clusters 1 and 2, cluster 1 would be a cluster requiring a defined tool with the ability to manage the peculiarities of the EDS wiring harnesses, even with the consideration that these peculiarities might not be similar to the requirements of alternative commodity departments. Also, some deliverables are shown to miss full interrelationship with the other clustered deliverables. It must be noted, though, that this miss-interaction is lower than that observed with the first manual assignment of clusters in DSM(1).

The third cluster is formed by 11 deliverables including prototype and production plans, procurement plans and timing, manufacturing plans including control and verification plans, tracking for virtual and manufacturing issues, record of design changes, and approval records. It is enlightening to view how this cluster includes the approval deliverable even though approvals are required at every phase-stage and might be duplicated due to iterations and reworks; approvals are indeed required to be clearly identified and managed from the inception (the early stages) of the development of products, especially once the design change iteration process begins. The fourth cluster includes 10 deliverables and encloses deliverables related to competitors Information, targets such as cost, craftsmanship, weight, quality, as well as production release records, manufacturing illustrations and manufacturing tooling trials documentation. Both the third and fourth clusters could be considered parallel clusters in the development of deliverables, if approval records were to be considered as independent deliverables that are not necessarily being cascaded from the third cluster to the fourth. Additionally, the third and fourth clusters show full interaction among the enclosed deliverables which can also be considered as a generic cluster across departments, though the manufacturing and procurement plans, as well as the targets mentioned above, can be subject to change considering the peculiarities of the commodity and the manual manufacturing process of the EDS parts versus others.

Next, the fifth cluster incorporates 7 deliverables including further definition of requirements, as well as the record of their compliance, and the definition of containment plans. Additionally, it includes records for the manufacturing readiness as well as any manufacturing changes taking place at the supplier facilities. The sixth cluster contains 6 deliverables mostly focused on the tracking and recording of design changes as well as the creation of issue lists and support plans for build events. The seventh cluster then includes further definition of program settings such as volumes and tooling targets. This seventh cluster also includes the tracking of the weight of the parts and the delivery of the product manual. The enclosing of deliverables in this particular cluster is slightly peculiar—program settings are usually managed at the early stages of the program and product manuals for example, are managed right before the product is launched; nevertheless, the indirect interactions enclosed in this cluster seem to have a medium and high interrelationship in the rearranged matrix.

Following next, the eighth and ninth cluster include 3 deliverables each, from the list eighth includes design concepts and the definition of design specifications and requirements, meantime the ninth cluster manages warranty information, customer wants and product content and its optioning. Finally, the tenth cluster pairs the cost of tooling and the craftsmanship properties of the commodity parts; the eleventh cluster includes the testing plan and methods with the recording of design and assembly issues; and the twelfth cluster encloses the record of final product integration and content optioning compliance.

When contemplating that the foregoing list of clusters compels the first proposal for the definition of tools to be utilized in the processing of deliverables relative to the EDS department's compliance to requirements, it should be remembered that most of the arrangements of deliverables were found to be feasible from an EDS perspective, especially with regard to how each deliverable is linked to the proximate ones (with few exceptions—e.g. the deliverable of product manuals in the seventh cluster and the support plans for build events in the sixth cluster).

From this initial proposal, a manual iteration of clustering shall pursue the rearrangement of clusters so that they reflect actual opportunities for improvements. One proposal, among the many that can be put together for a manual iteration of clustering, includes the following changes: 1) isolate the product manual deliverable or enclose it with the deliverable of 3D CAD files, given that product manuals include a sizable portion of CAD data for illustrative instructions; 2) relocate the support plans for build events into the third cluster; and 3) break-down approval and archiving records reflecting organizational policies and directives to manage the classification of deliverables in an independent manner. Nevertheless, any clustering proposal to override the clustering proposal resulting from running the Thebeau algorithm should pursue the integration of tools that enables the compliance of all PD requirements and not only the EDS specific ones.

4.3 The tools interface

As pointed out, the clustering from Figure 16 were found naturally, then clustering algorithms were applied to the DSM(1) to identify an improved arrangement of deliverables by the clustering of higher interactions, and finally, further optimizations to the arrangement were drafted in DSM(2). After a couple of subsequent iterations in striving to achieve an improved rearrangement of tools by looking at the deliverables' interactions, it is clear that many manual proposals can be constructed (like the first proposal drafted herein). However, without a distinct understanding of the risks embedded in every proposal, it is not a simple task to prioritize them accordingly for final integration.

Furthermore, it is relevant also to keep in mind that the proposal of new tools for the unique development of EDS components (e.g. the cluster including peculiarities for the EDS development) will have an impact on the way the entire organization already operates. As a case in point, any tool that manages deliverables of different stakeholders and authorities requires buy-off, full engagement and cooperation in establishing that new tool as a new corporate tool. For example, a unique program management initiative to launch a tool that had performed a more rapid escalation and traceability of issues was proposed a couple of years ago in the sample OEM; however, due to the lack of engagement and value-added to the final users—engineers—the tool was never adopted at this totality despite all the efforts imposed on making the tool feasible and the provision of such an issue management new tool to the PD team.

For this reason, it is essential that once the requirements placed upon the EDS team and the potential opportunities to group deliverables relative to specific tools and their smoother management, tracking, approval and archiving are all comprehended, a review of the software system tools already utilized by the EDS users in the sample OEM assesses potential areas for improvement and that drafting begins for how these opportunities could possibly align, or not align, to the previous proposal of retaining some of the large clusters but also incorporating some individual, or new clusters, for the management of deliverables not contained in those initial clusters.

As a first step for this tools' analysis, a list of tools utilized in the development of EDS components has been collated. This list entails a total of 93 tools directly utilized by EDS engineers.[7] They have again been mapped in the format of an Input-Output matrix against the deliverables previously defined in the analysis of requirements, and their titles, linked to the PDP phase names, have been retained. For purposes of comparison to the tools analyzed in a survey performed by the sample OEM (Time-to-engineer, 2016), the indirect tools have been linked to the next direct and recognized main tool in the sample OEM. A direct and recognized main tool in the sample OEM will be understood as a tool that can be utilized by an engineer of any vehicular commodity department and maintain its usability purpose towards a delivery compliance. Also, the list of tools has been classified within 11 key domains.

These domains have previously been set by the sample OEM in their initiative to analyze and optimize the use of tools in the overall PD department. Moreover, these domains have been arranged in a top-down fashion according to the time it takes for the engineers to process such domain deliverables (Time-to-engineer, 2016); however, the arrangement of classified tools within the list itself is not according to a specific order. The list of domains is defined as follows:

- Material Cost
- Procurement
- Release and Change
- Content Definition
- Test and Validate
- Investment and Tooling
- Prototype Build
- Quality

---

[7] An additional list of 15 system software tools and processes were left out of this analysis given its indirect and less frequent usability from the EDS team.

- Issues
- Weight
- Process

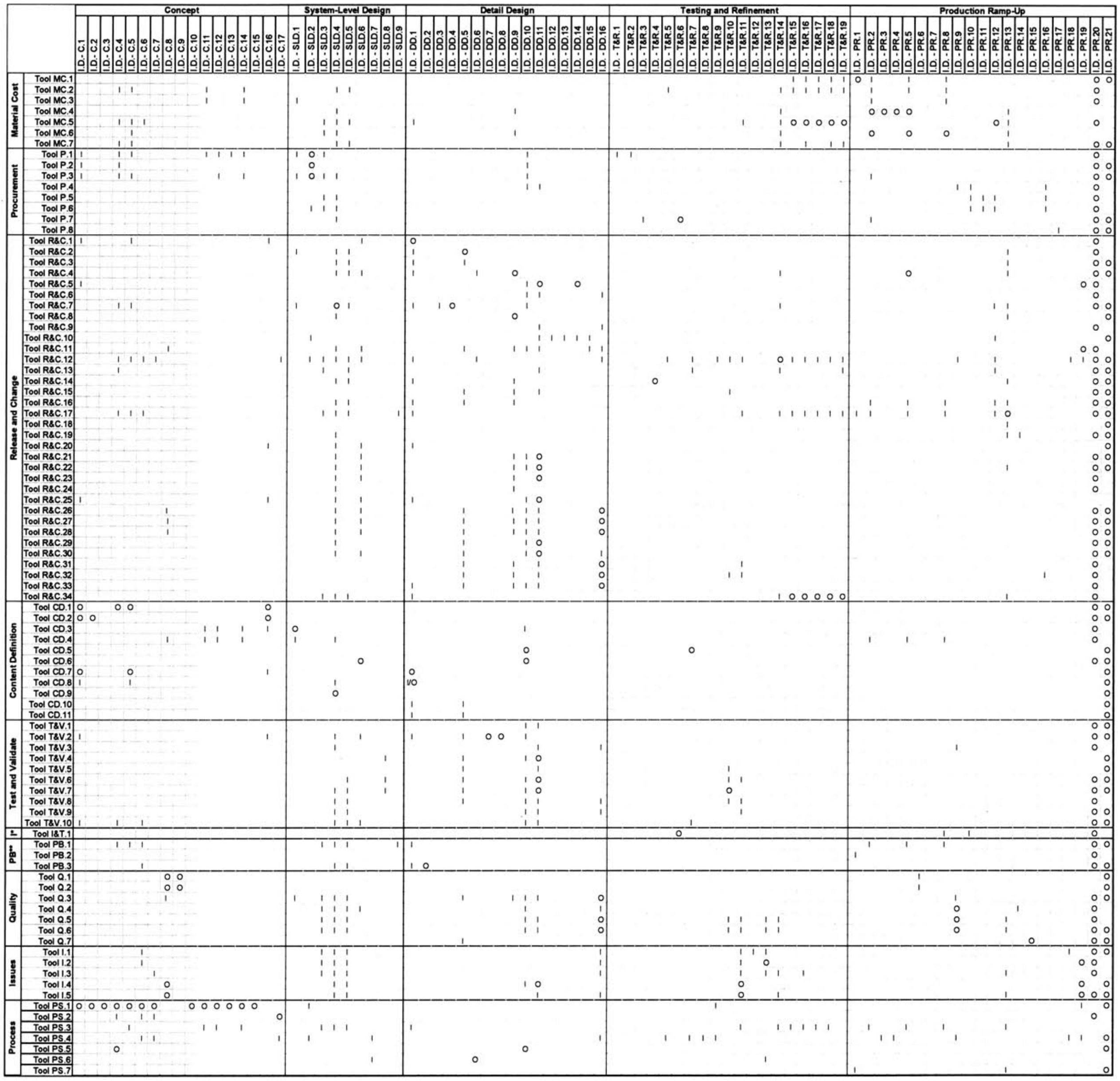


Figure 18. EDS Inputs-Outputs matrix (Deliverables to sample OEM Tools)[8]

---

[8] I*= Investment and Tooling; PB**= Prototype Build. The weight domain is not explicitly mentioned in the matrix given the tools utilized in the processing of its related deliverables are embedded already in other direct and indirect tools.

The above matrix (Figure 18) illustrates the interaction of informational data utilized by every process tool, set in a breakdown, decomposition-fashion, of Inputs and Outputs broadly managed by the EDS team. Some key findings from analyzing this EDS Input-Output Matrix are listed below:

- From the 93 tools in the matrix, 82 tools manage Inputs and Outputs of the total deliverables. Only 8 tools produce Outputs to the EDS team without any pre-required Input, such tools are part of the Content Definition, Quality and Process domains. While at the same time, Process domain includes a tool that requires only Inputs, with no further Output deliverables from the list identified.
- The majority of the informational deliverables have a high interaction with tools from all the different domains.
- In regard to the quantity of observed inputs, the component part ID deliverable (I.D. System-Level Design-4) has the greatest number of Inputs submitted into different tools, with 51 possibilities; in contrast, the approval deliverable hold the maximum amount of observed outputs, with 69 observations. It is significant and noteworthy to observe that the approval deliverable does not reflect inputs per se, but the definition of outputs at this deliverable reflects the approval required for the different outputs the tool in analysis provides (e.g. Tool MC.1 delivers I.D. – PR1(O) and I.D. – PR20(O); this means the deliverable of PR1 requires approval). If no further deliverables are identified in the same tool, then its unique deliverable of the tool is to obtain approval of the identified inputs (e.g. Tool MC.2 shows various inputs (I) but only one output: I.D. – PR20, this means Tool MC.2 processes the approval itself of the different identified inputs), without identifying another specific output from the list of deliverables previously defined in the mapping of requirements.
- The tools domain of Release and Change contains the greater amount of total inputs and outputs, followed by the domain of Materials Cost, and Test and Validate. In subsequent middle-range positions, the Procurement, Process, Quality, Content Definition, and Issue domains leave the domains of Prototype build, and Investment and Tooling on the last rung positions of interaction density.
- Retaking the ratio of outputs over inputs (Outputs/Inputs) introduced in the analysis of requirements, it is interesting to observe that from the 85 tools that receive inputs and provide outputs, only ~19% of the tools have a balanced output/input ratio equal or greater than 1, and 81% of the enlisted tools have an output/input ratio below 1; from this 81% of tools, a significant 40% of tools have an output/input ratio lower than 0.5.

Considering the tools described in the last observation (the 40% with a ratio>0.5), it is recommended that such given tools then become the subject of further analysis for improvement opportunities. Nevertheless, it is critical not to override the analysis of tools efficiency with the assumption that an Output/Input ratio, equal or greater than 1, is the desired outcome, given than all the identified deliverable Inputs and Outputs are managed in a manual manner; therefore, the transformation of manual into automatic operations of the tools with an Output/Input ratio, equal or greater than 1, could also become a subject of the analysis for operational optimization of tools.

As described previously, conclusions for dictating the efficiency of tools cannot be drafted immediately by Output/Input ratios. The ratios do, however, provide an introductory idea of how tools are highly interrelated by the informational deliverables. In order to visualize the deliverable interaction by the tools utilized in the sample OEM, it is critical to transform the Input-Output matrix in a DSM(2) into a manner in which it reflects such interaction and its frequency. Figure 19 depicts that matrix with a color coding of interaction frequencies as previously applied to the DSM(1).

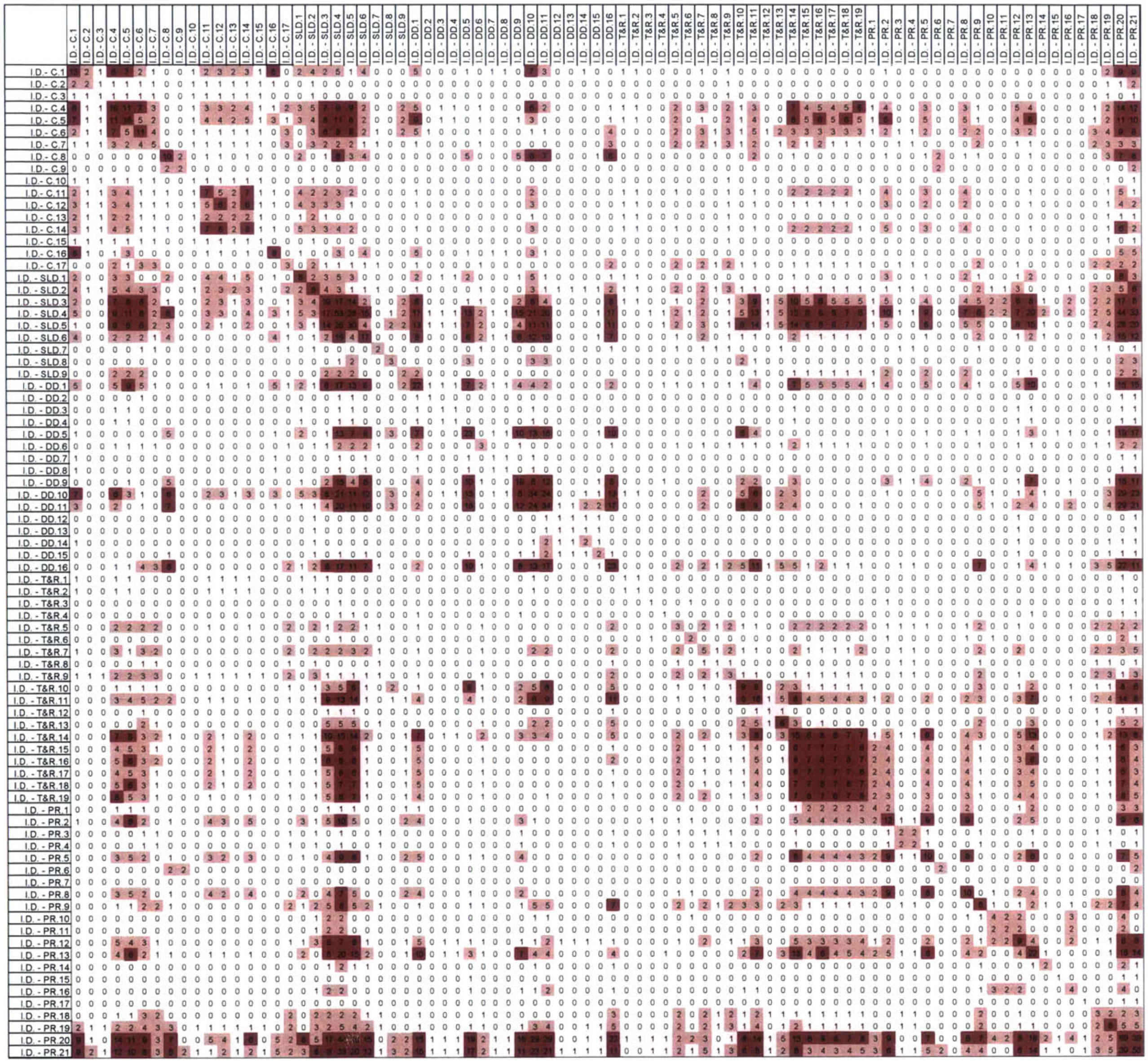


Figure 19. EDS DSM(3): Deliverable Interaction by the utilization of tools

In contrast to the previous DSM(2) of deliverables, as mapped from the analysis of requirements compliance, this DSM(3) of deliverables by the utilization of tools shows a higher interaction among deliverables. Considering only direct interactions, the difference of a 12% increase is represented by 832 additional interactions (additional to the previous total of 6724 interaction possibilities). When viewing direct as well as indirect interactions, the difference increased by 295%, which signifies that the 2,580 identified interactions in the DSM(1), or DSM(2), experienced a substantial increase—and increase of 7,614 interactions of deliverables in DSM(3).[9]

The interactions denoted in Figure 20, do not include the impact of expected iterations and potential reworks resulting from the PDP. Even considering only a 1-time processing of deliverables through the established tools, the significant amount of indirect interactions makes of the task to propose a cluster integration of tools, based on the interaction of deliverables, a difficult task to complete. A rearranged DSM(4) (Rearranged EDS DSM(4): Deliverable by the utilization of tools) resulting from the application of the Thebeau algorithm (Thebeau, 2001), and represented with a similar color and frequency coding as applied in DSM(2), shows an integration of deliverables in only 9 clusters.

The integration of processing deliverables with only the use of 9 tools (diminished from the 93 currently used), would require considerable effort; not to mention, that even with these 9 tools, potential opportunities for improvement could exist. In short, the effort to merge absolutely everything just by utilizing the tools as they are might be better utilized for analyzing and discovering best practice solutions for optimizing the usage and linkage of tools as well as their possible face-out and replacement.

---

[9] When performing such count of direct and indirect interactions in the DSM matrixes is important to keep the original values dropped from the transformation of the MDM, given that diagonal cells will include as well the value of the indirect interactions utilized in the attainment of deliverables.

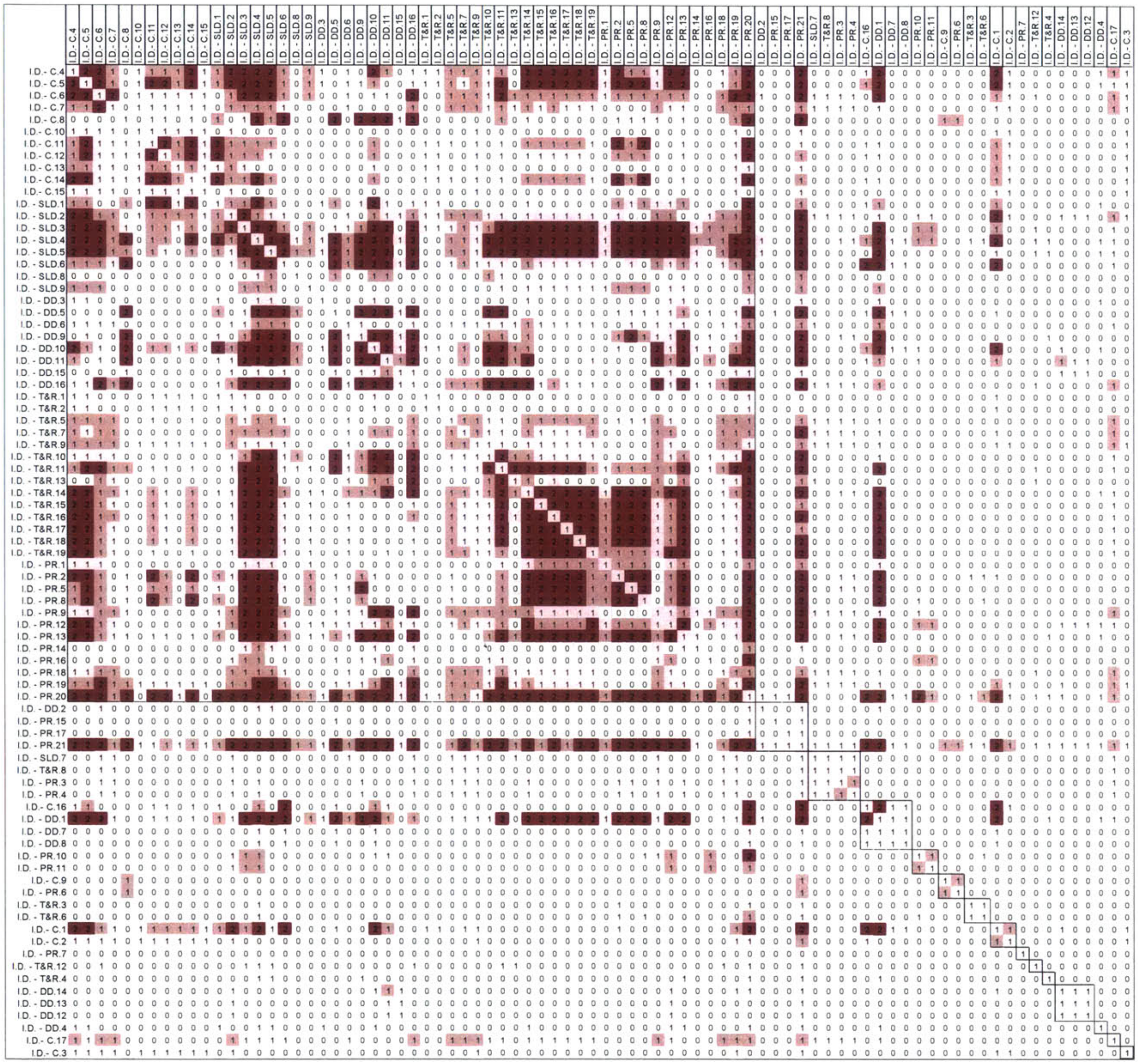


Figure 20. Rearranged EDS DSM(4): Deliverable by the utilization of tools[10]

It is evident that in the process of developing EDS components both the latest DSM(4) and the DSM(2), do not reflect a perfect or an iteration-free sequencing of deliverables. This drives the conclusion that the definition and usage of tools in the automotive sample OEM is limited by the particularities of the OEM dynamics in which information inputs are subject to change at any given phase, allowing for iterations (and reworks). The system of tools should therefore, be developed to such a degree as to contain the best, most perfect and adequate structure to facilitate the processing of deliverables repeatedly; that adequate structure would thus incorporate the correct number of linkage tools in order

---

[10] Cells with a shown value of 1 with light red color actually represent a value of 0.5, however, due size modification for figure representation cells were adjusted to be reduced and numbers were automatically adjusted to the next higher integer.

to bring about more expeditious iterations. Nevertheless, the process of system representation in MDMs and DSMs was useful to observe in relation to: 1) the dependencies and interactions among deliverables from a requirement perspective, 2) the dependencies and interactions among deliverables from a tools utilization operation, 3) the comparison data between the two setting of tools, which are the desired system and the current system.

For the remainder of this study, the "desired system" will be understood as the system resulting from the mapping of deliverables to the requirements, which was previously introduced. The "current system" then will be understood as the system resulting from the current usage of tools for processing deliverables to comply with the established requirements.

4.4 The comparison

In line with the example of how the change propagation research (Pasqual and de Weck 2011) utilized application of graph theory for its network analysis, and factoring in the basis of the researchers' foundation that many aspects of the product development are already modeled as a network, the comparative analysis of tools can be then performed utilizing basic elements of graph theory. With the knowledge that the previous DSMs can be utilized as adjacency matrixes for representation of the directed networks (Desired system and Current system), further network theory metrics (Bounova 2014, Newman 2003) can be employed to run a comparison between the two systems in order to identify opportunities for improvement; subsequently, a plan can be drafted for places/areas in which the current system can potentially be integrated to match the desired system.

Among the network properties that can be utilized in the comparison of the tools networks, several can be detected:

- Number of nodes: represents the amount of components, deliverables in this case, which conform the system – the tools network.
- Number of edges/links: the total amount of interactions, or dependencies, among deliverables (nodes).
- Link density: the amount of interactions (edges), divided by the maximum possible number of interactions (edges).
- Symmetry: "1" denotes whether the network matrix is symmetric.
- Average nodal degree: average number of links per deliverable (node).
- Diameter: longest path of interactions between any two deliverables (nodes).
- Connection: "1" determines whether or not all deliverables (nodes) in the network are connected by interactions or dependencies to another deliverable (node); in this case, by a tool.
- Connection characterizations: number of connections, description of connected deliverables (nodes), and the maximum set of connected deliverables (nodes).
- Clustering coefficient: measurement of how much the network deliverables (nodes) tend to cluster together.

Figure 21 includes a circle representation of both systems and shows a side-by-side comparison of the metrics briefly described above:

Desired system (Input from DSM(1))	**Network Properties**	**Current system (Input from DSM(3))**
82	Number of nodes	82
1691	Number of edges	4146
0.5092	Link density	1.3631
1 (yes)	Symmetry	1 (yes)
41.2439	Average nodal degree	110.4146
5	Diameter	Inf
1	Connection	0
1: [1x82 double]	Components connected	2: [1x81 double][68]
0.3272	Clustering coefficient	0.4369

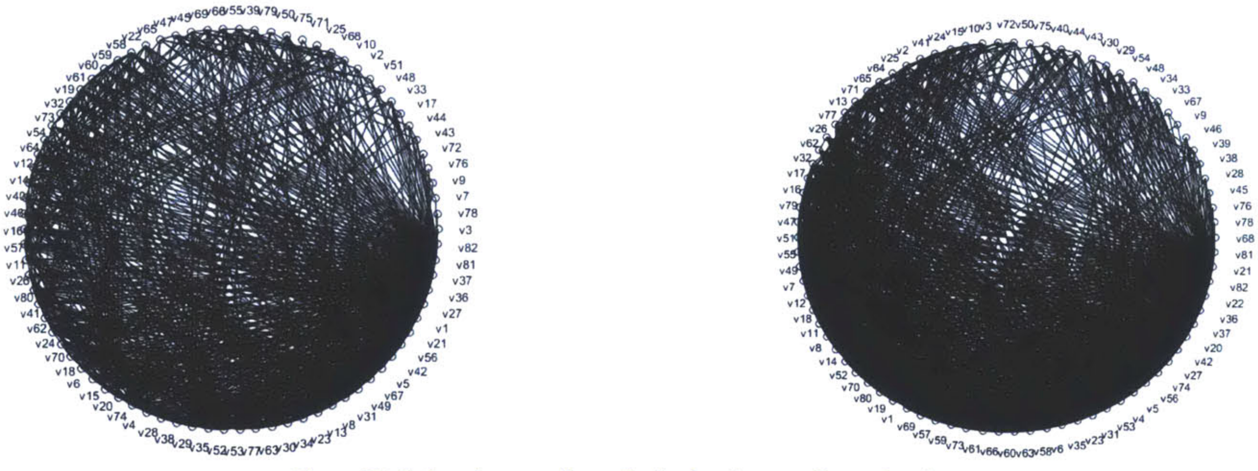


Figure 21. Network comparison: Desired system vs. Current system

Viewing the current system (from the above), opportunities are evident for optimization in the number of edges, the link density, the average node degree, and the connection of all components.

The previous comparison of networks reflected a significant opportunity relative to a key enabler of the product development process within the sample OEM: the tools. In order to continue the present analysis with one of the research objectives of this study: the identification of efficiency levels through the observation of redundancies in the application of tools, and consequently the processing of deliverables utilized in the fulfillment of requirements, it is necessary to assess whether or not tools process the same deliverables and which would translate to unnecessary duplication of tools.

In order to identify such tools, a likeness matrix (Appendix a.) has been constructed based on the Inputs and Outputs identified in Figure 18. This symmetrical matrix distinguishes the percentage of likeness between the tools identified in the selected row, versus each of the tools identified in the rest of the 92 rows in the matrix. Diagonal cells, for example, reflect a 100% likeness, meaning the tool of analysis and the tool of comparison are the same. For comparisons of likeness, assuming that cycled tools are potential prospects for analysis, inputs and outputs of deliverables are considered equal. Examining the likeness matrix generates the following observations:

- The minimum average percentage for likeness among tools stands at 64.5%, with minimum likeness percentages of 56.1%.

- The average percentage for maximum likeness among tools stands at 95.5%, with maximum likeness percentages of 100% in the processing of deliverables; tools with 100% likeness rates relative to other tools represent 7.5% of the total amount of tools and are paired as follows:
  - Tool Q.1–Tool Q.2;
  - Tool CD.10–Tool CD.11;
  - Tool R&C.26–Tool R&C.27;
  - Tool R&C.26–Tool R&C.28;
  - Tool R&C.27–Tool R&C.28.

- The breakdown of the amount of tools in the top ten percentages of likeness encompasses the following:
  - 99% – 100%: 7 tools
  - 98% – 99%: 10 tools
  - 97% – 98%: 22 tools
  - 96% – 97%: 16 tools
  - 95% – 96%: 13 tools
  - 94% – 95%: 0 tools
  - 93% – 94%: 8 tools
  - 92% – 93%: 4 tools
  - 91% – 92%: 3 tools
  - 90% – 91%: 3 tools

- Within the range of the average of maximum likeness value (95.5%) observed and the 99% value of likeness, 48 tools are included. This represent and opportunity for integration for another 51% of the tools under analysis. Such integration of opportunities are paired as follows:
  - Tool MC.4 – Tool MC.6;
  - Tool P.2 – Tool PS.5;
  - Tool P.5 – Tool P.6;
  - Tool P.8 – Tool R&C.18;
  - Tool P.8 – Tool CD.6;
  - Tool P.8 – Tool CD.9;
  - Tool P.8 – Tool T&V.1;
  - Tool P.8 – Tool PB.2;
  - Tool P.8 – Tool Q.7;
  - Tool R&C.1 – Tool CD.7;
  - Tool R&C.2 – Tool R&C.3;
  - Tool R&C.3 – Tool R&C.14;
  - Tool R&C.6 – Tool R&C.9;
  - Tool R&C.6 – Tool R&C.33;
  - Tool R&C.6 – Tool T&V.1;
  - Tool R&C.6 – Tool T&V.3;
  - Tool R&C.8 – Tool R&C.14;
  - Tool R&C.8 – Tool R&C.18;
  - Tool R&C.8 – Tool R&C.19;
  - Tool R&C.8 – Tool R&C.24;
  - Tool R&C.8 – Tool CD.9;
  - Tool R&C.8 – Tool PS.7;
  - Tool R&C.9 – Tool R&C.6;
  - Tool R&C.9 – Tool R&C.31;
  - Tool R&C.9 – Tool T&V.1;
  - Tool R&C.9 – Tool T&V.3;
  - Tool R&C.9 – Tool PB.2;
  - Tool R&C.11 – Tool R&C.26;
  - Tool R&C.11 – Tool R&C.27;
  - Tool R&C.11 – Tool R&C.28;
  - Tool R&C.14 – Tool R&C.19;
  - Tool R&C.14 – Tool R&C.24;
  - Tool R&C.15 – Tool T&V.5;
  - Tool R&C.18 – Tool R&C.19;
  - Tool R&C.18 – Tool CD.5;
  - Tool R&C.18 – Tool CD.9;
  - Tool R&C.18 – Tool CD.10;
  - Tool R&C.18 – Tool CD.11;
  - Tool R&C.18 – Tool Q.1;
  - Tool R&C.18 – Tool Q.2;
  - Tool R&C.18 – Tool PS.5;
  - Tool R&C.18 – Tool PS.7;
  - Tool R&C.19 – Tool CD.9;
  - Tool R&C.20 – Tool CD.9;
  - Tool R&C.21 – Tool R&C.22;
  - Tool R&C.21 – Tool R&C.23;
  - Tool R&C.21 – Tool R&C.26;
  - Tool R&C.21 – Tool R&C.27;
  - Tool R&C.21 – Tool R&C.28;
  - Tool R&C.21 – Tool R&C.29;
  - Tool R&C.21 – Tool R&C.30;
  - Tool R&C.21 – Tool CD.6;
  - Tool R&C.21 – Tool T&V.1;
  - Tool R&C.22 – Tool R&C.23;
  - Tool R&C.23 – Tool R&C.24;
  - Tool R&C.24 – Tool CD.9;
  - Tool R&C.24 – Tool PB.2;

Tool R&C.26 – Tool R&C.30; Tool R&C.27 – Tool R&C.30; Tool R&C.28 – Tool R&C.30;
Tool R&C.29 – Tool R&C.30; Tool R&C.29 – Tool T&V.1; Tool R&C.29 – Tool T&V.4;
Tool R&C.29 – Tool T&V.7; Tool R&C.31 – Tool R&C.32; Tool R&C.31 – Tool R&C.33;
Tool CD.1 – Tool CD.2; Tool CD.1 – Tool CD.7; Tool CD.5 – Tool CD.6;
Tool CD.5 – Tool CD.9; Tool CD.5 – Tool T&V.1; Tool CD.5 – Tool PS.5;
Tool CD.6 – Tool T&V.1; Tool CD.6 – Tool PS.5; Tool CD.7 – Tool CD.8;
Tool CD.8 – Tool CD.9; Tool CD.9 – Tool CD.10; Tool CD.9 – Tool CD.11;
Tool CD.9 – Tool Q.1; Tool CD.9 – Tool Q.2; Tool CD.9 – Tool PS.5;
Tool CD.9 – Tool PS.7; Tool CD.10 – Tool T&V.5; Tool CD.10 – Tool Q.7;
Tool CD.11 – Tool T&V.5; Tool CD.11 – Tool Q.7; Tool T&V.1 – Tool T&V.4;
Tool T&V.1 – Tool PS.5; Tool T&V.4 – Tool T&V.5; Tool T&V.6 – Tool T&V.7;
Tool T&V.8 – Tool T&V.9; Tool PB.2 – Tool PS.7; Tool Q.5 – Tool Q.6;

- Pairs of tools sharing a likeness rate above the maximum average are not isolated; this means a tool of the pair can share a relatively high likeness to another tool, which can also be linked to another tool and so forth.

4.5 The proposal: integration in the system of tools

"Principle of Focus (22): The number of identifiable issues that will influence a system at any point is beyond one's ability to understand. One must identify the most critical and consequential issues, and focus on them." (Cameron, Crawley and Selva 2016)

Based on the forgoing findings above, the research objectives of identifying opportunities for redundancy avoidance and incorporating new initiatives that optimize the EDS processes and the tools efficiency, the analysis arrives at the ultimate goal: concluding with a plan for optimizing the current system of tools. Keeping in mind first that this plan for optimization must focus on providing improvements to the network of tools already utilized (rather than creating a brand new network) and second, the advantages that a meta-heuristic optimization algorithm – population-based algorithm – provide in the optimization of such network architectural optimizations, the study will proceed with presenting a tools system-based search algorithm (Figure 22) that can be utilized in the pursuit of an integrated network of tools which would provide significant inter-operational improvements (Edward Crawley, 2016).

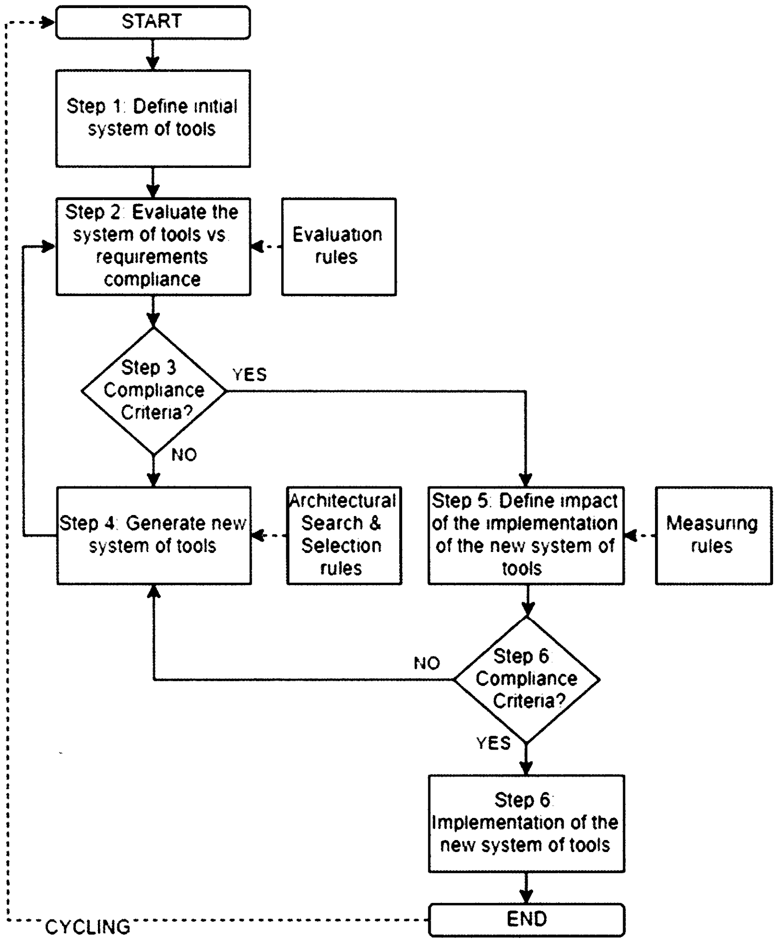


Figure 22. Tools system-based search algorithm[11]

The algorithm in Figure 22 begins with Step 1: Defining the initial system of tools. First, an MDM matrix that maps the utilization of existing tools for the processing of deliverables is required (as already laid out earlier in Chapter 4). Additionally, its transformation into a DSM will prepare the system in an adjacent matrix format that can be utilized in Step 2.

Step 2: Evaluation of the system of tools vs. requirements compliance. As part of the evaluation rules, a second MDM matrix that maps the processing of deliverables against the requirements placed upon the department is required. This second MDM matrix along with its transformation into a DSM will prepare the desired system—the target system – in an adjacent matrix format that can be used for making comparisons between it and the current system of tools. The Evaluation rules influencing this comparison of data are then driven mainly by three elements: 1) the input of requirements established by the OEM (which can be modified at any time); 2) the network properties of a desired system that result from the assessment of such requirement compliance, and 3) the expected network density improvement rates from each iteration. These final delineated network properties can be derived by running the network routines (Appendix c.) previously introduced in the obtainment of the network

---

[11] Modified from population-based search algorithm (Cameron, Crawley, and Silva, 2016)

properties applied in the comparison evaluation between the current state—the current tools' system—and the desired tools' systems (above). Additionally, the density properties are important due to the fact that they represent the manual inputs and outputs engineers must perform in order to process information for the completion of deliverables and therefore, the continuous optimization of this process save time to engineers when developing new EDS components, or any other commodity components.

Step 3: Does the newly derived system of tools' utilization meet the Compliance Criteria? The response to this question drives the decision as to whether or not to proceed with the implementation of the proposed (new) system of tools (Step 5), or to generate yet other new systems of tools options (Step 4).

Step 4: Generation of new system of tools. At this step, further systems of tools integration options must be generated. This step must be performed with reference to the Architectural Search & Selection rules as defined by the OEM. The setting of search and selection rules for the generation of a new system of tools that could be employed by the sample OEM is the subject of a future work recommendation. However, as outlined through the key findings of this study regarding the redundancy rates in the processing of deliverables, it is possible to define at least one search rule, and that is, to look at likeness rates in the utilization of tools, and then to select a specific range for the integration proposal as part of the generation of a new system of tools.

For the purposes of this study, and in order to provide an example in the utilization of such Search and Selection rule settings, a likeness rate of above 98% will be the scope for the generation of a new system. The generation of a new system then initiates with the update of the MDM so that it merges Inputs and Outputs from the pairs of tools to be integrated (e.g. Figure 23 in Appendix b.). These pairs can be listed for clear identification as follows:

Tool Q.1–Tool Q.2;
Tool R&C.18 – Tool PS.7;
Tool R&C.26–Tool R&C.28;
Tool CD.10–Tool CD.11;
Tool R&C.21–Tool R&C.22;
Tool Q.5 – Tool Q.6;
Tool R&C.6–Tool R&C.9;
Tool R&C.26–Tool R&C.27;
Tool P.5 – Tool P.6;

The MDM is now transformed into a DSM (ref. Figure 24 in Appendix b.) and is made available for the implementation of the steps to follow. As directed in Figure 22, the next step leads us back to Step 2, in which the new system of tools is evaluated against the desired system (resulting from the evaluation rules, by comparing the network properties of both systems—the new tools system and the desired tools system). The system resulting from the previous step (Step 4) which included the integration of tools with likeness rates above 98% was called the "new system"; the new system network properties are then compared to the desired system and the old (current) system according to:

Network Properties	**Desired system (Input from DSM(1))**	**Old (Current) system (Input from DSM(3))**	**New system (98% likeness)**
Number of nodes	82	82	**82**
Number of edges	1691	4146	**3894**
Link density	0.5092	1.3631	**1.2782**
Symmetry	1 (yes)	1 (yes)	**1 (yes)**
Average nodal degree	41.2439	110.4146	**103.5366**
Diameter	5	Inf	**Inf**
Connection	1	0	**0**
Components connected	1: [1x82 double]	2: [1x81 double][68]	**2: [1x81 double][68]**
Clustering coefficient	0.3272	0.4369	**0.4369**

Here, the third element in the evaluation rules—the expected improvement rates from each iteration—will dictate whether or not the New System meets the criteria. Assuming a random rate of improvement of 3%, the network density properties of the new system reflect improvements of about 6%; which incorporates the results that the number of edges in the network system, the link density and the average nodal degree are each reduced by approximately 6%. In the context of the evaluation rule regarding network improvements, addition properties – such as components connected and the clustering coefficient—could be integrated. However, for the purposes of this exercise overview, expected improvements to such elements are considered as null in the evaluation rules. Assuming that improvements are then found in this first iteration at Step 3, the new system of tools then proceeds to the next step, Step 5.

Step 5. Defining the impact of the implementation of the new system of tools. The definition of impact from the implementation of a new system of tools must be driven by directives mandated by the OEM in a set of measuring rules, which can also be additional evaluation rules. Implementation of the new system of tools will proceed (or not) according to the directive of the OEM. If the proposal for implementation is rejected, further (different) options for optimization will be explored. As access to directives regarding the rules for clear measurement of optimization were/are restricted (by the sample OEM), this study will cover only some aspects to be included in the development of such measuring rules. These aspects are mentioned in a non-exhaustive list of observations below. It should be noted that attempts were made to provide examples, when applicable, about the impact of the implementation of the new system of tools, found as compliant in Step 3. The list of aspects includes:

a) Impact to the final users and owners of the tools, inside and outside the EDS department. When proposing the integration of some tools, it is important to consider that the EDS team might not be the only user and owner of the tools to be integrated; consequently, the first step would require identifying whether or not the proposed tools are indirect tools utilized only by the EDS team. If they are not, the users and owners of those tools must be determined. For example, Tool Q.1 and Tool Q.2 are not unique indirect tools of the EDS team; their integration, though, from an EDS perspective is proposed as both systems are utilized in databases that provide information to the EDS team. However, the merging of both systems might require quality office owners and production plant users/owners to extend the usability scope of the software system to contain, and maintain the information to be managed in the same tool. Useful to assess as well are the benefits this integration of tools might bring to other departmental or PD teams, as it might facilitate the agreement from owners to sign-off on the integration of such tools.

b) Impact and improvements to the PDP overall timing.
Perhaps the identification of whether or not a system actually has an impact on the timing it takes for engineers to develop products, is the most important item to consider when proposing the merging of tools. Still, in the assumptions of this research it was considered that any duplicity in the inputs of information, or deliverables into different systems, already extends the time it takes for the engineers to process the deliverables. Nevertheless, assessing upfront the impact of the utilization of any tool relative to the timing engineers are given to process inputs into outputs will provide a prioritization guideline for pursuing the integration of tools (or to desist from such). An example of assessing the time impact to the merging of tools can be found in the proposed merging of Tool R&C.6 and Tool R&C.9; the first tool is utilized for maintaining, tracking and archiving the assessment of the development process at different stages of the PDP, and the second tool is utilized to prepare plans whenever the compliance to deliverables identified in the assessment of such development processes is not met. Merging these two tools facilitates the more efficient use of engineers' time through decreasing the time it takes for EDS engineers to track and report compliance and plans to compliance stage gate deliverables. Admittedly, the integration of such tools might also only require macro updates in order to merge both tools in such a way so that once essential fields are filled in Tool R&C.6, that information can be exported in a format currently requested and managed by the Tool R&C.9.

Another example of assessing the time impact to the merging of tools is found in the merging of Tool R&C.26, Tool R&C.27 and Tool R&C.28; all tools receive inputs from the same data base (issue and warranty databases). However each tool processes the information in an apparently similar but distinguishable manner. From the EDS team, this demand the assessment and documentation of similar, but sometimes exactly equivalent, information into three different tools. The merging of the tools identified in the previous examples optimizes the timing required of engineering to provide assessment, tracking, resolution, and planning for compliance to all the different items. However, the exact amount of time it would save engineers can be the subject of further analysis; it can be proposed to first pilot the exercise of such merging of tools into a key program that would assess whether or not that merging provides time savings. Overall, timing optimizations are foreseen as the tools included in both of the prior two proposed examples of the merging of tools are required to be filled-out at least at every PDP phase and minor stage gate approval, requiring at least the processing of information throughout these tools at least 8 times per project. A detailed definition of the impact on timing proposed by such integrations might be beneficial in acquiring survey or interview results, similar to the ones available from the direct tools analyzed in the survey performed by the sample OEM (Time-to-engineer, 2016), so that the EDS team documents, in the vault of performance, key timings in the processing of deliverables utilizing specific tools and provides feedback accordingly to the IT department about the systems available to the EDS team.

c) Feasibility impact: technology readiness.
In every merging proposal, the feasibility of the tools under analysis is required to be assessed as to whether or not, based on their capabilities, they can be integrated into one of the existing software systems. If not, it would then be necessary to implement brand new tools that more accurately meet the end goals of what the tools are needed for. Nevertheless, it is essential that such assessments are performed in the company by the information technology (IT) department, so that experts can assess the feasibility of such merging while, at the same time, receiving exposure to new challenges presented by the innovative proposals identified by the PD team. For instance, an example of this can be found in the proposed merging of Tool R&C.21 with Tool R&C.2: the first tool is an automatic checklist processed by CAD software in order to assess the compliance to predefined requirements; the second tool is a manual checklist that assesses some of the predefined requirements already being assessed in the first checklist. This second tool also performs some of the manual checks required to ensure the CAD drawings are delivered up to the corporate design and manufacturing standards. The merging of these tools requires a higher automatization of the first tool, in order to make up for the assessments performed manually with the second tool. As evident through many varied applications, it is however, a challenging task for software algorithms to defeat the human ability to assess variants and perform particular checks.

d) Impact of costs: resources, licensing and maintenance.
Any integration of tools has a cost. This cost is incurred by either the cost(s) of resources and/or the timing cost(s). The integration of tools, beginning with an assessment of whether or not the integration of a tool is necessary, already requires investment from the company. In order to offset the value to be created by the integration of tools, estimates must be provided for their integration. As well, a target value must be determined relative to the development of the EDS components needed for this integration to be implemented. The task(s) of assigning value could be difficult. Nonetheless, it is mandated that rough estimates are calculated. The estimates must include: 1) the cost of software licenses (if required); 2) the cost of the resources to be allocated for the integration or development of such tools; 3) the cost(s) associated with the maintenance of such tools; and moreover, 4) the cost of the tools' unavailability to the core team every time the tool requires maintenance. It may be the case that a given tool's integration would provide substantial value relative to the processing of EDS information, yet at the same time, that tool would also need to be shut-down on a regular basis for maintenance (& consequently, unavailable to the core team). In this scenario, the tool's integration would be more detrimental than beneficial in regard to the design of the EDS components.

e) Impact on auditing and regulating requirements: approval and archiving records.
The merging of software systems that do not meet software requirements of either or both systems, cannot be allowed to transpire. An example of a compliance to this observation is embedded in the integration proposal of Tool Q.5 and Tool Q.6. For this particular case, the proposal consists of merging Tool Q.5 into Tool Q.6, considering the capabilities already existing in the Tool Q.6. However, if for any other reason the proposal would necessitate the merging of other tools into the architecture of Tool Q.5, the proposal would be overriding the original requirement for the documenting of evidence (archiving) of approval records, and for this reason, it should be immediately rejected. A further example can be found in the merging of Tool R&C.18 and Tool PS.7, where both tools already have archiving capabilities; however, Tool PS.7 is only utilized to export reports from the database created by Tool R&C.18 and does not have the approval record capabilities as its pairing tool; therefore, the merging proposal cannot incorporate only the retention of Tool PS.7. Instead, the proposal should be that Tool R&C.18 be merged into Tool PS.7, thus synergizing their capabilities.

Assuming that the aspects mentioned above are considered in the definition of measuring rules for accurate assessments of impact regarding the implementation of the new system of tools, and also assuming that this impact meets the predefined criteria, Step 6 would then proceed with directions for the implementation of the new system of tools and to the end of the algorithm. Finally, Figure 22 includes a cycling linkage between the end and the beginning of the process algorithm to denote the importance of how continuous iterations of the process must be planned in order to support the evolution of the OEMs. Therefore, a proposal for the optimization and integration of tools must forecast a timeframe for how long the implementation of the new system will be useful to the OEM and how soon another iteration of optimization will be needed. This forecast can be developed from the analysis of how corporate strategies and directives change over time—changes that affect the EDS and the overall requirements of the PD which then, in turn affect information regarding the design, development and the delivery of EDS components and the vehicles themselves.

Finally, this chapter is designed to conclude with an overview of the existing initiatives from the sample OEM to optimize EDS processes and the efficiency of tools. As briefly mentioned before, the sample OEM recently launched an initiative to measure the time-to-engineer in order to assess whether engineers dedicate sufficient time to engineering deliverables versus the time dedicated to activities such as the managing and processing of information. As also mentioned previously, a set of direct tools were analyzed through the exhaustive review of the results from an internal survey (Time-to-engineer, 2016) in order to identify (among other elements) the value of tools, the satisfaction rate assigned by direct users, and the time dedicated to the usage of each tool. Driven by the opportunities identified in the results of the time-to-engineer aforementioned analysis, actions to consolidate the integration of tools in different domains such as material cost, release and change, procurement, prototype build, content definition, and investment and tooling, have been initiated with an aggressive completion target of the near future. The details of this survey and the results and optimization actions it produced are intended to remain confidential to the sample OEM; the comparison of this initiative with regard to the optimization plan of utilizing a tools system-based search algorithm is therefore limited to the recommendations to be outlined in Chapter 5.

Chapter 5.Conclusion

This study was established in order to perform an integral mapping of the tools utilized by the Electrical Distribution System (EDS) team within a sample OEM. The primary purpose of that mapping was to identify opportunities for optimization relative to the EDS components' design and development processes. By focusing on the use of a key enabler—the tools—that purpose could be achieved. With the results obtained from the analysis performed in Chapter 4, it was then possible to identify potential opportunities for optimization which could further be translated into the compilation of a proposal to integrate an improved and more efficient system of tools.

Highlighted as well and functioning as an indirect objective was the suggestion that such an analysis of tools and processes could enlighten and bring greater understanding to the Product Development (PD) team about the critical roles tools play in product development. The opportunities discovered through this study and the proposals for improvements could be expanded to include other vehicular commodity departments to improve performance within the whole of the OEM. Considering the number of tools that were not isolated as solely used by the EDS department, the achievement of such an indirect objective is feasible as long as a clear mapping of requirements is analyzed as part of the departmental personalization of the study for different commodity applications. Furthermore, at an OEM level, a holistic mapping of requirements would be beneficial to the entire OEM in that it would more comprehensively illuminate all potential opportunities for improvement.

As an indirect objective, it was mentioned the example of this analysis of tools and processes in the EDS department could bring more understanding to the PD team about the importance of the utilization of tools so that the opportunities found at this study, and the proposals for improvements could be expanded in other vehicular commodity departments for an overall OEM performance improvement. Considering the amount of tools mapped in the analysis and that were not unique to the usage of the EDS department, it is possible to conclude the indirect objective would be feasible to achieve as long as a clear mapping of requirements is analyzed as part of the personalization of the study for different commodity applications. Furthermore, a holistic mapping of requirements at an OEM level, to the totality of tools utilized in the OEM, despite the partitioning in commodity departments and cross functional teams, would bring an even major understanding for potential identifications of improvement.

5.1 Observations and opportunities

During their developmental stages, all commodities within automotive OEMs, to include those of the EDS commodity, are susceptible to the effects of late changes. The current metrics employed to assess how these late changes affect the development of a product—metrics such as cost, schedule and timing—do not at this time, however, consider the peculiarities embedded in the nature of each commodity.

Some of the observations found as unique to the EDS commodity include the following: 1) Having structural interactions with external elements at a subsystem level, EDS components are not encapsulated in the subsystem boundary; 2) EDS team members have direct interactions with specific stakeholders inside the EDS and EESE boundaries, as well as with other cross-functional stakeholders inside and outside the PD boundary; and 3) The EDS team is placed under an additional degree of control through the actions of stakeholders at varying hierarchical levels.

Probing further into the PD requirements for the EDS team, it was revealed that a piece of the puzzle was missing: although it was only necessary to submit a minimal number of requirements to other cross-functional teams for approval, a detailed explanation of just how those requirements fit into the overall PD organizational requirements was elusive. Though it did limit the validation of the requirements placed on the EDS team relative to the compliance to the organizational requirements, the lack of this puzzle piece did not represent a roadblock in the development of this study. Additionally, most of the items on the list of EDS requirements defined WHAT was required from the EDS team while, in defining HOW to fulfill any given requirement, others delineated in advance which tools should be used. These specific HOWs therefore, were translated to remove such tool definitions from the requirements in order to create a straight mapping of functional needs and deliverables.

The mapping of deliverables to provide a linkage with which to analyze the fulfillment of requirements, and the use of current tools for the processing of such deliverables, allows for the application of this analysis in the future; operational processes resulting in the usage of new systems of tools can be evaluated and compared relative to how they enhance the fulfillment of new requirements. Up to this point, this study was found to be beneficial in regard to determining to what extent the employment of tools in the PD EDS commodity department is efficient in the development of new EDS components. With a broadened perspective, it can be expanded to incorporate an analysis of the entire PD organization and its development of new products, and later, it can be even further expanded and applied to the development of services.

Recalling the analysis of how current tools are utilized for the completion of EDS deliverables, it was determined that a single iteration in the clustering – optimization – of the tools systems will not yield the direct answer to draft a solution specific enough and thus, sufficient for drafting an integration of tools that once implemented, could be stepped on as a platform for providing the most optimum solution for developing EDS components. With this in mind, it is recommended that additional iterations are performed in order to realize significant improvements in the development of EDS components, the compliance to requirements, and in short, to realize improvements in the functioning and overall performance of the PD organization.

The assumption that this type of tools' system analysis should initiate with a highly complex system was indeed an accurate assumption. However, having made the discovery that the majority of tools employed in the processing of deliverables are not solely utilized by the EDS team, a critical recommendation for future works is evident: such future works must be focused on an integrated analysis across PD and functional departments. In order to achieve the development and implementation of a tools' platform it is essential that all departments collaborate in an initiative to revise how the requirements from different departments are related, which means examining the functional inputs and outputs required across departments and determining how those inputs and outputs can be managed by a single integrative set of tools. As brought to light throughout the mapping of the utilization of tools that a detailed analysis of how the approval structures (underscored by the absence of a clearly detailed definition of the approval requirement) induce EDS team members to duplicate the input and output of information into several tools, further emphasis was placed on the imperatives that all departments collaborate and that program management and authority stakeholders must be fully engaged as participants in such an initiative. Furthermore, the lack of a dedicated EDS engineering process was revealed through both the EDS interactions' map and the EDS hierarchical control structure. Therefore, the proposal to have the commitment of all parties in order to achieve the success of this initiative depends upon a further reassessment of resources such that upper-management approves the addition of dedicated employees who lead the project and propel the company toward that success.

Specifically exploring the mapping of utilized tools for an integration and efficiency analysis, the mapping of this tools' system—in an Input-Output matrix format, a DSM format, an adjacent matrix format, and then in a network graphing format—made clear the need for an assessment of similarity that then led to identifying where significant improvements could be made given the interconnection of tools utilized in the processing of deliverables to fulfill EDS requirements. As well, the pursuit to identify opportunities for optimization and for redundancy avoidance in the usage of tools, supplemented the indirect objective of distinguishing opportunities of how this analysis could be expanded for improvements of the rest of the PD commodities, facilitating the definition of a plan that could utilize the steps taken in this study, to identify opportunities in the plan to be employed throughout the entire PD organization. The forgoing two statements describe complementary approaches that were adopted for the development and completion of this study. Both of them demonstrate how solutions, from a clear understanding of needs and main objectives, can be arrived at. Provided with this example and closely inspecting the plan furnished at the end of the study, it is essential that the list of areas for potential improvement begin with an emphasis on the need for merging corporate and commodity requirements in such a way that they are clear, concise, and traceable. This merging will allow for a proper cascading of: 1) the evaluation rules utilized in Step 2 of the proposed Tools' system-based search algorithm as well as 2) the measuring rules utilized in Step 5—the impact definition of the implementation of the proposed new system of tools.

5.2 Future work recommendations

The procurement of the right inputs into a system, a clear definition of controls to be considered in the processing of activities, as well as the allocation of the proper enablers, will result in the expected outputs. One of the controls to be applied to the plan proposed in this study for the integration of tools for optimization of utilization, remains with the OEM—that is, the rules to be defined by the OEM in regard to the evaluation of systems and the measurement of the impact of the proposals; once OEMs can link the impacts of their decision-making on the integration of tools and their attributes and on the corporate performance metrics, these measuring rules will then contribute to additional rules that can be helpful for the early evaluation and comparison of tools used and their benefit (or not) to the fulfillment of requirements.

The initiative briefly mentioned in regard to the survey that was launched in the sample OEM for the purpose(s) of determining a definition of "Time-to-Engineer" through researching how much time engineers spent using engineering tools, can be utilized as a starting point for an approach to determine how much time every deliverable requires for its completion. Once such data is detailed and compiled, it can be translated into measurements of impact on product development. These impact measurements—measurements that can assist in assessing and improving the improvement of the OEM—can be defined in terms of current metrics or new and more traceable metrics.

As clarified in this present study, the just previously mentioned survey did not include the evaluation of an exhaustive list of indirect tools. Given the purpose of surveys—that they must be abbreviated in order to obtain concise results representative of the most current realities—this is understandable. Nevertheless, it is obvious that opportunities to assess the unique utilization of tools, not only by the EDS team but also by other commodity team, remain open.

Moreover, a further recommendation for exploration relies on updates to PD requirements that include the consideration of timing relative to the definition of operational and processing requirements. Although OEMs currently specify the timing-to-launch of every product, the detailed mapping of how long each process take in the development of EDS components and overall PD components in not standard. In some cases, it has not even yet been measured, and in many others has not been outlined in terms of target metrics that can be traded-off and add increases to the scope of the project. Additionally, the timing to process iterations and reworks in the PDP, as well as the variances to this timing, depending on the PDP phase of the project, are subject to further analysis, measurement and standardization. An opportunity for future exploration also exists in the analysis of the previous proposals as an element of discovery for an integral analysis that then proceeds to an implementation stage wherein the setting of timing target metrics for the processing of deliverables, considering the impact they have on the performance of the OEM, can be a potential driver for improvement once merged with the PD requirements being cascaded to each commodity team.

Up to now, opportunities that relate to the timing it takes to utilize tools and complete deliverables seem to continually appear. Timing can be considered a valuable attribute of the PDP for the sample OEM. Quality, brand equity and many other attributes can be drivers for further optimization analysis. Thus, the subsequent recommendation for future work involves the data analysis of the value of each of these attributes in such a manner as to improve the utilization of tools and in such a way that the processing of deliverables can then be prioritized. Key findings from this future study can then replace the Architectural Search and Selection rules relative to levels of duplicity and rates of similarity (likeness) that have been established in this study. All of this can then be exacted for the generation of new systems of tools.

Appendix a. Likeness matrix of tools

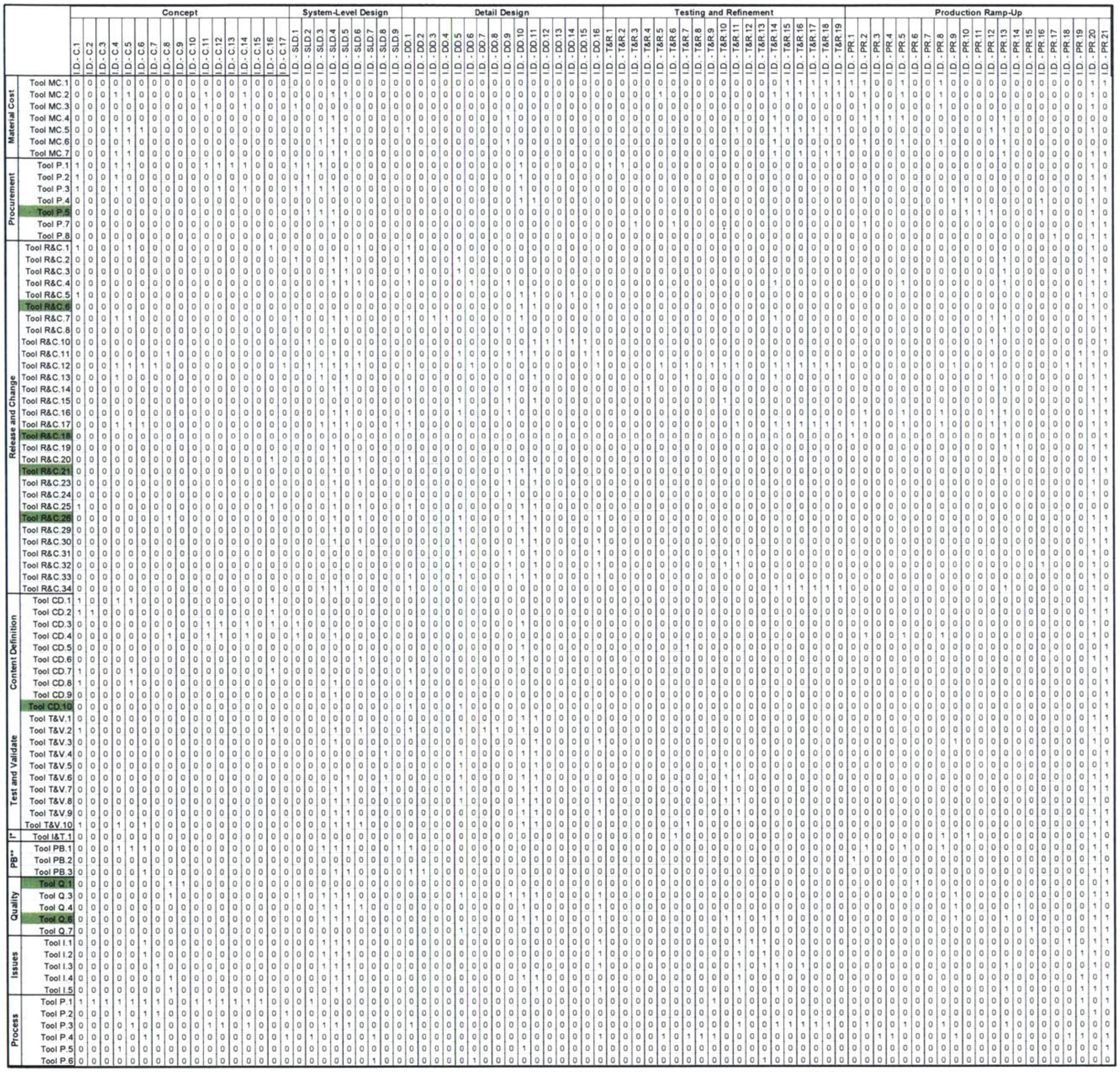
	Tool MC.1	Tool MC.2	Tool MC.3	Tool MC.4	Tool MC.5	Tool MC.6	Tool MC.7	Tool P.1	Tool P.2	Tool P.3	Tool P.4	Tool P.5	Tool P.6	Tool P.7	Tool P.8	Tool R&C.1	Tool R&C.2	Tool R&C.3	Tool R&C.4	Tool R&C.5	Tool R&C.6	Tool R&C.7	Tool R&C.8	Tool R&C.9	Tool R&C.10	Tool R&C.11	Tool R&C.12	Tool R&C.13	Tool R&C.14	Tool R&C.15
Tool MC.1	100%	87.8%	86.6%	84.1%	80.5%	82.9%	85.4%	72.0%	84.1%	78.0%	81.7%	80.5%	79.3%	86.6%	87.8%	81.7%	80.5%	82.9%	80.5%	81.7%	84.1%	74.4%	84.1%	85.4%	79.3%	75.6%	67.1%	81.7%	84.1%	84.1%
Tool MC.2	87.8%	100%	84.1%	81.7%	85.4%	82.9%	87.8%	74.4%	76.8%	78.0%	74.4%	75.6%	74.4%	79.3%	78.0%	76.8%	78.0%	78.0%	78.0%	74.4%	76.8%	76.8%	76.8%	78.0%	69.5%	70.7%	72.0%	79.3%	79.3%	74.4%
Tool MC.3	86.6%	84.1%	100%	87.8%	74.4%	86.6%	81.7%	85.4%	87.8%	86.6%	87.8%	86.6%	85.4%	90.2%	91.5%	87.8%	89.0%	86.6%	81.7%	87.8%	90.2%	80.5%	87.8%	91.5%	82.9%	81.7%	58.5%	82.9%	87.8%	87.8%
Tool MC.4	84.1%	81.7%	87.8%	100%	79.3%	96.3%	86.6%	75.6%	85.4%	81.7%	85.4%	86.6%	85.4%	90.2%	89.0%	85.4%	89.0%	89.0%	91.5%	85.4%	87.8%	82.9%	95.1%	89.0%	82.9%	84.1%	61.0%	82.9%	92.7%	87.8%
Tool MC.5	80.5%	85.4%	74.4%	79.3%	100%	80.5%	90.2%	72.0%	76.8%	75.6%	74.4%	80.5%	79.3%	76.8%	78.0%	79.3%	82.9%	82.9%	80.5%	74.4%	76.8%	84.1%	79.3%	78.0%	72.0%	70.7%	81.7%	84.1%	81.7%	74.4%
Tool MC.6	82.9%	82.9%	86.6%	96.3%	80.5%	100%	85.4%	76.8%	81.7%	82.9%	81.7%	85.4%	84.1%	86.6%	85.4%	84.1%	85.4%	85.4%	87.8%	81.7%	84.1%	81.7%	91.5%	85.4%	79.3%	80.5%	62.2%	81.7%	89.0%	84.1%
Tool MC.7	85.4%	87.8%	81.7%	86.6%	90.2%	85.4%	100%	76.8%	86.6%	82.9%	81.7%	82.9%	81.7%	86.6%	87.8%	84.1%	87.8%	90.2%	87.8%	81.7%	84.1%	89.0%	89.0%	85.4%	79.3%	78.0%	74.4%	89.0%	91.5%	84.1%
Tool P.1	72.0%	74.4%	85.4%	75.6%	72.0%	76.8%	76.8%	100%	87.8%	91.5%	80.5%	79.3%	80.5%	78.0%	81.7%	82.9%	79.3%	76.8%	72.0%	82.9%	82.9%	78.0%	78.0%	81.7%	75.6%	74.4%	58.5%	78.0%	78.0%	78.0%
Tool P.2	84.1%	76.8%	87.8%	85.4%	76.8%	81.7%	86.6%	87.8%	100%	91.5%	90.2%	86.6%	87.8%	90.2%	93.9%	90.2%	86.6%	89.0%	84.1%	92.7%	92.7%	85.4%	90.2%	91.5%	87.8%	84.1%	65.9%	87.8%	90.2%	90.2%
Tool P.3	78.0%	78.0%	86.6%	81.7%	75.6%	82.9%	82.9%	91.5%	91.5%	100%	81.7%	82.9%	84.1%	86.6%	85.4%	84.1%	82.9%	82.9%	78.0%	84.1%	84.1%	84.1%	84.1%	82.9%	79.3%	78.0%	64.6%	81.7%	84.1%	81.7%
Tool P.4	81.7%	74.4%	87.8%	85.4%	74.4%	81.7%	81.7%	80.5%	90.2%	81.7%	100%	91.5%	90.2%	87.8%	91.5%	87.8%	86.6%	86.6%	81.7%	92.7%	95.1%	80.5%	87.8%	93.9%	85.4%	86.6%	61.0%	85.4%	87.8%	90.2%
Tool P.5	80.5%	75.6%	86.6%	86.6%	80.5%	85.4%	82.9%	79.3%	86.6%	82.9%	91.5%	100%	98.8%	89.0%	90.2%	86.6%	87.8%	87.8%	82.9%	86.6%	89.0%	81.7%	89.0%	90.2%	84.1%	82.9%	64.6%	86.6%	89.0%	86.6%
Tool P.6	79.3%	74.4%	85.4%	85.4%	79.3%	84.1%	81.7%	80.5%	87.8%	84.1%	90.2%	98.8%	100%	87.8%	89.0%	85.4%	86.6%	86.6%	81.7%	85.4%	87.8%	80.5%	87.8%	89.0%	85.4%	81.7%	65.9%	85.4%	87.8%	85.4%
Tool P.7	86.6%	79.3%	90.2%	90.2%	76.8%	86.6%	86.6%	78.0%	90.2%	86.6%	87.8%	89.0%	87.8%	100%	93.9%	87.8%	89.0%	91.5%	86.6%	87.8%	90.2%	82.9%	92.7%	91.5%	85.4%	84.1%	63.4%	85.4%	92.7%	90.2%
Tool P.8	87.8%	78.0%	91.5%	89.0%	78.0%	85.4%	87.8%	81.7%	93.9%	85.4%	91.5%	90.2%	89.0%	93.9%	100%	91.5%	90.2%	92.7%	87.8%	91.5%	93.9%	84.1%	93.9%	95.1%	89.0%	85.4%	64.6%	89.0%	93.9%	93.9%
Tool R&C.1	81.7%	76.8%	87.8%	85.4%	79.3%	84.1%	84.1%	82.9%	90.2%	84.1%	87.8%	86.6%	85.4%	87.8%	91.5%	100%	89.0%	89.0%	86.6%	90.2%	90.2%	82.9%	87.8%	91.5%	82.9%	84.1%	65.9%	82.9%	87.8%	87.8%
Tool R&C.2	80.5%	78.0%	89.0%	89.0%	82.9%	85.4%	87.8%	79.3%	86.6%	82.9%	86.6%	87.8%	86.6%	89.0%	90.2%	89.0%	100%	97.6%	90.2%	86.6%	89.0%	89.0%	91.5%	90.2%	81.7%	85.4%	64.6%	84.1%	93.9%	89.0%
Tool R&C.3	82.9%	78.0%	86.6%	89.0%	82.9%	85.4%	90.2%	76.8%	89.0%	82.9%	86.6%	87.8%	86.6%	91.5%	92.7%	89.0%	97.6%	100%	92.7%	86.6%	89.0%	89.0%	93.9%	90.2%	84.1%	85.4%	67.1%	86.6%	96.3%	91.5%
Tool R&C.4	80.5%	78.0%	81.7%	91.5%	80.5%	87.8%	87.8%	72.0%	84.1%	78.0%	81.7%	82.9%	81.7%	86.6%	87.8%	86.6%	90.2%	92.7%	100%	81.7%	84.1%	86.6%	91.5%	85.4%	79.3%	82.9%	69.5%	84.1%	93.9%	86.6%
Tool R&C.5	81.7%	74.4%	87.8%	85.4%	74.4%	81.7%	81.7%	82.9%	92.7%	84.1%	92.7%	86.6%	85.4%	87.8%	91.5%	90.2%	86.6%	86.6%	81.7%	100%	95.1%	80.5%	87.8%	93.9%	87.8%	89.0%	61.0%	85.4%	87.8%	90.2%
Tool R&C.6	84.1%	76.8%	90.2%	87.8%	76.8%	84.1%	84.1%	82.9%	92.7%	84.1%	95.1%	89.0%	87.8%	90.2%	93.9%	90.2%	89.0%	89.0%	84.1%	95.1%	100%	82.9%	90.2%	98.8%	87.8%	91.5%	63.4%	87.8%	90.2%	92.7%
Tool R&C.7	74.4%	76.8%	80.5%	82.9%	84.1%	81.7%	89.0%	78.0%	85.4%	84.1%	80.5%	81.7%	80.5%	82.9%	84.1%	82.9%	89.0%	89.0%	86.6%	80.5%	82.9%	100%	85.4%	81.7%	78.0%	76.8%	68.3%	85.4%	87.8%	80.5%
Tool R&C.8	84.1%	76.8%	87.8%	95.1%	79.3%	91.5%	89.0%	78.0%	90.2%	84.1%	87.8%	89.0%	87.8%	92.7%	93.9%	87.8%	91.5%	93.9%	91.5%	87.8%	90.2%	85.4%	100%	91.5%	87.8%	86.6%	63.4%	85.4%	97.6%	92.7%
Tool R&C.9	85.4%	78.0%	91.5%	89.0%	78.0%	85.4%	85.4%	81.7%	91.5%	82.9%	93.9%	90.2%	89.0%	91.5%	95.1%	91.5%	90.2%	90.2%	85.4%	93.9%	98.8%	81.7%	91.5%	100%	89.0%	90.2%	64.6%	89.0%	91.5%	93.9%
Tool R&C.10	79.3%	69.5%	82.9%	82.9%	72.0%	79.3%	79.3%	75.6%	87.8%	79.3%	85.4%	84.1%	85.4%	85.4%	89.0%	82.9%	81.7%	84.1%	79.3%	87.8%	87.8%	78.0%	87.8%	89.0%	100%	81.7%	61.0%	85.4%	85.4%	87.8%
Tool R&C.11	75.6%	70.7%	81.7%	84.1%	70.7%	80.5%	78.0%	74.4%	84.1%	78.0%	86.6%	82.9%	81.7%	84.1%	85.4%	84.1%	85.4%	85.4%	82.9%	89.0%	91.5%	76.8%	86.6%	90.2%	81.7%	100%	62.2%	79.3%	86.6%	89.0%
Tool R&C.12	67.1%	72.0%	58.5%	61.0%	81.7%	62.2%	74.4%	58.5%	65.9%	64.6%	61.0%	64.6%	65.9%	63.4%	64.6%	65.9%	64.6%	67.1%	69.5%	61.0%	63.4%	68.3%	63.4%	64.6%	61.0%	62.2%	100%	73.2%	65.9%	63.4%
Tool R&C.13	81.7%	79.3%	82.9%	82.9%	84.1%	81.7%	89.0%	78.0%	87.8%	81.7%	85.4%	86.6%	85.4%	85.4%	89.0%	82.9%	84.1%	86.6%	84.1%	85.4%	87.8%	85.4%	85.4%	89.0%	85.4%	79.3%	73.2%	100%	87.8%	87.8%
Tool R&C.14	84.1%	79.3%	87.8%	92.7%	81.7%	89.0%	91.5%	78.0%	90.2%	84.1%	87.8%	89.0%	87.8%	92.7%	93.9%	87.8%	93.9%	96.3%	93.9%	87.8%	90.2%	87.8%	97.6%	91.5%	85.4%	86.6%	65.9%	87.8%	100%	92.7%
Tool R&C.15	84.1%	74.4%	87.8%	87.8%	74.4%	84.1%	84.1%	78.0%	90.2%	81.7%	90.2%	86.6%	85.4%	90.2%	93.9%	87.8%	89.0%	91.5%	86.6%	90.2%	92.7%	80.5%	92.7%	93.9%	87.8%	89.0%	63.4%	87.8%	92.7%	100%
Tool R&C.16	84.1%	79.3%	85.4%	90.2%	79.3%	89.0%	84.1%	70.7%	82.9%	79.3%	80.5%	84.1%	82.9%	87.8%	86.6%	82.9%	91.5%	93.9%	91.5%	80.5%	82.9%	85.4%	90.2%	84.1%	80.5%	81.7%	63.4%	82.9%	92.7%	87.8%
Tool R&C.17	85.4%	85.4%	72.0%	76.8%	92.7%	80.5%	85.4%	64.6%	72.0%	73.2%	67.1%	73.2%	72.0%	74.4%	73.2%	72.0%	75.6%	78.0%	78.0%	67.1%	69.5%	79.3%	74.4%	70.7%	67.1%	63.4%	76.8%	79.3%	76.8%	69.5%
Tool R&C.18	86.6%	76.8%	90.2%	92.7%	79.3%	89.0%	89.0%	80.5%	92.7%	84.1%	90.2%	89.0%	87.8%	92.7%	96.3%	90.2%	91.5%	93.9%	89.0%	90.2%	92.7%	85.4%	97.6%	93.9%	90.2%	84.1%	63.4%	87.8%	95.1%	92.7%
Tool R&C.19	85.4%	78.0%	89.0%	91.5%	80.5%	87.8%	90.2%	79.3%	91.5%	85.4%	89.0%	90.2%	89.0%	93.9%	95.1%	89.0%	92.7%	95.1%	90.2%	89.0%	91.5%	86.6%	96.3%	92.7%	86.6%	85.4%	64.6%	86.6%	96.3%	91.5%
Tool R&C.20	82.9%	75.6%	86.6%	89.0%	78.0%	85.4%	85.4%	76.8%	89.0%	82.9%	86.6%	87.8%	86.6%	91.5%	92.7%	93.9%	90.2%	92.7%	90.2%	86.6%	89.0%	84.1%	93.9%	90.2%	86.6%	85.4%	67.1%	84.1%	91.5%	89.0%
Tool R&C.21	82.9%	75.6%	86.6%	89.0%	75.6%	85.4%	85.4%	79.3%	91.5%	85.4%	91.5%	87.8%	86.6%	91.5%	92.7%	89.0%	87.8%	90.2%	90.2%	91.5%	93.9%	84.1%	93.9%	92.7%	86.6%	92.7%	64.6%	86.6%	93.9%	93.9%
Tool R&C.22	81.7%	74.4%	85.4%	90.2%	76.8%	86.6%	86.6%	78.0%	90.2%	84.1%	90.2%	86.6%	85.4%	90.2%	91.5%	87.8%	89.0%	91.5%	91.5%	90.2%	92.7%	85.4%	95.1%	91.5%	85.4%	91.5%	63.4%	85.4%	95.1%	92.7%
Tool R&C.23	82.9%	78.0%	89.0%	91.5%	78.0%	87.8%	85.4%	79.3%	89.0%	82.9%	91.5%	90.2%	89.0%	91.5%	92.7%	91.5%	90.2%	90.2%	90.2%	91.5%	93.9%	81.7%	93.9%	95.1%	86.6%	92.7%	64.6%	86.6%	93.9%	93.9%
Tool R&C.24	85.4%	80.5%	91.5%	93.9%	80.5%	90.2%	87.8%	81.7%	91.5%	85.4%	91.5%	92.7%	91.5%	93.9%	95.1%	91.5%	92.7%	92.7%	90.2%	91.5%	93.9%	84.1%	96.3%	95.1%	86.6%	90.2%	64.6%	86.6%	96.3%	93.9%
Tool R&C.25	78.0%	73.2%	84.1%	86.6%	75.6%	82.9%	80.5%	79.3%	89.0%	82.9%	89.0%	85.4%	84.1%	86.6%	87.8%	93.9%	87.8%	87.8%	85.4%	91.5%	91.5%	81.7%	89.0%	90.2%	84.1%	87.8%	62.2%	81.7%	86.6%	86.6%
Tool R&C.26	79.3%	72.0%	82.9%	85.4%	72.0%	81.7%	81.7%	75.6%	87.8%	81.7%	87.8%	84.1%	82.9%	87.8%	89.0%	85.4%	86.6%	89.0%	86.6%	87.8%	92.7%	80.5%	90.2%	91.5%	82.9%	96.3%	63.4%	82.9%	90.2%	92.7%
Tool R&C.27	79.3%	72.0%	82.9%	85.4%	72.0%	81.7%	81.7%	75.6%	87.8%	81.7%	87.8%	84.1%	82.9%	87.8%	89.0%	85.4%	86.6%	89.0%	86.6%	87.8%	92.7%	80.5%	90.2%	91.5%	82.9%	96.3%	63.4%	82.9%	90.2%	92.7%
Tool R&C.28	79.3%	72.0%	82.9%	85.4%	72.0%	81.7%	81.7%	75.6%	87.8%	81.7%	87.8%	84.1%	82.9%	87.8%	89.0%	85.4%	86.6%	89.0%	86.6%	87.8%	92.7%	80.5%	90.2%	91.5%	82.9%	96.3%	63.4%	82.9%	90.2%	92.7%
Tool R&C.29	84.1%	76.8%	87.8%	87.8%	76.8%	84.1%	86.6%	80.5%	92.7%	86.6%	92.7%	89.0%	87.8%	92.7%	93.9%	87.8%	91.5%	93.9%	86.6%	92.7%	95.1%	85.4%	92.7%	93.9%	87.8%	91.5%	63.4%	87.8%	92.7%	95.1%
Tool R&C.30	81.7%	74.4%	85.4%	85.4%	74.4%	81.7%	84.1%	78.0%	90.2%	84.1%	90.2%	86.6%	85.4%	90.2%	91.5%	87.8%	89.0%	91.5%	86.6%	90.2%	95.1%	82.9%	90.2%	93.9%	85.4%	93.9%	65.9%	85.4%	90.2%	92.7%
Tool R&C.31	81.7%	74.4%	87.8%	87.8%	76.8%	84.1%	81.7%	78.0%	87.8%	79.3%	90.2%	86.6%	85.4%	87.8%	91.5%	87.8%	89.0%	89.0%	84.1%	90.2%	95.1%	78.0%	90.2%	96.3%	85.4%	91.5%	63.4%	85.4%	90.2%	95.1%
Tool R&C.32	79.3%	72.0%	85.4%	85.4%	74.4%	81.7%	79.3%	75.6%	85.4%	76.8%	90.2%	86.6%	85.4%	85.4%	89.0%	85.4%	86.6%	86.6%	81.7%	87.8%	92.7%	75.6%	87.8%	93.9%	82.9%	89.0%	63.4%	82.9%	87.8%	95.1%
Tool R&C.33	80.5%	73.2%	86.6%	86.6%	75.6%	82.9%	80.5%	79.3%	89.0%	80.5%	91.5%	85.4%	84.1%	86.6%	90.2%	89.0%	90.2%	90.2%	85.4%	91.5%	96.3%	81.7%	89.0%	95.1%	84.1%	92.7%	62.2%	84.1%	89.0%	93.9%
Tool R&C.34	86.6%	86.6%	80.5%	85.4%	93.9%	84.1%	91.5%	73.2%	80.5%	76.8%	80.5%	84.1%	82.9%	82.9%	84.1%	82.9%	89.0%	89.0%	86.6%	80.5%	82.9%	82.9%	85.4%	84.1%	75.6%	76.8%	75.6%	85.4%	87.8%	80.5%
Tool CD.1	84.1%	79.3%	87.8%	85.4%	79.3%	84.1%	89.0%	85.4%	95.1%	89.0%	87.8%	86.6%	85.4%	90.2%	93.9%	95.1%	86.6%	89.0%	84.1%	90.2%	90.2%	85.4%	90.2%	91.5%	85.4%	81.7%	65.9%	87.8%	90.2%	90.2%
Tool CD.2	85.4%	75.6%	89.0%	86.6%	75.6%	82.9%	85.4%	81.7%	93.9%	85.4%	89.0%	87.8%	86.6%	91.5%	95.1%	93.9%	87.8%	90.2%	85.4%	91.5%	91.5%	81.7%	91.5%	92.7%	86.6%	82.9%	62.2%	86.6%	91.5%	91.5%
Tool CD.3	80.5%	78.0%	93.9%	84.1%	73.2%	80.5%	80.5%	89.0%	89.0%	87.8%	89.0%	85.4%	84.1%	86.6%	90.2%	89.0%	87.8%	85.4%	80.5%	89.0%	91.5%	81.7%	86.6%	90.2%	81.7%	82.9%	57.3%	81.7%	86.6%	86.6%
Tool CD.4	84.1%	84.1%	95.1%	87.8%	72.0%	86.6%	79.3%	82.9%	82.9%	86.6%	82.9%	84.1%	82.9%	87.8%	86.6%	82.9%	86.6%	84.1%	81.7%	82.9%	85.4%	78.0%	85.4%	86.6%	78.0%	81.7%	56.1%	78.0%	85.4%	82.9%
Tool CD.5	85.4%	75.6%	89.0%	89.0%	75.6%	85.4%	85.4%	81.7%	93.9%	85.4%	91.5%	87.8%	86.6%	91.5%	95.1%	89.0%	87.8%	90.2%	85.4%	91.5%	93.9%	84.1%	93.9%	92.7%	89.0%	85.4%	64.6%	89.0%	91.5%	91.5%
Tool CD.6	86.6%	76.8%	90.2%	87.8%	76.8%	84.1%	86.6%	82.9%	95.1%	86.6%	92.7%	89.0%	87.8%	92.7%	96.3%	92.7%	89.0%	91.5%	89.0%	92.7%	95.1%	85.4%	92.7%	93.9%	87.8%	89.0%	65.9%	87.8%	92.7%	92.7%
Tool CD.7	82.9%	75.6%	86.6%	86.6%	78.0%	85.4%	85.4%	81.7%	91.5%	85.4%	86.6%	85.4%	84.1%	89.0%	92.7%	96.3%	87.8%	90.2%	85.4%	89.0%	89.0%	84.1%	91.5%	90.2%	86.6%	80.5%	64.6%	84.1%	89.0%	89.0%
Tool CD.8	82.9%	78.0%	86.6%	89.0%	80.5%	87.8%	87.8%	81.7%	91.5%	87.8%	86.6%	87.8%	86.6%	91.5%	92.7%	93.9%	90.2%	92.7%	87.8%	89.0%	89.0%	86.6%	93.9%	90.2%	86.6%	82.9%	67.1%	84.1%	91.5%	89.0%
Tool CD.9	86.6%	79.3%	90.2%	92.7%	79.3%	89.0%	89.0%	80.5%	92.7%	86.6%	90.2%	91.5%	90.2%	95.1%	96.3%	90.2%	91.5%	93.9%	89.0%	90.2%	92.7%	85.4%	97.6%	93.9%	90.2%	86.6%	65.9%	87.8%	95.1%	92.7%
Tool CD.10	85.4%	75.6%	89.0%	89.0%	78.0%	85.4%	85.4%	79.3%	91.5%	82.9%	89.0%	87.8%	86.6%	91.5%	95.1%	91.5%	92.7%	95.1%	87.8%	89.0%	91.5%	84.1%	93.9%	92.7%	89.0%	85.4%	64.6%	86.6%	91.5%	93.9%
Tool CD.11	85.4%	75.6%	89.0%	89.0%	78.0%	85.4%	85.4%	79.3%	91.5%	82.9%	89.0%	87.8%	86.6%	91.5%	95.1%	91.5%	92.7%	95.1%	87.8%	89.0%	91.5%	84.1%	93.9%	92.7%	89.0%	85.4%	64.6%	86.6%	91.5%	93.9%
Tool T&V.1	86.6%	76.8%	90.2%	87.8%	76.8%	84.1%	86.6%	82.9%	95.1%	86.6%	95.1%	89.0%	87.8%	92.7%	96.3%	90.2%	89.0%	91.5%	86.6%	95.1%	97.6%	85.4%	92.7%	96.3%	90.2%	89.0%	63.4%	90.2%	92.7%	95.1%
Tool T&V.2	80.5%	73.2%	84.1%	84.1%	75.6%	80.5%	82.9%	79.3%	91.5%	85.4%	86.6%	85.4%	84.1%	89.0%	90.2%	93.9%	90.2%	92.7%	87.8%	89.0%	89.0%	84.1%	89.0%	87.8%	81.7%	87.8%	64.6%	81.7%	89.0%	89.0%
Tool T&V.3	82.9%	78.0%	89.0%	89.0%	78.0%	85.4%	85.4%	79.3%	89.0%	82.9%	93.9%	90.2%	89.0%	91.5%	92.7%	89.0%	90.2%	90.2%	85.4%	91.5%	96.3%	81.7%	91.5%	97.6%	86.6%	90.2%	67.1%	86.6%	91.5%	91.5%
Tool T&V.4	82.9%	73.2%	86.6%	86.6%	73.2%	82.9%	82.9%	79.3%	91.5%	82.9%	91.5%	85.4%	84.1%	89.0%	92.7%	86.6%	87.8%	90.2%	82.9%	91.5%	93.9%	81.7%	91.5%	92.7%	89.0%	87.8%	59.8%	86.6%	89.0%	93.9%
Tool T&V.5	84.1%	74.4%	87.8%	87.8%	74.4%	84.1%	84.1%	78.0%	90.2%	81.7%	90.2%	86.6%	85.4%	90.2%	93.9%	87.8%	89.0%	91.5%	84.1%	90.2%	92.7%	80.5%	92.7%	93.9%	90.2%	86.6%	63.4%	87.8%	90.2%	97.6%
Tool T&V.6	80.5%	73.2%	84.1%	81.7%	75.6%	78.0%	82.9%	76.8%	89.0%	80.5%	89.0%	82.9%	81.7%	86.6%	90.2%	84.1%	87.8%	90.2%	82.9%	89.0%	91.5%	81.7%	86.6%	90.2%	84.1%	85.4%	64.6%	86.6%	89.0%	93.9%
Tool T&V.7	80.5%	75.6%	84.1%	84.1%	75.6%	80.5%	85.4%	76.8%	89.0%	82.9%	89.0%	85.4%	84.1%	89.0%	90.2%	84.1%	90.2%	92.7%	85.4%	89.0%	91.5%	84.1%	89.0%	90.2%	84.1%	87.8%	64.6%	86.6%	91.5%	93.9%
Tool T&V.8	78.0%	75.6%	84.1%	84.1%	78.0%	80.5%	82.9%	76.8%	86.6%	80.5%	89.0%	85.4%	84.1%	86.6%	87.8%	84.1%	90.2%	90.2%	82.9%	89.0%	93.9%	81.7%	86.6%	92.7%	81.7%	90.2%	67.1%	84.1%	89.0%	91.5%
Tool T&V.9	81.7%	76.8%	85.4%	85.4%	79.3%	81.7%	86.6%	78.0%	90.2%	84.1%	90.2%	86.6%	85.4%	90.2%	91.5%	85.4%	89.0%	91.5%	86.6%	90.2%	95.1%	85.4%	90.2%	93.9%	85.4%	89.0%	68.3%	87.8%	92.7%	90.2%
Tool T&V.10	78.0%	75.6%	81.7%	81.7%	78.0%	78.0%	85.4%	79.3%	91.5%	85.4%	86.6%	82.9%	81.7%	86.6%	87.8%	86.6%	85.4%	87.8%	85.4%	89.0%	89.0%	84.1%	86.6%	87.8%	81.7%	85.4%	69.5%	89.0%	89.0%	86.6%
Tool I&T.1	86.6%	79.3%	92.7%	87.8%	76.8%	86.6%	84.1%	80.5%	90.2%	81.7%	92.7%	91.5%	90.2%	92.7%	93.9%	90.2%	89.0%	89.0%	84.1%	90.2%	92.7%	80.5%	90.2%	93.9%	85.4%	84.1%	61.0%	85.4%	90.2%	90.2%
Tool PB.1	82.9%	82.9%	84.1%	84.1%	82.9%	87.8%	85.4%	76.8%	84.1%	85.4%	79.3%	82.9%	81.7%	86.6%	85.4%	84.1%	85.4%	87.8%	85.4%	79.3%	81.7%	84.1%	84.1%	82.9%	76.8%	75.6%	69.5%	84.1%	86.6%	81.7%
Tool PB.2	89.0%	79.3%	92.7%	90.2%	79.3%	86.6%	86.6%	82.9%	92.7%	84.1%	92.7%	91.5%	90.2%	92.7%	96.3%	92.7%	91.5%	91.5%	86.6%	92.7%	95.1%	82.9%	92.7%	96.3%	87.8%	86.6%	63.4%	87.8%	92.7%	92.7%
Tool PB.3	82.9%	78.0%	86.6%	86.6%	82.9%	82.9%	87.8%	76.8%	89.0%	82.9%	86.6%	87.8%	86.6%	91.5%	92.7%	89.0%	92.7%	95.1%	90.2%	86.6%	89.0%	86.6%	91.5%	90.2%	84.1%	82.9%	69.5%	86.6%	93.9%	89.0%
Tool Q.1	85.4%	75.6%	89.0%	89.0%	75.6%	85.4%	85.4%	79.3%	91.5%	82.9%	89.0%	87.8%	86.6%	91.5%	95.1%	89.0%	87.8%	90.2%	85.4%	89.0%	91.5%	81.7%	93.9%	92.7%	89.0%	85.4%	62.2%	86.6%	91.5%	91.5%
Tool Q.2	85.4%	75.6%	89.0%	89.0%	75.6%	85.4%	85.4%	79.3%	91.5%	82.9%	89.0%	87.8%	86.6%	91.5%	95.1%	89.0%	87.8%	90.2%	85.4%	89.0%	91.5%	81.7%	93.9%	92.7%	89.0%	85.4%	62.2%	86.6%	91.5%	91.5%
Tool Q.3	75.6%	70.7%	81.7%	81.7%	73.2%	80.5%	80.5%	76.8%	84.1%	82.9%	86.6%	82.9%	81.7%	84.1%	85.4%	79.3%	87.8%	87.8%	82.9%	84.1%	89.0%	81.7%	86.6%	87.8%	79.3%	90.2%	64.6%	84.1%	89.0%	89.0%
Tool Q.4	78.0%	75.6%	84.1%	84.1%	78.0%	82.9%	82.9%	79.3%	86.6%	82.9%	89.0%	87.8%	86.6%	86.6%	87.8%	86.6%	87.8%	87.8%	85.4%	86.6%	91.5%	81.7%	86.6%	90.2%	79.3%	87.8%	69.5%	84.1%	89.0%	84.1%
Tool Q.5	73.2%	73.2%	79.3%	84.1%	80.5%	82.9%	82.9%	74.4%	81.7%	78.0%	86.6%	82.9%	81.7%	81.7%	82.9%	79.3%	85.4%	85.4%	82.9%	84.1%	89.0%	81.7%	84.1%	87.8%	76.8%	82.9%	69.5%	84.1%	86.6%	84.1%
Tool Q.6	74.4%	72.0%	78.0%	82.9%	79.3%	81.7%	84.1%	73.2%	82.9%	79.3%	85.4%	81.7%	80.5%	82.9%	84.1%	78.0%	84.1%	86.6%	84.1%	82.9%	87.8%	82.9%	85.4%	86.6%	78.0%	81.7%	70.7%	85.4%	87.8%	85.4%
Tool Q.7	86.6%	76.8%	90.2%	87.8%	76.8%	84.1%	86.6%	80.5%	92.7%	84.1%	90.2%	89.0%	87.8%	92.7%	96.3%	90.2%	91.5%	93.9%	86.6%	90.2%	92.7%	82.9%	92.7%	93.9%	87.8%	86.6%	63.4%	87.8%	92.7%	95.1%
Tool I.1	78.0%	73.2%	81.7%	81.7%	80.5%	80.5%	82.9%	74.4%	84.1%	80.5%	81.7%	85.4%	84.1%	86.6%	87.8%	81.7%	85.4%	87.8%	82.9%	81.7%	86.6%	79.3%	86.6%	87.8%	79.3%	80.5%	72.0%	84.1%	89.0%	84.1%
Tool I.2	78.0%	75.6%	84.1%	84.1%	82.9%	82.9%	82.9%	76.8%	84.1%	80.5%	84.1%	87.8%	86.6%	86.6%	87.8%	84.1%	87.8%	87.8%	82.9%	86.6%	89.0%	79.3%	86.6%	90.2%	79.3%	85.4%	72.0%	84.1%	89.0%	84.1%
Tool I.3	78.0%	78.0%	81.7%	86.6%	85.4%	85.4%	87.8%	74.4%	81.7%	78.0%	81.7%	85.4%	84.1%	84.1%	85.4%	81.7%	87.8%	87.8%	85.4%	81.7%	86.6%	81.7%	86.6%	87.8%	76.8%	80.5%	72.0%	84.1%	89.0%	81.7%
Tool I.4	79.3%	74.4%	82.9%	85.4%	76.8%	81.7%	84.1%	75.6%	87.8%	81.7%	87.8%	84.1%	82.9%	87.8%	89.0%	82.9%	86.6%	89.0%	84.1%	90.2%	90.2%	82.9%	90.2%	89.0%	85.4%	89.0%	65.9%	85.4%	90.2%	87.8%
Tool I.5	78.0%	75.6%	81.7%	86.6%	80.5%	82.9%	87.8%	72.0%	84.1%	78.0%	84.1%	82.9%	81.7%	86.6%	87.8%	81.7%	87.8%	90.2%	87.8%	86.6%	89.0%	84.1%	89.0%	90.2%	81.7%	87.8%	69.5%	86.6%	91.5%	86.6%
Tool PS.1	68.3%	68.3%	76.8%	72.0%	65.9%	70.7%	73.2%	81.7%	81.7%	80.5%	72.0%	70.7%	72.0%	74.4%	78.0%	76.8%	70.7%	73.2%	68.3%	76.8%	74.4%	69.5%	76.8%	75.6%	74.4%	68.3%	62.2%	72.0%	74.4%	74.4%
Tool PS.2	82.9%	78.0%	89.0%	86.6%	80.5%	82.9%	85.4%	81.7%	91.5%	82.9%	89.0%	87.8%	86.6%	89.0%	92.7%	89.0%	87.8%	87.8%	82.9%	89.0%	91.5%	81.7%	89.0%	92.7%	84.1%	82.9%	69.5%	86.6%	89.0%	89.0%
Tool PS.3	81.7%	89.0%	80.5%	82.9%	86.6%	86.6%	81.7%	73.2%	70.7%	76.8%	70.7%	74.4%	73.2%	75.6%	74.4%	75.6%	79.3%	79.3%	79.3%	70.7%	73.2%	75.6%	78.0%	74.4%	68.3%	67.1%	68.3%	73.2%	78.0%	70.7%
Tool PS.4	74.4%	67.1%	78.0%	78.0%	67.1%	74.4%	74.4%	70.7%	82.9%	74.4%	80.5%	76.8%	78.0%	80.5%	84.1%	78.0%	76.8%	79.3%	74.4%	80.5%	82.9%	70.7%	82.9%	84.1%	80.5%	76.8%	78.0%	78.0%	80.5%	80.5%
Tool PS.5	85.4%	78.0%	89.0%	89.0%	78.0%	85.4%	87.8%	84.1%	96.3%	87.8%	91.5%	87.8%	86.6%	91.5%	95.1%	89.0%	87.8%	90.2%	85.4%	91.5%	93.9%	86.6%	93.9%	92.7%	89.0%	85.4%	64.6%	89.0%	91.5%	91.5%
Tool PS.6	84.1%	76.8%	90.2%	90.2%	76.8%	86.6%	84.1%	80.5%	90.2%	81.7%	90.2%	89.0%	87.8%	90.2%	93.9%	90.2%	89.0%	89.0%	86.6%	90.2%	92.7%	80.5%	92.7%	93.9%	87.8%	84.1%	63.4%	85.4%	90.2%	90.2%
Tool PS.7	87.8%	75.6%	89.0%	91.5%	78.0%	87.8%	87.8%	79.3%	91.5%	82.9%	89.0%	87.8%	86.6%	91.5%	95.1%	89.0%	90.2%	92.7%	87.8%	89.0%	91.5%	84.1%	96.3%	92.7%	89.0%	82.9%	62.2%	86.6%	93.9%	91.5%

	Tool R&C.16	Tool R&C.17	Tool R&C.18	Tool R&C.19	Tool R&C.20	Tool R&C.21	Tool R&C.22	Tool R&C.23	Tool R&C.24	Tool R&C.25	Tool R&C.26	Tool R&C.27	Tool R&C.28	Tool R&C.29	Tool R&C.30	Tool R&C.31	Tool R&C.32	Tool R&C.33	Tool R&C.34	Tool CD.1	Tool CD.2	Tool CD.3	Tool CD.4	Tool CD.5	Tool CD.6	Tool CD.7	Tool CD.8	Tool CD.9	Tool CD.10	Tool CD.11	Tool T&V.1
Tool MC.1	84.1%	85.4%	86.6%	85.4%	82.9%	82.9%	81.7%	82.9%	85.4%	78.0%	79.3%	79.3%	79.3%	84.1%	81.7%	81.7%	79.3%	80.5%	86.6%	84.1%	85.4%	80.5%	84.1%	85.4%	86.6%	82.9%	82.9%	86.6%	85.4%	85.4%	86.6%
Tool MC.2	79.3%	85.4%	76.8%	78.0%	75.6%	75.6%	74.4%	78.0%	80.5%	73.2%	72.0%	72.0%	72.0%	76.8%	74.4%	74.4%	72.0%	73.2%	86.6%	79.3%	75.6%	78.0%	84.1%	75.6%	76.8%	75.6%	78.0%	79.3%	75.6%	75.6%	76.8%
Tool MC.3	85.4%	72.0%	90.2%	89.0%	86.6%	86.6%	85.4%	89.0%	91.5%	84.1%	82.9%	82.9%	82.9%	87.8%	85.4%	87.8%	85.4%	86.6%	80.5%	87.8%	89.0%	93.9%	95.1%	89.0%	90.2%	86.6%	86.6%	90.2%	89.0%	89.0%	90.2%
Tool MC.4	90.2%	76.8%	92.7%	91.5%	89.0%	89.0%	90.2%	91.5%	93.9%	86.6%	85.4%	85.4%	85.4%	87.8%	85.4%	87.8%	85.4%	86.6%	85.4%	85.4%	86.6%	84.1%	87.8%	89.0%	87.8%	86.6%	89.0%	92.7%	89.0%	89.0%	87.8%
Tool MC.5	79.3%	92.7%	79.3%	80.5%	78.0%	75.6%	76.8%	78.0%	80.5%	75.6%	72.0%	72.0%	72.0%	76.8%	74.4%	76.8%	74.4%	75.6%	93.9%	79.3%	75.6%	73.2%	72.0%	75.6%	76.8%	78.0%	80.5%	79.3%	78.0%	78.0%	76.8%
Tool MC.6	89.0%	80.5%	89.0%	87.8%	85.4%	85.4%	86.6%	87.8%	90.2%	82.9%	81.7%	81.7%	81.7%	84.1%	81.7%	84.1%	81.7%	82.9%	84.1%	84.1%	82.9%	80.5%	86.6%	85.4%	84.1%	85.4%	87.8%	89.0%	85.4%	85.4%	84.1%
Tool MC.7	84.1%	85.4%	89.0%	90.2%	85.4%	85.4%	86.6%	85.4%	87.8%	80.5%	81.7%	81.7%	81.7%	86.6%	84.1%	81.7%	79.3%	80.5%	91.5%	89.0%	85.4%	80.5%	79.3%	85.4%	86.6%	85.4%	87.8%	89.0%	85.4%	85.4%	86.6%
Tool P.1	70.7%	64.6%	80.5%	79.3%	76.8%	79.3%	78.0%	79.3%	81.7%	79.3%	75.6%	75.6%	75.6%	80.5%	78.0%	78.0%	75.6%	79.3%	73.2%	85.4%	81.7%	89.0%	82.9%	81.7%	82.9%	81.7%	81.7%	80.5%	79.3%	79.3%	82.9%
Tool P.2	82.9%	72.0%	92.7%	91.5%	89.0%	91.5%	90.2%	89.0%	91.5%	89.0%	87.8%	87.8%	87.8%	92.7%	90.2%	87.8%	85.4%	89.0%	80.5%	95.1%	93.9%	89.0%	82.9%	93.9%	95.1%	91.5%	91.5%	92.7%	91.5%	91.5%	95.1%
Tool P.3	79.3%	73.2%	84.1%	85.4%	82.9%	85.4%	84.1%	82.9%	85.4%	82.9%	81.7%	81.7%	81.7%	86.6%	84.1%	79.3%	76.8%	80.5%	76.8%	89.0%	85.4%	87.8%	86.6%	85.4%	86.6%	85.4%	87.8%	86.6%	82.9%	82.9%	86.6%
Tool P.4	80.5%	67.1%	90.2%	89.0%	86.6%	91.5%	90.2%	91.5%	91.5%	89.0%	87.8%	87.8%	87.8%	92.7%	90.2%	90.2%	90.2%	91.5%	80.5%	87.8%	89.0%	89.0%	82.9%	91.5%	92.7%	86.6%	86.6%	90.2%	89.0%	89.0%	95.1%
Tool P.5	84.1%	73.2%	89.0%	90.2%	87.8%	87.8%	86.6%	90.2%	92.7%	85.4%	84.1%	84.1%	84.1%	89.0%	86.6%	86.6%	86.6%	85.4%	84.1%	86.6%	87.8%	85.4%	84.1%	87.8%	89.0%	85.4%	87.8%	91.5%	87.8%	87.8%	89.0%
Tool P.6	82.9%	72.0%	87.8%	89.0%	86.6%	86.6%	85.4%	89.0%	91.5%	84.1%	82.9%	82.9%	82.9%	87.8%	85.4%	85.4%	85.4%	84.1%	82.9%	85.4%	86.6%	84.1%	82.9%	86.6%	87.8%	84.1%	86.6%	90.2%	86.6%	86.6%	87.8%
Tool P.7	87.8%	74.4%	92.7%	93.9%	91.5%	91.5%	90.2%	91.5%	93.9%	86.6%	87.8%	87.8%	87.8%	92.7%	90.2%	87.8%	85.4%	86.6%	82.9%	90.2%	91.5%	86.6%	87.8%	91.5%	92.7%	89.0%	91.5%	95.1%	91.5%	91.5%	92.7%
Tool P.8	86.6%	73.2%	96.3%	95.1%	92.7%	92.7%	91.5%	92.7%	95.1%	87.8%	89.0%	89.0%	89.0%	93.9%	91.5%	91.5%	89.0%	90.2%	84.1%	93.9%	95.1%	90.2%	86.6%	95.1%	96.3%	92.7%	92.7%	96.3%	95.1%	95.1%	96.3%
Tool R&C.1	82.9%	72.0%	90.2%	89.0%	93.9%	89.0%	87.8%	91.5%	91.5%	93.9%	85.4%	85.4%	85.4%	87.8%	87.8%	87.8%	85.4%	89.0%	82.9%	95.1%	93.9%	89.0%	82.9%	89.0%	92.7%	96.3%	93.9%	90.2%	91.5%	91.5%	90.2%
Tool R&C.2	91.5%	75.6%	91.5%	92.7%	90.2%	87.8%	89.0%	90.2%	92.7%	87.8%	86.6%	86.6%	86.6%	91.5%	89.0%	89.0%	86.6%	90.2%	89.0%	86.6%	87.8%	87.8%	86.6%	87.8%	89.0%	87.8%	90.2%	91.5%	92.7%	92.7%	89.0%
Tool R&C.3	93.9%	78.0%	93.9%	95.1%	92.7%	90.2%	91.5%	90.2%	92.7%	87.8%	89.0%	89.0%	89.0%	93.9%	91.5%	89.0%	86.6%	90.2%	89.0%	89.0%	90.2%	85.4%	84.1%	90.2%	91.5%	90.2%	92.7%	93.9%	95.1%	95.1%	91.5%
Tool R&C.4	91.5%	78.0%	89.0%	90.2%	90.2%	90.2%	91.5%	90.2%	90.2%	85.4%	86.6%	86.6%	86.6%	86.6%	86.6%	84.1%	81.7%	85.4%	86.6%	84.1%	85.4%	80.5%	81.7%	85.4%	89.0%	85.4%	87.8%	89.0%	87.8%	87.8%	86.6%
Tool R&C.5	80.5%	67.1%	90.2%	89.0%	86.6%	91.5%	90.2%	91.5%	91.5%	91.5%	87.8%	87.8%	87.8%	92.7%	90.2%	90.2%	87.8%	91.5%	80.5%	90.2%	91.5%	89.0%	82.9%	91.5%	92.7%	89.0%	89.0%	90.2%	89.0%	89.0%	95.1%
Tool R&C.6	82.9%	69.5%	92.7%	91.5%	89.0%	93.9%	92.7%	93.9%	93.9%	91.5%	92.7%	92.7%	92.7%	95.1%	95.1%	95.1%	92.7%	96.3%	82.9%	90.2%	91.5%	91.5%	85.4%	93.9%	95.1%	89.0%	89.0%	92.7%	91.5%	91.5%	97.6%
Tool R&C.7	85.4%	79.3%	85.4%	86.6%	84.1%	84.1%	85.4%	81.7%	84.1%	81.7%	80.5%	80.5%	80.5%	85.4%	82.9%	78.0%	75.6%	81.7%	82.9%	85.4%	81.7%	81.7%	78.0%	84.1%	85.4%	84.1%	86.6%	85.4%	84.1%	84.1%	85.4%
Tool R&C.8	90.2%	74.4%	97.6%	96.3%	93.9%	93.9%	95.1%	93.9%	96.3%	89.0%	90.2%	90.2%	90.2%	92.7%	90.2%	90.2%	87.8%	89.0%	85.4%	90.2%	91.5%	86.6%	85.4%	93.9%	92.7%	91.5%	93.9%	97.6%	93.9%	93.9%	92.7%
Tool R&C.9	84.1%	70.7%	93.9%	92.7%	90.2%	92.7%	91.5%	95.1%	95.1%	90.2%	91.5%	91.5%	91.5%	93.9%	93.9%	96.3%	93.9%	95.1%	84.1%	91.5%	92.7%	90.2%	86.6%	92.7%	93.9%	90.2%	90.2%	93.9%	92.7%	92.7%	96.3%
Tool R&C.10	80.5%	67.1%	90.2%	86.6%	86.6%	86.6%	85.4%	86.6%	86.6%	84.1%	82.9%	82.9%	82.9%	87.8%	85.4%	85.4%	82.9%	84.1%	75.6%	85.4%	86.6%	81.7%	78.0%	89.0%	87.8%	86.6%	86.6%	90.2%	89.0%	89.0%	90.2%
Tool R&C.11	81.7%	63.4%	84.1%	85.4%	85.4%	92.7%	91.5%	92.7%	90.2%	87.8%	96.3%	96.3%	96.3%	91.5%	93.9%	91.5%	89.0%	92.7%	76.8%	81.7%	82.9%	82.9%	81.7%	85.4%	89.0%	80.5%	82.9%	86.6%	85.4%	85.4%	89.0%
Tool R&C.12	63.4%	76.8%	63.4%	64.6%	67.1%	64.6%	63.4%	64.6%	64.6%	62.2%	63.4%	63.4%	63.4%	63.4%	65.9%	63.4%	63.4%	62.2%	75.6%	65.9%	62.2%	57.3%	56.1%	64.6%	65.9%	64.6%	67.1%	65.9%	64.6%	64.6%	63.4%
Tool R&C.13	82.9%	79.3%	87.8%	86.6%	84.1%	86.6%	85.4%	86.6%	86.6%	81.7%	82.9%	82.9%	82.9%	87.8%	85.4%	85.4%	82.9%	84.1%	85.4%	87.8%	86.6%	81.7%	78.0%	89.0%	87.8%	84.1%	84.1%	87.8%	86.6%	86.6%	90.2%
Tool R&C.14	92.7%	76.8%	95.1%	96.3%	91.5%	93.9%	95.1%	93.9%	96.3%	86.6%	90.2%	90.2%	90.2%	92.7%	90.2%	90.2%	87.8%	89.0%	87.8%	90.2%	91.5%	86.6%	85.4%	91.5%	92.7%	89.0%	91.5%	95.1%	91.5%	91.5%	92.7%
Tool R&C.15	87.8%	69.5%	92.7%	91.5%	89.0%	93.9%	92.7%	93.9%	93.9%	86.6%	92.7%	92.7%	92.7%	95.1%	92.7%	95.1%	95.1%	93.9%	80.5%	90.2%	91.5%	86.6%	82.9%	91.5%	92.7%	89.0%	89.0%	92.7%	93.9%	93.9%	95.1%
Tool R&C.16	100%	81.7%	87.8%	89.0%	86.6%	86.6%	87.8%	86.6%	89.0%	81.7%	85.4%	85.4%	85.4%	87.8%	85.4%	85.4%	82.9%	86.6%	82.9%	82.9%	84.1%	79.3%	85.4%	84.1%	85.4%	84.1%	86.6%	87.8%	89.0%	89.0%	85.4%
Tool R&C.17	81.7%	100%	74.4%	75.6%	73.2%	70.7%	72.0%	70.7%	73.2%	68.3%	67.1%	67.1%	67.1%	72.0%	69.5%	69.5%	67.1%	68.3%	86.6%	74.4%	70.7%	65.9%	72.0%	70.7%	72.0%	73.2%	75.6%	74.4%	73.2%	73.2%	72.0%
Tool R&C.18	87.8%	74.4%	100%	96.3%	93.9%	91.5%	92.7%	91.5%	93.9%	89.0%	87.8%	87.8%	87.8%	92.7%	90.2%	90.2%	87.8%	89.0%	85.4%	92.7%	93.9%	89.0%	85.4%	96.3%	95.1%	93.9%	93.9%	97.6%	96.3%	96.3%	95.1%
Tool R&C.19	89.0%	75.6%	96.3%	100%	92.7%	92.7%	93.9%	92.7%	95.1%	87.8%	89.0%	89.0%	89.0%	93.9%	91.5%	89.0%	86.6%	87.8%	86.6%	91.5%	92.7%	87.8%	86.6%	92.7%	93.9%	90.2%	92.7%	96.3%	92.7%	92.7%	93.9%
Tool R&C.20	86.6%	73.2%	93.9%	92.7%	100%	92.7%	91.5%	92.7%	92.7%	95.1%	89.0%	89.0%	89.0%	91.5%	91.5%	86.6%	84.1%	87.8%	84.1%	91.5%	92.7%	87.8%	84.1%	92.7%	93.9%	95.1%	95.1%	96.3%	95.1%	95.1%	91.5%
Tool R&C.21	86.6%	70.7%	91.5%	92.7%	92.7%	100%	98.8%	97.6%	95.1%	92.7%	96.3%	96.3%	96.3%	96.3%	96.3%	91.5%	89.0%	92.7%	81.7%	89.0%	90.2%	87.8%	84.1%	92.7%	96.3%	87.8%	90.2%	93.9%	90.2%	90.2%	96.3%
Tool R&C.22	87.8%	72.0%	92.7%	93.9%	91.5%	98.8%	100%	96.3%	93.9%	91.5%	95.1%	95.1%	95.1%	95.1%	95.1%	90.2%	87.8%	91.5%	82.9%	87.8%	89.0%	86.6%	82.9%	91.5%	95.1%	86.6%	89.0%	92.7%	89.0%	89.0%	95.1%
Tool R&C.23	86.6%	70.7%	91.5%	92.7%	92.7%	97.6%	96.3%	100%	97.6%	92.7%	93.9%	93.9%	93.9%	93.9%	93.9%	93.9%	91.5%	92.7%	84.1%	89.0%	90.2%	87.8%	86.6%	90.2%	93.9%	87.8%	90.2%	93.9%	90.2%	90.2%	93.9%
Tool R&C.24	89.0%	73.2%	93.9%	95.1%	92.7%	95.1%	93.9%	97.6%	100%	90.2%	91.5%	91.5%	91.5%	93.9%	91.5%	93.9%	91.5%	92.7%	86.6%	91.5%	92.7%	90.2%	89.0%	92.7%	93.9%	90.2%	92.7%	96.3%	92.7%	92.7%	93.9%
Tool R&C.25	81.7%	68.3%	89.0%	87.8%	95.1%	92.7%	91.5%	92.7%	90.2%	100%	89.0%	89.0%	89.0%	91.5%	91.5%	86.6%	84.1%	90.2%	81.7%	89.0%	90.2%	87.8%	81.7%	90.2%	91.5%	92.7%	92.7%	91.5%	90.2%	90.2%	91.5%
Tool R&C.26	85.4%	67.1%	87.8%	89.0%	89.0%	96.3%	95.1%	93.9%	91.5%	89.0%	100%	100%	100%	95.1%	97.6%	92.7%	90.2%	93.9%	78.0%	85.4%	86.6%	84.1%	82.9%	89.0%	92.7%	84.1%	86.6%	90.2%	89.0%	89.0%	92.7%
Tool R&C.27	85.4%	67.1%	87.8%	89.0%	89.0%	96.3%	95.1%	93.9%	91.5%	89.0%	100%	100%	100%	95.1%	97.6%	92.7%	90.2%	93.9%	78.0%	85.4%	86.6%	84.1%	82.9%	89.0%	92.7%	84.1%	86.6%	90.2%	89.0%	89.0%	92.7%
Tool R&C.28	85.4%	67.1%	87.8%	89.0%	89.0%	96.3%	95.1%	93.9%	91.5%	89.0%	100%	100%	100%	95.1%	97.6%	92.7%	90.2%	93.9%	78.0%	85.4%	86.6%	84.1%	82.9%	89.0%	92.7%	84.1%	86.6%	90.2%	89.0%	89.0%	92.7%
Tool R&C.29	87.8%	72.0%	92.7%	93.9%	91.5%	96.3%	95.1%	93.9%	93.9%	91.5%	95.1%	95.1%	95.1%	100%	97.6%	92.7%	90.2%	93.9%	82.9%	90.2%	91.5%	89.0%	85.4%	93.9%	95.1%	89.0%	91.5%	95.1%	93.9%	93.9%	97.6%
Tool R&C.30	85.4%	69.5%	90.2%	91.5%	91.5%	96.3%	95.1%	93.9%	91.5%	91.5%	97.6%	97.6%	97.6%	97.6%	100%	92.7%	90.2%	93.9%	80.5%	87.8%	89.0%	86.6%	82.9%	91.5%	95.1%	86.6%	89.0%	92.7%	91.5%	91.5%	95.1%
Tool R&C.31	85.4%	69.5%	90.2%	89.0%	86.6%	91.5%	90.2%	93.9%	93.9%	86.6%	92.7%	92.7%	92.7%	92.7%	92.7%	100%	97.6%	96.3%	80.5%	87.8%	89.0%	86.6%	82.9%	89.0%	90.2%	86.6%	86.6%	90.2%	91.5%	91.5%	92.7%
Tool R&C.32	82.9%	67.1%	87.8%	86.6%	84.1%	89.0%	87.8%	91.5%	91.5%	84.1%	90.2%	90.2%	90.2%	90.2%	90.2%	97.6%	100%	93.9%	78.0%	85.4%	86.6%	84.1%	80.5%	86.6%	87.8%	84.1%	84.1%	87.8%	89.0%	89.0%	90.2%
Tool R&C.33	86.6%	68.3%	89.0%	87.8%	87.8%	92.7%	91.5%	92.7%	92.7%	90.2%	93.9%	93.9%	93.9%	93.9%	93.9%	96.3%	93.9%	100%	81.7%	86.6%	87.8%	87.8%	81.7%	90.2%	91.5%	87.8%	87.8%	89.0%	92.7%	92.7%	93.9%
Tool R&C.34	82.9%	86.6%	85.4%	86.6%	84.1%	81.7%	82.9%	84.1%	86.6%	81.7%	78.0%	78.0%	78.0%	82.9%	80.5%	80.5%	78.0%	81.7%	100%	80.5%	81.7%	79.3%	78.0%	81.7%	82.9%	81.7%	84.1%	85.4%	84.1%	84.1%	82.9%
Tool CD.1	82.9%	74.4%	92.7%	91.5%	91.5%	89.0%	87.8%	89.0%	91.5%	89.0%	85.4%	85.4%	85.4%	90.2%	87.8%	87.8%	85.4%	86.6%	80.5%	100%	96.3%	89.0%	82.9%	91.5%	92.7%	96.3%	93.9%	92.7%	91.5%	91.5%	92.7%
Tool CD.2	84.1%	70.7%	93.9%	92.7%	92.7%	90.2%	89.0%	90.2%	92.7%	90.2%	86.6%	86.6%	86.6%	91.5%	89.0%	89.0%	86.6%	87.8%	81.7%	96.3%	100%	90.2%	84.1%	92.7%	93.9%	95.1%	92.7%	93.9%	92.7%	92.7%	93.9%
Tool CD.3	79.3%	65.9%	89.0%	87.8%	87.8%	87.8%	86.6%	87.8%	90.2%	87.8%	84.1%	84.1%	84.1%	89.0%	86.6%	86.6%	84.1%	87.8%	79.3%	89.0%	90.2%	100%	91.5%	90.2%	91.5%	87.8%	85.4%	89.0%	87.8%	87.8%	91.5%
Tool CD.4	85.4%	72.0%	85.4%	86.6%	84.1%	84.1%	82.9%	86.6%	89.0%	81.7%	82.9%	82.9%	82.9%	85.4%	82.9%	82.9%	80.5%	81.7%	78.0%	82.9%	84.1%	91.5%	100%	84.1%	85.4%	81.7%	84.1%	87.8%	84.1%	84.1%	85.4%
Tool CD.5	84.1%	70.7%	96.3%	92.7%	92.7%	92.7%	91.5%	90.2%	92.7%	90.2%	89.0%	89.0%	89.0%	93.9%	91.5%	89.0%	86.6%	90.2%	81.7%	91.5%	92.7%	90.2%	84.1%	100%	96.3%	92.7%	92.7%	96.3%	95.1%	95.1%	96.3%
Tool CD.6	85.4%	72.0%	95.1%	93.9%	93.9%	96.3%	95.1%	93.9%	93.9%	91.5%	92.7%	92.7%	92.7%	95.1%	95.1%	90.2%	87.8%	91.5%	82.9%	92.7%	93.9%	91.5%	85.4%	96.3%	100%	91.5%	91.5%	95.1%	93.9%	93.9%	97.6%
Tool CD.7	84.1%	73.2%	93.9%	90.2%	95.1%	87.8%	86.6%	87.8%	90.2%	92.7%	84.1%	84.1%	84.1%	89.0%	86.6%	86.6%	84.1%	87.8%	81.7%	96.3%	95.1%	87.8%	81.7%	92.7%	91.5%	100%	97.6%	93.9%	95.1%	95.1%	91.5%
Tool CD.8	86.6%	75.6%	93.9%	92.7%	95.1%	90.2%	89.0%	90.2%	92.7%	92.7%	86.6%	86.6%	86.6%	91.5%	89.0%	86.6%	84.1%	87.8%	84.1%	93.9%	92.7%	85.4%	84.1%	92.7%	91.5%	97.6%	100%	96.3%	95.1%	95.1%	91.5%
Tool CD.9	87.8%	74.4%	97.6%	96.3%	96.3%	93.9%	92.7%	93.9%	96.3%	91.5%	90.2%	90.2%	90.2%	95.1%	92.7%	90.2%	87.8%	89.0%	85.4%	92.7%	93.9%	89.0%	87.8%	96.3%	95.1%	93.9%	96.3%	100%	96.3%	96.3%	95.1%
Tool CD.10	89.0%	73.2%	96.3%	92.7%	95.1%	90.2%	89.0%	90.2%	92.7%	90.2%	89.0%	89.0%	89.0%	93.9%	91.5%	91.5%	89.0%	92.7%	84.1%	91.5%	92.7%	87.8%	84.1%	95.1%	93.9%	95.1%	95.1%	96.3%	100%	100%	93.9%
Tool CD.11	89.0%	73.2%	96.3%	92.7%	95.1%	90.2%	89.0%	90.2%	92.7%	90.2%	89.0%	89.0%	89.0%	93.9%	91.5%	91.5%	89.0%	92.7%	84.1%	91.5%	92.7%	87.8%	84.1%	95.1%	93.9%	95.1%	95.1%	96.3%	100%	100%	93.9%
Tool T&V.1	85.4%	72.0%	95.1%	93.9%	91.5%	96.3%	95.1%	93.9%	93.9%	91.5%	92.7%	92.7%	92.7%	97.6%	95.1%	92.7%	90.2%	93.9%	82.9%	92.7%	93.9%	91.5%	85.4%	96.3%	97.6%	91.5%	91.5%	95.1%	93.9%	93.9%	100%
Tool T&V.2	86.6%	70.7%	89.0%	90.2%	95.1%	92.7%	91.5%	90.2%	90.2%	95.1%	91.5%	91.5%	91.5%	93.9%	93.9%	86.6%	84.1%	90.2%	81.7%	91.5%	92.7%	87.8%	81.7%	90.2%	93.9%	92.7%	92.7%	91.5%	92.7%	92.7%	91.5%
Tool T&V.3	84.1%	70.7%	91.5%	92.7%	90.2%	92.7%	91.5%	95.1%	95.1%	90.2%	91.5%	91.5%	91.5%	93.9%	93.9%	93.9%	91.5%	92.7%	84.1%	89.0%	90.2%	87.8%	86.6%	90.2%	91.5%	87.8%	90.2%	93.9%	90.2%	90.2%	93.9%
Tool T&V.4	84.1%	68.3%	93.9%	90.2%	90.2%	92.7%	91.5%	90.2%	90.2%	90.2%	91.5%	91.5%	91.5%	96.3%	93.9%	91.5%	89.0%	92.7%	79.3%	89.0%	90.2%	87.8%	81.7%	95.1%	93.9%	90.2%	90.2%	93.9%	95.1%	95.1%	96.3%
Tool T&V.5	85.4%	69.5%	95.1%	91.5%	91.5%	91.5%	90.2%	91.5%	91.5%	89.0%	90.2%	90.2%	90.2%	95.1%	92.7%	92.7%	92.7%	91.5%	80.5%	90.2%	91.5%	86.6%	82.9%	93.9%	92.7%	91.5%	91.5%	95.1%	96.3%	96.3%	95.1%
Tool T&V.6	84.1%	70.7%	89.0%	87.8%	85.4%	90.2%	89.0%	87.8%	87.8%	85.4%	89.0%	89.0%	89.0%	93.9%	91.5%	91.5%	91.5%	90.2%	79.3%	86.6%	87.8%	85.4%	79.3%	90.2%	91.5%	85.4%	85.4%	89.0%	90.2%	90.2%	93.9%
Tool T&V.7	86.6%	70.7%	89.0%	90.2%	87.8%	92.7%	91.5%	90.2%	90.2%	87.8%	91.5%	91.5%	91.5%	96.3%	93.9%	89.0%	89.0%	90.2%	81.7%	86.6%	87.8%	85.4%	81.7%	90.2%	91.5%	85.4%	87.8%	91.5%	90.2%	90.2%	93.9%
Tool T&V.8	84.1%	70.7%	86.6%	87.8%	85.4%	90.2%	89.0%	90.2%	90.2%	87.8%	91.5%	91.5%	91.5%	93.9%	93.9%	93.9%	93.9%	92.7%	81.7%	84.1%	85.4%	85.4%	81.7%	87.8%	89.0%	82.9%	85.4%	89.0%	87.8%	87.8%	91.5%
Tool T&V.9	85.4%	74.4%	90.2%	91.5%	89.0%	93.9%	92.7%	91.5%	91.5%	89.0%	92.7%	92.7%	92.7%	95.1%	95.1%	92.7%	90.2%	91.5%	82.9%	87.8%	89.0%	86.6%	82.9%	91.5%	92.7%	86.6%	89.0%	92.7%	89.0%	89.0%	95.1%
Tool T&V.10	81.7%	73.2%	86.6%	87.8%	87.8%	92.7%	91.5%	90.2%	87.8%	90.2%	89.0%	89.0%	89.0%	91.5%	91.5%	84.1%	81.7%	85.4%	79.3%	89.0%	87.8%	82.9%	79.3%	90.2%	91.5%	85.4%	87.8%	89.0%	85.4%	85.4%	91.5%
Tool I&T.1	85.4%	72.0%	92.7%	91.5%	89.0%	89.0%	87.8%	91.5%	93.9%	86.6%	85.4%	85.4%	85.4%	90.2%	87.8%	90.2%	87.8%	89.0%	82.9%	90.2%	91.5%	89.0%	87.8%	91.5%	92.7%	89.0%	89.0%	92.7%	91.5%	91.5%	92.7%
Tool PB.1	89.0%	87.8%	84.1%	85.4%	85.4%	82.9%	81.7%	82.9%	85.4%	80.5%	79.3%	79.3%	79.3%	84.1%	81.7%	79.3%	76.8%	80.5%	81.7%	86.6%	82.9%	78.0%	84.1%	82.9%	84.1%	85.4%	87.8%	86.6%	85.4%	85.4%	84.1%
Tool PB.2	85.4%	74.4%	95.1%	93.9%	91.5%	91.5%	90.2%	93.9%	96.3%	89.0%	87.8%	87.8%	87.8%	92.7%	90.2%	92.7%	90.2%	91.5%	85.4%	92.7%	93.9%	91.5%	87.8%	93.9%	95.1%	91.5%	91.5%	95.1%	93.9%	93.9%	95.1%
Tool PB.3	89.0%	78.0%	91.5%	92.7%	92.7%	90.2%	89.0%	90.2%	92.7%	87.8%	86.6%	86.6%	86.6%	91.5%	89.0%	86.6%	84.1%	87.8%	86.6%	89.0%	90.2%	85.4%	84.1%	90.2%	91.5%	90.2%	92.7%	93.9%	92.7%	92.7%	91.5%
Tool Q.1	84.1%	70.7%	96.3%	92.7%	92.7%	90.2%	89.0%	90.2%	92.7%	87.8%	89.0%	89.0%	89.0%	91.5%	89.0%	89.0%	86.6%	87.8%	81.7%	91.5%	92.7%	87.8%	86.6%	95.1%	93.9%	92.7%	92.7%	96.3%	95.1%	95.1%	93.9%
Tool Q.2	84.1%	70.7%	96.3%	92.7%	92.7%	90.2%	89.0%	90.2%	92.7%	87.8%	89.0%	89.0%	89.0%	91.5%	89.0%	89.0%	86.6%	87.8%	81.7%	91.5%	92.7%	87.8%	86.6%	95.1%	93.9%	92.7%	92.7%	96.3%	95.1%	95.1%	93.9%
Tool Q.3	84.1%	68.3%	84.1%	85.4%	82.9%	90.2%	89.0%	87.8%	87.8%	82.9%	93.9%	93.9%	93.9%	91.5%	91.5%	89.0%	86.6%	90.2%	79.3%	81.7%	82.9%	82.9%	81.7%	85.4%	86.6%	80.5%	82.9%	86.6%	85.4%	85.4%	89.0%
Tool Q.4	81.7%	70.7%	86.6%	90.2%	87.8%	90.2%	89.0%	90.2%	90.2%	87.8%	89.0%	89.0%	89.0%	89.0%	91.5%	86.6%	84.1%	87.8%	84.1%	84.1%	85.4%	85.4%	81.7%	87.8%	91.5%	82.9%	85.4%	89.0%	85.4%	85.4%	89.0%
Tool Q.5	79.3%	73.2%	84.1%	85.4%	80.5%	85.4%	86.6%	85.4%	85.4%	82.9%	84.1%	84.1%	84.1%	86.6%	86.6%	86.6%	86.6%	85.4%	84.1%	79.3%	80.5%	80.5%	76.8%	82.9%	84.1%	78.0%	80.5%	84.1%	80.5%	80.5%	86.6%
Tool Q.6	80.5%	74.4%	85.4%	86.6%	81.7%	86.6%	87.8%	84.1%	84.1%	81.7%	85.4%	85.4%	85.4%	87.8%	87.8%	85.4%	85.4%	84.1%	82.9%	80.5%	81.7%	79.3%	75.6%	84.1%	85.4%	79.3%	81.7%	85.4%	81.7%	81.7%	87.8%
Tool Q.7	87.8%	72.0%	95.1%	93.9%	91.5%	91.5%	90.2%	91.5%	93.9%	86.6%	90.2%	90.2%	90.2%	95.1%	92.7%	92.7%	90.2%	91.5%	82.9%	92.7%	93.9%	89.0%	85.4%	93.9%	95.1%	91.5%	91.5%	95.1%	96.3%	96.3%	95.1%
Tool I.1	81.7%	75.6%	86.6%	87.8%	85.4%	85.4%	84.1%	85.4%	87.8%	80.5%	84.1%	84.1%	84.1%	86.6%	86.6%	86.6%	84.1%	82.9%	81.7%	84.1%	85.4%	80.5%	79.3%	85.4%	86.6%	82.9%	85.4%	89.0%	85.4%	85.4%	86.6%
Tool I.2	81.7%	75.6%	86.6%	87.8%	85.4%	85.4%	84.1%	87.8%	90.2%	82.9%	84.1%	84.1%	84.1%	86.6%	86.6%	89.0%	86.6%	85.4%	84.1%	84.1%	85.4%	82.9%	81.7%	85.4%	86.6%	82.9%	85.4%	89.0%	85.4%	85.4%	86.6%
Tool I.3	81.7%	78.0%	86.6%	87.8%	82.9%	82.9%	84.1%	85.4%	87.8%	80.5%	81.7%	81.7%	81.7%	84.1%	84.1%	86.6%	84.1%	82.9%	89.0%	81.7%	82.9%	80.5%	79.3%	82.9%	84.1%	80.5%	82.9%	86.6%	82.9%	82.9%	84.1%
Tool I.4	82.9%	72.0%	90.2%	89.0%	89.0%	91.5%	90.2%	89.0%	89.0%	89.0%	90.2%	90.2%	90.2%	92.7%	90.2%	87.8%	85.4%	86.6%	80.5%	85.4%	86.6%	84.1%	82.9%	91.5%	90.2%	86.6%	89.0%	92.7%	89.0%	89.0%	92.7%
Tool I.5	84.1%	75.6%	89.0%	90.2%	85.4%	87.8%	89.0%	87.8%	87.8%	82.9%	89.0%	89.0%	89.0%	89.0%	89.0%	89.0%	86.6%	85.4%	84.1%	84.1%	85.4%	80.5%	81.7%	85.4%	86.6%	82.9%	85.4%	89.0%	85.4%	85.4%	89.0%
Tool PS.1	67.1%	61.0%	79.3%	75.6%	75.6%	73.2%	72.0%	73.2%	75.6%	73.2%	69.5%	69.5%	69.5%	74.4%	72.0%	72.0%	69.5%	70.7%	64.6%	81.7%	80.5%	78.0%	74.4%	78.0%	76.8%	80.5%	80.5%	79.3%	78.0%	78.0%	76.8%
Tool PS.2	81.7%	73.2%	91.5%	90.2%	87.8%	87.8%	86.6%	90.2%	92.7%	85.4%	84.1%	84.1%	84.1%	89.0%	86.6%	89.0%	86.6%	87.8%	81.7%	91.5%	90.2%	87.8%	84.1%	90.2%	91.5%	87.8%	87.8%	91.5%	90.2%	90.2%	91.5%
Tool PS.3	80.5%	86.6%	78.0%	76.8%	76.8%	72.0%	73.2%	74.4%	76.8%	74.4%	68.3%	68.3%	68.3%	73.2%	70.7%	73.2%	70.7%	72.0%	87.8%	73.2%	72.0%	76.8%	82.9%	74.4%	73.2%	76.8%	79.3%	78.0%	76.8%	76.8%	73.2%
Tool PS.4	73.2%	62.2%	85.4%	81.7%	81.7%	79.3%	78.0%	79.3%	81.7%	76.8%	78.0%	78.0%	78.0%	80.5%	80.5%	80.5%	78.0%	79.3%	70.7%	80.5%	81.7%	76.8%	73.2%	86.6%	82.9%	81.7%	81.7%	85.4%	84.1%	84.1%	82.9%
Tool PS.5	84.1%	73.2%	96.3%	92.7%	92.7%	92.7%	91.5%	90.2%	92.7%	90.2%	89.0%	89.0%	89.0%	93.9%	91.5%	89.0%	86.6%	90.2%	81.7%	93.9%	92.7%	90.2%	84.1%	97.6%	96.3%	92.7%	92.7%	96.3%	95.1%	95.1%	96.3%
Tool PS.6	82.9%	69.5%	95.1%	91.5%	91.5%	89.0%	87.8%	91.5%	93.9%	89.0%	85.4%	85.4%	85.4%	90.2%	87.8%	90.2%	87.8%	89.0%	82.9%	90.2%	91.5%	89.0%	85.4%	93.9%	92.7%	91.5%	91.5%	95.1%	93.9%	93.9%	92.7%
Tool PS.7	86.6%	75.6%	98.8%	95.1%	92.7%	90.2%	91.5%	90.2%	92.7%	87.8%	86.6%	86.6%	86.6%	91.5%	89.0%	89.0%	86.6%	87.8%	84.1%	91.5%	92.7%	87.8%	84.1%	95.1%	93.9%	92.7%	92.7%	96.3%	95.1%	95.1%	93.9%

	Tool T&V.2	Tool T&V.3	Tool T&V.4	Tool T&V.5	Tool T&V.6	Tool T&V.7	Tool T&V.8	Tool T&V.9	Tool T&V.10	Tool I&T.1	Tool PB.1	Tool PB.2	Tool PB.3	Tool Q.1	Tool Q.2	Tool Q.3	Tool Q.4	Tool Q.5	Tool Q.6	Tool Q.7	Tool I.1	Tool I.2	Tool I.3	Tool I.4	Tool I.5	Tool PS.1	Tool PS.2	Tool PS.3	Tool PS.4	Tool PS.5	Tool PS.6	Tool PS.7
Tool MC.1	80.5%	82.9%	82.9%	84.1%	80.5%	80.5%	78.0%	81.7%	78.0%	86.6%	82.9%	89.0%	82.9%	85.4%	85.4%	75.6%	78.0%	73.2%	74.4%	86.6%	78.0%	78.0%	78.0%	79.3%	78.0%	68.3%	82.9%	81.7%	74.4%	85.4%	84.1%	87.8%
Tool MC.2	73.2%	78.0%	73.2%	74.4%	73.2%	75.6%	75.6%	76.8%	75.6%	79.3%	82.9%	79.3%	78.0%	75.6%	75.6%	70.7%	75.6%	73.2%	72.0%	76.8%	73.2%	75.6%	78.0%	74.4%	75.6%	68.3%	78.0%	89.0%	67.1%	78.0%	76.8%	75.6%
Tool MC.3	84.1%	89.0%	86.6%	87.8%	84.1%	84.1%	84.1%	85.4%	81.7%	92.7%	84.1%	92.7%	86.6%	89.0%	89.0%	81.7%	84.1%	79.3%	78.0%	90.2%	81.7%	84.1%	81.7%	82.9%	81.7%	76.8%	89.0%	80.5%	78.0%	89.0%	90.2%	89.0%
Tool MC.4	84.1%	89.0%	86.6%	87.8%	81.7%	84.1%	84.1%	85.4%	81.7%	87.8%	84.1%	90.2%	86.6%	89.0%	89.0%	81.7%	84.1%	84.1%	82.9%	87.8%	81.7%	84.1%	86.6%	85.4%	86.6%	72.0%	86.6%	82.9%	78.0%	89.0%	90.2%	91.5%
Tool MC.5	75.6%	78.0%	73.2%	74.4%	75.6%	75.6%	78.0%	79.3%	78.0%	76.8%	82.9%	79.3%	82.9%	75.6%	75.6%	73.2%	78.0%	80.5%	79.3%	76.8%	80.5%	82.9%	85.4%	76.8%	80.5%	65.9%	80.5%	86.6%	67.1%	78.0%	76.8%	78.0%
Tool MC.6	80.5%	85.4%	82.9%	84.1%	78.0%	80.5%	80.5%	81.7%	78.0%	86.6%	87.8%	86.6%	82.9%	85.4%	85.4%	80.5%	82.9%	82.9%	81.7%	84.1%	80.5%	82.9%	85.4%	81.7%	82.9%	70.7%	82.9%	86.6%	74.4%	85.4%	86.6%	87.8%
Tool MC.7	82.9%	85.4%	82.9%	84.1%	82.9%	85.4%	82.9%	86.6%	85.4%	84.1%	85.4%	86.6%	87.8%	85.4%	85.4%	80.5%	82.9%	82.9%	84.1%	86.6%	82.9%	82.9%	87.8%	84.1%	87.8%	73.2%	85.4%	81.7%	74.4%	87.8%	84.1%	87.8%
Tool P.1	79.3%	79.3%	79.3%	78.0%	76.8%	76.8%	76.8%	78.0%	79.3%	80.5%	76.8%	82.9%	76.8%	79.3%	79.3%	76.8%	79.3%	74.4%	73.2%	80.5%	74.4%	76.8%	74.4%	75.6%	72.0%	81.7%	81.7%	73.2%	70.7%	84.1%	80.5%	79.3%
Tool P.2	91.5%	89.0%	91.5%	90.2%	89.0%	89.0%	86.6%	90.2%	91.5%	90.2%	84.1%	92.7%	89.0%	91.5%	91.5%	84.1%	86.6%	81.7%	82.9%	92.7%	84.1%	84.1%	81.7%	87.8%	84.1%	81.7%	91.5%	70.7%	82.9%	96.3%	90.2%	91.5%
Tool P.3	85.4%	82.9%	82.9%	81.7%	80.5%	82.9%	80.5%	84.1%	85.4%	81.7%	85.4%	84.1%	82.9%	82.9%	82.9%	82.9%	82.9%	78.0%	79.3%	84.1%	80.5%	80.5%	78.0%	81.7%	78.0%	80.5%	82.9%	76.8%	74.4%	87.8%	81.7%	82.9%
Tool P.4	86.6%	93.9%	91.5%	90.2%	89.0%	89.0%	89.0%	90.2%	86.6%	92.7%	79.3%	92.7%	86.6%	89.0%	89.0%	86.6%	89.0%	86.6%	85.4%	90.2%	81.7%	84.1%	81.7%	87.8%	84.1%	72.0%	89.0%	70.7%	80.5%	91.5%	90.2%	89.0%
Tool P.5	85.4%	90.2%	85.4%	86.6%	82.9%	85.4%	85.4%	86.6%	82.9%	91.5%	82.9%	91.5%	87.8%	87.8%	87.8%	82.9%	87.8%	82.9%	81.7%	89.0%	85.4%	87.8%	85.4%	84.1%	82.9%	70.7%	87.8%	74.4%	76.8%	87.8%	89.0%	87.8%
Tool P.6	84.1%	89.0%	84.1%	85.4%	81.7%	84.1%	84.1%	85.4%	81.7%	90.2%	81.7%	90.2%	86.6%	86.6%	86.6%	81.7%	86.6%	81.7%	80.5%	87.8%	84.1%	86.6%	84.1%	82.9%	81.7%	72.0%	86.6%	73.2%	78.0%	86.6%	87.8%	86.6%
Tool P.7	89.0%	91.5%	89.0%	90.2%	86.6%	89.0%	86.6%	90.2%	86.6%	92.7%	86.6%	92.7%	91.5%	91.5%	91.5%	84.1%	86.6%	81.7%	82.9%	92.7%	86.6%	86.6%	84.1%	87.8%	86.6%	74.4%	89.0%	75.6%	80.5%	91.5%	90.2%	91.5%
Tool P.8	90.2%	92.7%	92.7%	93.9%	90.2%	90.2%	87.8%	91.5%	87.8%	93.9%	85.4%	96.3%	92.7%	95.1%	95.1%	85.4%	87.8%	82.9%	84.1%	96.3%	87.8%	87.8%	85.4%	89.0%	87.8%	78.0%	92.7%	74.4%	84.1%	95.1%	93.9%	95.1%
Tool R&C.1	93.9%	89.0%	86.6%	87.8%	84.1%	84.1%	84.1%	85.4%	86.6%	90.2%	84.1%	92.7%	89.0%	89.0%	89.0%	79.3%	86.6%	79.3%	78.0%	90.2%	81.7%	84.1%	81.7%	82.9%	81.7%	76.8%	89.0%	75.6%	78.0%	89.0%	90.2%	89.0%
Tool R&C.2	90.2%	90.2%	87.8%	89.0%	87.8%	90.2%	90.2%	89.0%	85.4%	89.0%	85.4%	91.5%	92.7%	87.8%	87.8%	87.8%	87.8%	85.4%	84.1%	91.5%	85.4%	87.8%	87.8%	86.6%	87.8%	70.7%	87.8%	79.3%	76.8%	87.8%	89.0%	90.2%
Tool R&C.3	92.7%	90.2%	90.2%	91.5%	90.2%	92.7%	90.2%	91.5%	87.8%	89.0%	87.8%	91.5%	95.1%	90.2%	90.2%	87.8%	87.8%	85.4%	86.6%	93.9%	87.8%	87.8%	87.8%	89.0%	90.2%	73.2%	87.8%	79.3%	79.3%	90.2%	89.0%	92.7%
Tool R&C.4	87.8%	85.4%	82.9%	84.1%	82.9%	85.4%	82.9%	86.6%	85.4%	84.1%	85.4%	86.6%	90.2%	85.4%	85.4%	82.9%	85.4%	82.9%	84.1%	86.6%	82.9%	82.9%	85.4%	84.1%	87.8%	68.3%	82.9%	79.3%	74.4%	85.4%	86.6%	87.8%
Tool R&C.5	89.0%	91.5%	91.5%	90.2%	89.0%	89.0%	89.0%	90.2%	89.0%	90.2%	79.3%	92.7%	86.6%	89.0%	89.0%	84.1%	86.6%	84.1%	82.9%	90.2%	81.7%	86.6%	81.7%	90.2%	86.6%	76.8%	89.0%	70.7%	80.5%	91.5%	90.2%	89.0%
Tool R&C.6	89.0%	96.3%	93.9%	92.7%	91.5%	91.5%	93.9%	95.1%	89.0%	92.7%	81.7%	95.1%	89.0%	91.5%	91.5%	89.0%	91.5%	89.0%	87.8%	92.7%	86.6%	89.0%	86.6%	90.2%	89.0%	74.4%	91.5%	73.2%	82.9%	93.9%	92.7%	91.5%
Tool R&C.7	84.1%	81.7%	81.7%	80.5%	81.7%	84.1%	81.7%	85.4%	84.1%	80.5%	84.1%	82.9%	86.6%	81.7%	81.7%	81.7%	81.7%	81.7%	82.9%	82.9%	79.3%	79.3%	81.7%	82.9%	84.1%	69.5%	81.7%	75.6%	70.7%	86.6%	80.5%	84.1%
Tool R&C.8	89.0%	91.5%	91.5%	92.7%	86.6%	89.0%	86.6%	90.2%	86.6%	90.2%	84.1%	92.7%	91.5%	93.9%	93.9%	86.6%	86.6%	84.1%	85.4%	92.7%	86.6%	86.6%	86.6%	90.2%	89.0%	76.8%	89.0%	78.0%	82.9%	93.9%	92.7%	96.3%
Tool R&C.9	87.8%	97.6%	92.7%	93.9%	90.2%	90.2%	92.7%	93.9%	87.8%	93.9%	82.9%	96.3%	90.2%	92.7%	92.7%	87.8%	90.2%	87.8%	86.6%	93.9%	87.8%	90.2%	87.8%	89.0%	90.2%	75.6%	92.7%	74.4%	84.1%	92.7%	93.9%	92.7%
Tool R&C.10	81.7%	86.6%	89.0%	90.2%	84.1%	84.1%	81.7%	85.4%	81.7%	85.4%	76.8%	87.8%	84.1%	89.0%	89.0%	79.3%	79.3%	76.8%	78.0%	87.8%	79.3%	79.3%	76.8%	85.4%	81.7%	74.4%	84.1%	68.3%	80.5%	89.0%	87.8%	89.0%
Tool R&C.11	87.8%	90.2%	87.8%	86.6%	85.4%	87.8%	90.2%	89.0%	85.4%	84.1%	75.6%	86.6%	82.9%	85.4%	85.4%	90.2%	87.8%	82.9%	81.7%	86.6%	80.5%	85.4%	80.5%	89.0%	87.8%	68.3%	82.9%	67.1%	76.8%	85.4%	84.1%	82.9%
Tool R&C.12	64.6%	67.1%	59.8%	63.4%	64.6%	64.6%	67.1%	68.3%	69.5%	61.0%	69.5%	63.4%	69.5%	62.2%	62.2%	64.6%	69.5%	69.5%	70.7%	63.4%	72.0%	72.0%	72.0%	65.9%	69.5%	62.2%	69.5%	68.3%	78.0%	64.6%	63.4%	62.2%
Tool R&C.13	81.7%	86.6%	86.6%	87.8%	86.6%	86.6%	84.1%	87.8%	89.0%	85.4%	84.1%	87.8%	86.6%	86.6%	86.6%	84.1%	84.1%	84.1%	85.4%	87.8%	84.1%	84.1%	84.1%	85.4%	86.6%	72.0%	86.6%	73.2%	78.0%	89.0%	85.4%	86.6%
Tool R&C.14	89.0%	91.5%	89.0%	90.2%	89.0%	91.5%	89.0%	92.7%	89.0%	90.2%	86.6%	92.7%	93.9%	91.5%	91.5%	89.0%	89.0%	86.6%	87.8%	92.7%	89.0%	89.0%	89.0%	90.2%	91.5%	74.4%	89.0%	78.0%	80.5%	91.5%	90.2%	93.9%
Tool R&C.15	89.0%	91.5%	93.9%	97.6%	93.9%	93.9%	91.5%	90.2%	86.6%	90.2%	81.7%	92.7%	89.0%	91.5%	91.5%	89.0%	84.1%	84.1%	85.4%	95.1%	84.1%	84.1%	81.7%	87.8%	86.6%	74.4%	89.0%	70.7%	80.5%	91.5%	90.2%	91.5%
Tool R&C.16	86.6%	84.1%	84.1%	85.4%	84.1%	86.6%	84.1%	85.4%	81.7%	85.4%	89.0%	85.4%	89.0%	84.1%	84.1%	84.1%	81.7%	79.3%	80.5%	87.8%	81.7%	81.7%	81.7%	82.9%	84.1%	67.1%	81.7%	80.5%	73.2%	84.1%	82.9%	86.6%
Tool R&C.17	70.7%	70.7%	68.3%	69.5%	70.7%	70.7%	70.7%	74.4%	73.2%	72.0%	87.8%	74.4%	78.0%	70.7%	70.7%	68.3%	70.7%	73.2%	74.4%	72.0%	75.6%	75.6%	78.0%	72.0%	75.6%	61.0%	73.2%	86.6%	62.2%	73.2%	69.5%	75.6%
Tool R&C.18	89.0%	91.5%	93.9%	95.1%	89.0%	89.0%	86.6%	90.2%	86.6%	92.7%	84.1%	95.1%	91.5%	96.3%	96.3%	84.1%	86.6%	84.1%	85.4%	95.1%	86.6%	86.6%	86.6%	90.2%	89.0%	79.3%	91.5%	78.0%	85.4%	96.3%	95.1%	98.8%
Tool R&C.19	90.2%	92.7%	90.2%	91.5%	87.8%	90.2%	87.8%	91.5%	87.8%	91.5%	85.4%	93.9%	92.7%	92.7%	92.7%	85.4%	90.2%	85.4%	86.6%	93.9%	87.8%	87.8%	87.8%	89.0%	90.2%	75.6%	90.2%	76.8%	81.7%	92.7%	91.5%	95.1%
Tool R&C.20	95.1%	90.2%	90.2%	91.5%	85.4%	87.8%	85.4%	89.0%	87.8%	89.0%	85.4%	91.5%	92.7%	92.7%	92.7%	82.9%	87.8%	80.5%	81.7%	91.5%	85.4%	85.4%	82.9%	89.0%	85.4%	75.6%	87.8%	76.8%	81.7%	92.7%	91.5%	92.7%
Tool R&C.21	92.7%	92.7%	92.7%	91.5%	90.2%	92.7%	90.2%	93.9%	92.7%	89.0%	82.9%	91.5%	90.2%	90.2%	90.2%	90.2%	90.2%	85.4%	86.6%	91.5%	85.4%	85.4%	82.9%	91.5%	87.8%	73.2%	87.8%	72.0%	79.3%	92.7%	89.0%	90.2%
Tool R&C.22	91.5%	91.5%	91.5%	90.2%	89.0%	91.5%	89.0%	92.7%	91.5%	87.8%	81.7%	90.2%	89.0%	89.0%	89.0%	89.0%	89.0%	86.6%	87.8%	90.2%	84.1%	84.1%	84.1%	90.2%	89.0%	72.0%	86.6%	73.2%	78.0%	91.5%	87.8%	91.5%
Tool R&C.23	90.2%	95.1%	90.2%	91.5%	87.8%	90.2%	90.2%	91.5%	90.2%	91.5%	82.9%	93.9%	90.2%	90.2%	90.2%	87.8%	90.2%	85.4%	84.1%	91.5%	85.4%	87.8%	85.4%	89.0%	87.8%	73.2%	90.2%	74.4%	79.3%	90.2%	91.5%	90.2%
Tool R&C.24	90.2%	95.1%	90.2%	91.5%	87.8%	90.2%	90.2%	91.5%	87.8%	93.9%	85.4%	96.3%	92.7%	92.7%	92.7%	87.8%	90.2%	85.4%	84.1%	93.9%	87.8%	90.2%	87.8%	89.0%	87.8%	75.6%	92.7%	76.8%	81.7%	92.7%	93.9%	92.7%
Tool R&C.25	95.1%	90.2%	90.2%	89.0%	85.4%	87.8%	87.8%	89.0%	90.2%	86.6%	80.5%	89.0%	87.8%	87.8%	87.8%	82.9%	87.8%	82.9%	81.7%	86.6%	80.5%	82.9%	80.5%	89.0%	82.9%	73.2%	85.4%	74.4%	76.8%	90.2%	89.0%	87.8%
Tool R&C.26	91.5%	91.5%	91.5%	90.2%	89.0%	91.5%	91.5%	92.7%	89.0%	85.4%	79.3%	87.8%	86.6%	89.0%	89.0%	93.9%	89.0%	84.1%	85.4%	90.2%	84.1%	84.1%	81.7%	90.2%	89.0%	69.5%	84.1%	68.3%	78.0%	89.0%	85.4%	86.6%
Tool R&C.27	91.5%	91.5%	91.5%	90.2%	89.0%	91.5%	91.5%	92.7%	89.0%	85.4%	79.3%	87.8%	86.6%	89.0%	89.0%	93.9%	89.0%	84.1%	85.4%	90.2%	84.1%	84.1%	81.7%	90.2%	89.0%	69.5%	84.1%	68.3%	78.0%	89.0%	85.4%	86.6%
Tool R&C.28	91.5%	91.5%	91.5%	90.2%	89.0%	91.5%	91.5%	92.7%	89.0%	85.4%	79.3%	87.8%	86.6%	89.0%	89.0%	93.9%	89.0%	84.1%	85.4%	90.2%	84.1%	84.1%	81.7%	90.2%	89.0%	69.5%	84.1%	68.3%	78.0%	89.0%	85.4%	86.6%
Tool R&C.29	93.9%	93.9%	96.3%	95.1%	93.9%	96.3%	93.9%	95.1%	91.5%	90.2%	84.1%	92.7%	91.5%	91.5%	91.5%	91.5%	89.0%	86.6%	87.8%	95.1%	86.6%	86.6%	84.1%	92.7%	89.0%	74.4%	89.0%	73.2%	80.5%	93.9%	90.2%	91.5%
Tool R&C.30	93.9%	93.9%	93.9%	92.7%	91.5%	93.9%	93.9%	95.1%	91.5%	87.8%	81.7%	90.2%	89.0%	89.0%	89.0%	91.5%	91.5%	86.6%	87.8%	92.7%	86.6%	86.6%	84.1%	90.2%	89.0%	72.0%	86.6%	70.7%	80.5%	91.5%	87.8%	89.0%
Tool R&C.31	86.6%	93.9%	91.5%	92.7%	91.5%	89.0%	93.9%	92.7%	84.1%	90.2%	79.3%	92.7%	86.6%	89.0%	89.0%	89.0%	86.6%	86.6%	85.4%	92.7%	86.6%	89.0%	86.6%	87.8%	89.0%	72.0%	89.0%	73.2%	80.5%	89.0%	90.2%	89.0%
Tool R&C.32	84.1%	91.5%	89.0%	92.7%	91.5%	89.0%	93.9%	90.2%	81.7%	87.8%	76.8%	90.2%	84.1%	86.6%	86.6%	86.6%	84.1%	86.6%	85.4%	90.2%	84.1%	86.6%	84.1%	85.4%	86.6%	69.5%	86.6%	70.7%	78.0%	86.6%	87.8%	86.6%
Tool R&C.33	90.2%	92.7%	92.7%	91.5%	90.2%	90.2%	92.7%	91.5%	85.4%	89.0%	80.5%	91.5%	87.8%	87.8%	87.8%	90.2%	87.8%	85.4%	84.1%	91.5%	82.9%	85.4%	82.9%	86.6%	85.4%	70.7%	87.8%	72.0%	79.3%	90.2%	89.0%	87.8%
Tool R&C.34	81.7%	84.1%	79.3%	80.5%	79.3%	81.7%	81.7%	82.9%	79.3%	82.9%	81.7%	85.4%	86.6%	81.7%	81.7%	79.3%	84.1%	84.1%	82.9%	82.9%	81.7%	84.1%	89.0%	80.5%	84.1%	64.6%	81.7%	87.8%	70.7%	81.7%	82.9%	84.1%
Tool CD.1	91.5%	89.0%	89.0%	90.2%	86.6%	86.6%	84.1%	87.8%	89.0%	90.2%	86.6%	92.7%	89.0%	91.5%	91.5%	81.7%	84.1%	79.3%	80.5%	92.7%	84.1%	84.1%	81.7%	85.4%	84.1%	81.7%	91.5%	73.2%	80.5%	93.9%	90.2%	91.5%
Tool CD.2	92.7%	90.2%	90.2%	91.5%	87.8%	87.8%	85.4%	89.0%	87.8%	91.5%	82.9%	93.9%	90.2%	92.7%	92.7%	82.9%	85.4%	80.5%	81.7%	93.9%	85.4%	85.4%	82.9%	86.6%	85.4%	80.5%	90.2%	72.0%	81.7%	92.7%	91.5%	92.7%
Tool CD.3	87.8%	87.8%	87.8%	86.6%	85.4%	85.4%	85.4%	86.6%	82.9%	89.0%	78.0%	91.5%	85.4%	87.8%	87.8%	82.9%	85.4%	80.5%	79.3%	89.0%	80.5%	82.9%	80.5%	84.1%	80.5%	78.0%	87.8%	76.8%	76.8%	90.2%	89.0%	87.8%
Tool CD.4	81.7%	86.6%	81.7%	82.9%	79.3%	81.7%	81.7%	82.9%	79.3%	87.8%	84.1%	87.8%	84.1%	86.6%	86.6%	81.7%	81.7%	76.8%	75.6%	85.4%	79.3%	81.7%	79.3%	82.9%	81.7%	74.4%	84.1%	82.9%	73.2%	84.1%	85.4%	84.1%
Tool CD.5	90.2%	90.2%	95.1%	93.9%	90.2%	90.2%	87.8%	91.5%	90.2%	91.5%	82.9%	93.9%	90.2%	95.1%	95.1%	85.4%	87.8%	82.9%	84.1%	93.9%	85.4%	85.4%	82.9%	91.5%	85.4%	78.0%	90.2%	74.4%	86.6%	97.6%	93.9%	95.1%
Tool CD.6	93.9%	91.5%	93.9%	92.7%	91.5%	91.5%	89.0%	92.7%	91.5%	92.7%	84.1%	95.1%	91.5%	93.9%	93.9%	86.6%	91.5%	84.1%	85.4%	95.1%	86.6%	86.6%	84.1%	90.2%	86.6%	76.8%	91.5%	73.2%	82.9%	96.3%	92.7%	93.9%
Tool CD.7	92.7%	87.8%	90.2%	91.5%	85.4%	85.4%	82.9%	86.6%	85.4%	89.0%	85.4%	91.5%	90.2%	92.7%	92.7%	80.5%	82.9%	78.0%	79.3%	91.5%	82.9%	82.9%	80.5%	86.6%	82.9%	80.5%	87.8%	76.8%	81.7%	92.7%	91.5%	92.7%
Tool CD.8	92.7%	90.2%	90.2%	91.5%	85.4%	87.8%	85.4%	89.0%	87.8%	89.0%	87.8%	91.5%	92.7%	92.7%	92.7%	82.9%	85.4%	80.5%	81.7%	91.5%	85.4%	85.4%	82.9%	89.0%	85.4%	80.5%	87.8%	79.3%	81.7%	92.7%	91.5%	92.7%
Tool CD.9	91.5%	93.9%	93.9%	95.1%	89.0%	91.5%	89.0%	92.7%	89.0%	92.7%	86.6%	95.1%	93.9%	96.3%	96.3%	86.6%	89.0%	84.1%	85.4%	95.1%	89.0%	89.0%	86.6%	92.7%	89.0%	79.3%	91.5%	78.0%	85.4%	96.3%	95.1%	96.3%
Tool CD.10	92.7%	90.2%	95.1%	96.3%	90.2%	90.2%	87.8%	89.0%	85.4%	91.5%	85.4%	93.9%	92.7%	95.1%	95.1%	85.4%	85.4%	80.5%	81.7%	96.3%	85.4%	85.4%	82.9%	89.0%	85.4%	78.0%	90.2%	76.8%	84.1%	95.1%	93.9%	95.1%
Tool CD.11	92.7%	90.2%	95.1%	96.3%	90.2%	90.2%	87.8%	89.0%	85.4%	91.5%	85.4%	93.9%	92.7%	95.1%	95.1%	85.4%	85.4%	80.5%	81.7%	96.3%	85.4%	85.4%	82.9%	89.0%	85.4%	78.0%	90.2%	76.8%	84.1%	95.1%	93.9%	95.1%
Tool T&V.1	91.5%	93.9%	96.3%	95.1%	93.9%	93.9%	91.5%	95.1%	91.5%	92.7%	84.1%	95.1%	91.5%	93.9%	93.9%	89.0%	89.0%	86.6%	87.8%	95.1%	86.6%	86.6%	84.1%	92.7%	89.0%	76.8%	91.5%	73.2%	82.9%	96.3%	92.7%	93.9%
Tool T&V.2	100%	87.8%	90.2%	89.0%	87.8%	90.2%	87.8%	89.0%	90.2%	86.6%	82.9%	89.0%	90.2%	87.8%	87.8%	85.4%	87.8%	80.5%	81.7%	91.5%	82.9%	82.9%	80.5%	86.6%	82.9%	73.2%	85.4%	72.0%	76.8%	90.2%	86.6%	87.8%
Tool T&V.3	87.8%	100%	90.2%	91.5%	87.8%	90.2%	92.7%	93.9%	87.8%	91.5%	82.9%	93.9%	90.2%	90.2%	90.2%	90.2%	92.7%	90.2%	89.0%	91.5%	87.8%	90.2%	87.8%	89.0%	90.2%	73.2%	90.2%	74.4%	84.1%	90.2%	91.5%	90.2%
Tool T&V.4	90.2%	90.2%	100%	96.3%	95.1%	95.1%	90.2%	91.5%	87.8%	89.0%	80.5%	91.5%	87.8%	92.7%	92.7%	87.8%	85.4%	82.9%	84.1%	93.9%	82.9%	82.9%	80.5%	91.5%	85.4%	75.6%	87.8%	72.0%	81.7%	95.1%	91.5%	92.7%
Tool T&V.5	89.0%	91.5%	96.3%	100%	93.9%	93.9%	91.5%	90.2%	86.6%	90.2%	81.7%	92.7%	89.0%	93.9%	93.9%	86.6%	84.1%	84.1%	85.4%	95.1%	84.1%	84.1%	81.7%	90.2%	86.6%	76.8%	89.0%	73.2%	82.9%	93.9%	92.7%	93.9%
Tool T&V.6	87.8%	87.8%	95.1%	93.9%	100%	97.6%	95.1%	93.9%	87.8%	86.6%	80.5%	89.0%	87.8%	87.8%	87.8%	87.8%	85.4%	87.8%	89.0%	91.5%	85.4%	85.4%	82.9%	91.5%	87.8%	70.7%	85.4%	72.0%	76.8%	90.2%	86.6%	87.8%
Tool T&V.7	90.2%	90.2%	95.1%	93.9%	97.6%	100%	95.1%	93.9%	90.2%	86.6%	82.9%	89.0%	90.2%	87.8%	87.8%	90.2%	87.8%	87.8%	89.0%	91.5%	85.4%	85.4%	82.9%	91.5%	87.8%	70.7%	85.4%	72.0%	76.8%	90.2%	86.6%	87.8%
Tool T&V.8	87.8%	92.7%	90.2%	91.5%	95.1%	95.1%	100%	96.3%	87.8%	86.6%	80.5%	89.0%	87.8%	85.4%	85.4%	90.2%	90.2%	92.7%	91.5%	89.0%	87.8%	90.2%	87.8%	91.5%	90.2%	68.3%	85.4%	74.4%	76.8%	87.8%	86.6%	85.4%
Tool T&V.9	89.0%	93.9%	91.5%	90.2%	93.9%	93.9%	96.3%	100%	91.5%	87.8%	84.1%	90.2%	91.5%	89.0%	89.0%	91.5%	91.5%	91.5%	92.7%	90.2%	91.5%	91.5%	89.0%	95.1%	93.9%	72.0%	86.6%	75.6%	80.5%	91.5%	87.8%	89.0%
Tool T&V.10	90.2%	87.8%	87.8%	86.6%	87.8%	90.2%	87.8%	91.5%	100%	84.1%	85.4%	86.6%	90.2%	85.4%	85.4%	85.4%	87.8%	82.9%	84.1%	86.6%	85.4%	85.4%	80.5%	89.0%	85.4%	75.6%	87.8%	69.5%	79.3%	90.2%	84.1%	85.4%
Tool I&T.1	86.6%	91.5%	89.0%	90.2%	86.6%	86.6%	86.6%	87.8%	84.1%	100%	84.1%	95.1%	89.0%	91.5%	91.5%	81.7%	86.6%	81.7%	80.5%	92.7%	84.1%	86.6%	84.1%	85.4%	84.1%	74.4%	91.5%	75.6%	80.5%	91.5%	92.7%	91.5%
Tool PB.1	82.9%	82.9%	80.5%	81.7%	80.5%	82.9%	80.5%	84.1%	85.4%	84.1%	100%	84.1%	90.2%	82.9%	82.9%	80.5%	82.9%	78.0%	79.3%	84.1%	85.4%	85.4%	80.5%	81.7%	80.5%	73.2%	85.4%	81.7%	74.4%	85.4%	81.7%	82.9%
Tool PB.2	89.0%	93.9%	91.5%	92.7%	89.0%	89.0%	89.0%	90.2%	86.6%	95.1%	84.1%	100%	91.5%	93.9%	93.9%	84.1%	89.0%	84.1%	82.9%	95.1%	86.6%	89.0%	86.6%	87.8%	86.6%	76.8%	93.9%	75.6%	82.9%	93.9%	95.1%	96.3%
Tool PB.3	90.2%	90.2%	87.8%	89.0%	87.8%	90.2%	87.8%	91.5%	90.2%	89.0%	90.2%	91.5%	100%	90.2%	90.2%	85.4%	87.8%	82.9%	84.1%	91.5%	90.2%	90.2%	85.4%	89.0%	87.8%	75.6%	90.2%	76.8%	81.7%	90.2%	89.0%	90.2%
Tool Q.1	87.8%	90.2%	92.7%	93.9%	87.8%	87.8%	85.4%	89.0%	85.4%	91.5%	82.9%	93.9%	90.2%	100%	100%	85.4%	85.4%	80.5%	81.7%	93.9%	85.4%	85.4%	82.9%	91.5%	87.8%	78.0%	90.2%	74.4%	84.1%	95.1%	93.9%	95.1%
Tool Q.2	87.8%	90.2%	92.7%	93.9%	87.8%	87.8%	85.4%	89.0%	85.4%	91.5%	82.9%	93.9%	90.2%	100%	100%	85.4%	85.4%	80.5%	81.7%	93.9%	85.4%	85.4%	82.9%	91.5%	87.8%	78.0%	90.2%	74.4%	84.1%	95.1%	93.9%	95.1%
Tool Q.3	85.4%	90.2%	87.8%	86.6%	87.8%	90.2%	90.2%	91.5%	85.4%	81.7%	80.5%	84.1%	85.4%	85.4%	85.4%	100%	90.2%	87.8%	89.0%	86.6%	85.4%	85.4%	82.9%	89.0%	87.8%	65.9%	80.5%	69.5%	76.8%	85.4%	81.7%	82.9%
Tool Q.4	87.8%	92.7%	85.4%	84.1%	85.4%	87.8%	90.2%	91.5%	87.8%	86.6%	82.9%	89.0%	87.8%	85.4%	85.4%	90.2%	100%	90.2%	89.0%	86.6%	87.8%	90.2%	87.8%	86.6%	85.4%	68.3%	85.4%	74.4%	79.3%	87.8%	86.6%	85.4%
Tool Q.5	80.5%	90.2%	82.9%	84.1%	87.8%	87.8%	92.7%	91.5%	82.9%	81.7%	78.0%	84.1%	82.9%	80.5%	80.5%	87.8%	90.2%	100%	98.8%	81.7%	87.8%	90.2%	92.7%	86.6%	90.2%	63.4%	80.5%	76.8%	74.4%	82.9%	84.1%	82.9%
Tool Q.6	81.7%	89.0%	84.1%	85.4%	89.0%	89.0%	91.5%	92.7%	84.1%	80.5%	79.3%	82.9%	84.1%	81.7%	81.7%	89.0%	89.0%	98.8%	100%	82.9%	89.0%	89.0%	91.5%	87.8%	91.5%	64.6%	79.3%	75.6%	75.6%	84.1%	82.9%	84.1%
Tool Q.7	91.5%	91.5%	93.9%	95.1%	91.5%	91.5%	89.0%	90.2%	86.6%	92.7%	84.1%	95.1%	91.5%	93.9%	93.9%	86.6%	86.6%	81.7%	82.9%	100%	86.6%	86.6%	84.1%	87.8%	86.6%	76.8%	91.5%	73.2%	82.9%	93.9%	92.7%	93.9%
Tool I.1	82.9%	87.8%	82.9%	84.1%	85.4%	85.4%	87.8%	91.5%	85.4%	84.1%	85.4%	86.6%	90.2%	85.4%	85.4%	85.4%	87.8%	87.8%	89.0%	86.6%	100%	95.1%	90.2%	86.6%	87.8%	70.7%	85.4%	74.4%	81.7%	85.4%	86.6%	85.4%
Tool I.2	82.9%	90.2%	82.9%	84.1%	85.4%	85.4%	90.2%	91.5%	85.4%	86.6%	85.4%	89.0%	90.2%	85.4%	85.4%	85.4%	90.2%	90.2%	89.0%	86.6%	95.1%	100%	92.7%	89.0%	90.2%	73.2%	87.8%	76.8%	81.7%	85.4%	89.0%	85.4%
Tool I.3	80.5%	87.8%	80.5%	81.7%	82.9%	82.9%	87.8%	89.0%	80.5%	84.1%	80.5%	86.6%	85.4%	82.9%	82.9%	82.9%	87.8%	92.7%	91.5%	84.1%	90.2%	92.7%	100%	84.1%	90.2%	68.3%	85.4%	81.7%	76.8%	82.9%	86.6%	85.4%
Tool I.4	86.6%	89.0%	91.5%	90.2%	91.5%	91.5%	91.5%	95.1%	89.0%	85.4%	81.7%	87.8%	89.0%	91.5%	91.5%	89.0%	86.6%	86.6%	87.8%	87.8%	86.6%	89.0%	84.1%	100%	93.9%	74.4%	84.1%	75.6%	80.5%	91.5%	87.8%	89.0%
Tool I.5	82.9%	90.2%	85.4%	86.6%	87.8%	87.8%	90.2%	93.9%	85.4%	84.1%	80.5%	86.6%	87.8%	87.8%	87.8%	87.8%	85.4%	90.2%	91.5%	86.6%	87.8%	90.2%	90.2%	93.9%	100%	70.7%	82.9%	76.8%	79.3%	85.4%	84.1%	87.8%
Tool PS.1	73.2%	73.2%	75.6%	76.8%	70.7%	70.7%	68.3%	72.0%	75.6%	74.4%	73.2%	76.8%	75.6%	78.0%	78.0%	65.9%	68.3%	63.4%	64.6%	76.8%	70.7%	73.2%	68.3%	74.4%	70.7%	100%	80.5%	67.1%	79.3%	80.5%	76.8%	78.0%
Tool PS.2	85.4%	90.2%	87.8%	89.0%	85.4%	85.4%	85.4%	86.6%	87.8%	91.5%	85.4%	93.9%	90.2%	90.2%	90.2%	80.5%	85.4%	80.5%	79.3%	91.5%	85.4%	87.8%	85.4%	84.1%	82.9%	80.5%	100%	72.0%	86.6%	92.7%	91.5%	90.2%
Tool PS.3	72.0%	74.4%	72.0%	73.2%	72.0%	72.0%	74.4%	75.6%	69.5%	75.6%	81.7%	75.6%	76.8%	74.4%	74.4%	69.5%	74.4%	76.8%	75.6%	73.2%	74.4%	76.8%	81.7%	75.6%	76.8%	67.1%	72.0%	100%	63.4%	74.4%	75.6%	76.8%
Tool PS.4	76.8%	84.1%	81.7%	82.9%	76.8%	76.8%	76.8%	80.5%	79.3%	80.5%	74.4%	82.9%	81.7%	84.1%	84.1%	76.8%	79.3%	74.4%	75.6%	82.9%	81.7%	81.7%	76.8%	80.5%	79.3%	79.3%	86.6%	63.4%	100%	84.1%	82.9%	84.1%
Tool PS.5	90.2%	90.2%	95.1%	93.9%	90.2%	90.2%	87.8%	91.5%	90.2%	91.5%	85.4%	93.9%	90.2%	95.1%	95.1%	85.4%	87.8%	82.9%	84.1%	93.9%	85.4%	85.4%	82.9%	91.5%	85.4%	80.5%	92.7%	74.4%	84.1%	100%	93.9%	95.1%
Tool PS.6	86.6%	91.5%	91.5%	92.7%	86.6%	86.6%	86.6%	87.8%	84.1%	92.7%	81.7%	95.1%	89.0%	93.9%	93.9%	81.7%	86.6%	84.1%	82.9%	92.7%	86.6%	89.0%	86.6%	87.8%	84.1%	76.8%	91.5%	75.6%	82.9%	93.9%	100%	93.9%
Tool PS.7	87.8%	90.2%	92.7%	93.9%	87.8%	87.8%	85.4%	89.0%	85.4%	91.5%	82.9%	96.3%	90.2%	95.1%	95.1%	82.9%	85.4%	82.9%	84.1%	93.9%	85.4%	85.4%	85.4%	89.0%	87.8%	78.0%	90.2%	76.8%	84.1%	95.1%	93.9%	100%

Appendix b. Figures from example run.

(Integration of tools with likeness rate above 98%)

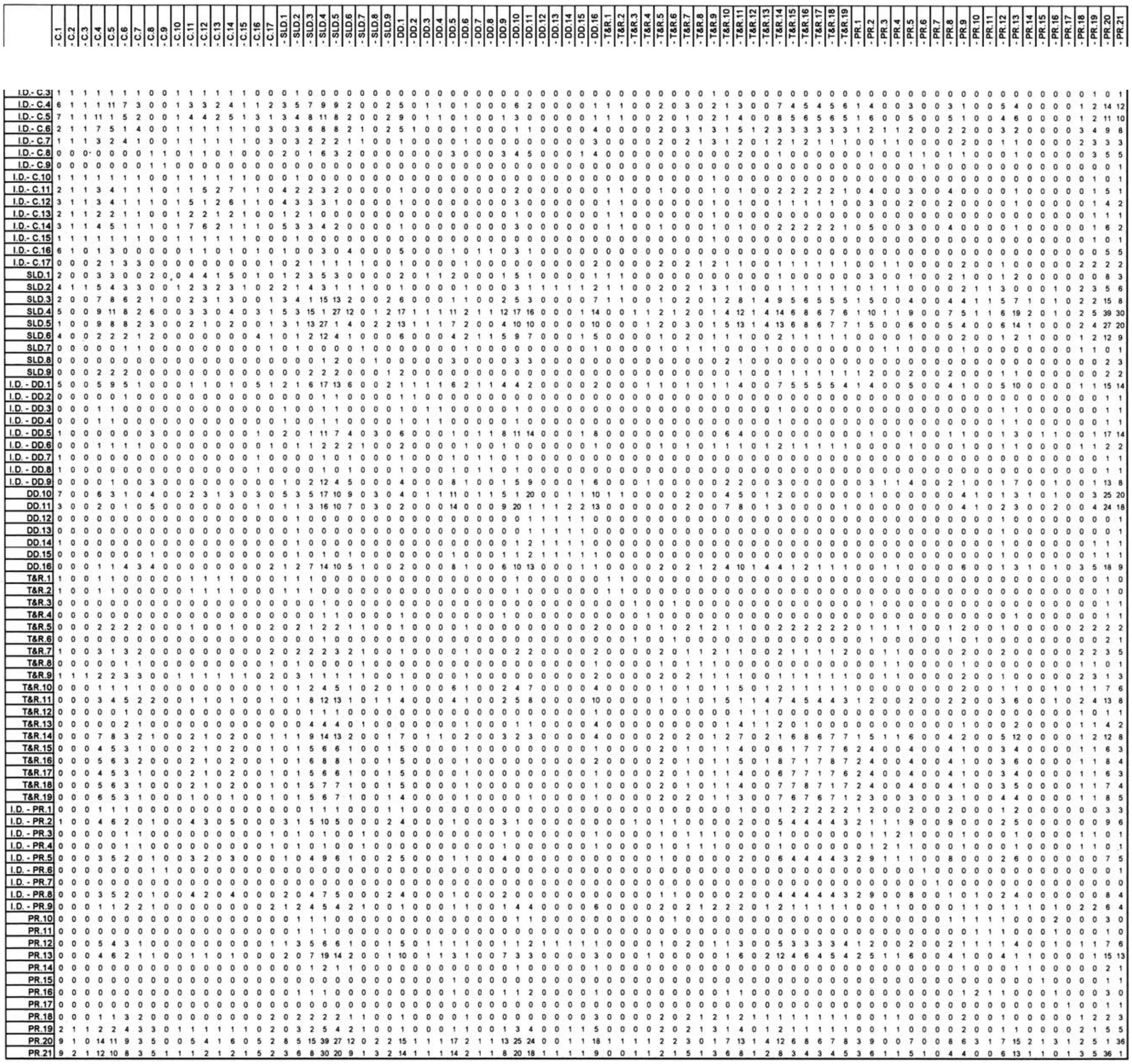


		Concept																	System-Level Design									Detail Design																Testing and Refinement																			Production Ramp-Up																				
		I.D.- C.1	I.D.- C.2	I.D.- C.3	I.D.- C.4	I.D.- C.5	I.D.- C.6	I.D.- C.7	I.D.- C.8	I.D.- C.9	I.D.- C.10	I.D.- C.11	I.D.- C.12	I.D.- C.13	I.D.- C.14	I.D.- C.15	I.D.- C.16	I.D.- C.17	I.D. - SLD.1	I.D. - SLD.2	I.D. - SLD.3	I.D. - SLD.4	I.D. - SLD.5	I.D. - SLD.6	I.D. - SLD.7	I.D. - SLD.8	I.D. - SLD.9	I.D. - DD.1	I.D. - DD.2	I.D. - DD.3	I.D. - DD.4	I.D. - DD.5	I.D. - DD.6	I.D. - DD.7	I.D. - DD.8	I.D. - DD.9	I.D. - DD.10	I.D. - DD.11	I.D. - DD.12	I.D. - DD.13	I.D. - DD.14	I.D. - DD.15	I.D. - DD.16	I.D. - T&R.1	I.D. - T&R.2	I.D. - T&R.3	I.D. - T&R.4	I.D. - T&R.5	I.D. - T&R.6	I.D. - T&R.7	I.D. - T&R.8	I.D. - T&R.9	I.D. - T&R.10	I.D. - T&R.11	I.D. - T&R.12	I.D. - T&R.13	I.D. - T&R.14	I.D. - T&R.15	I.D. - T&R.16	I.D. - T&R.17	I.D. - T&R.18	I.D. - T&R.19	I.D. - PR.1	I.D. - PR.2	I.D. - PR.3	I.D. - PR.4	I.D. - PR.5	I.D. - PR.6	I.D. - PR.7	I.D. - PR.8	I.D. - PR.9	I.D. - PR.10	I.D. - PR.11	I.D. - PR.12	I.D. - PR.13	I.D. - PR.14	I.D. - PR.15	I.D. - PR.16	I.D. - PR.17	I.D. - PR.18	I.D. - PR.19	I.D. - PR.20	I.D. - PR.21
Material Cost	Tool MC.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool MC.2	0	0	0	1	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
	Tool MC.3	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
	Tool MC.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	Tool MC.5	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0
	Tool MC.6	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
	Tool MC.7	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1
Procurement	Tool P.1	1	0	0	1	1	0	0	0	0	0	1	1	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Tool P.2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool P.3	1	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool P.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	1	0
	Tool P.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	0	0	1	0
	Tool P.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool P.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
Release and Change	Tool R&C.1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Tool R&C.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
	Tool R&C.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1
	Tool R&C.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1
	Tool R&C.5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
	Tool R&C.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Tool R&C.7	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
	Tool R&C.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
	Tool R&C.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
	Tool R&C.11	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
	Tool R&C.12	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	1	1	1	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	1	1
	Tool R&C.13	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1
	Tool R&C.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1
	Tool R&C.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool R&C.16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0	1	1
	Tool R&C.17	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1	1	1	0	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0	1	1
	Tool R&C.18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
	Tool R&C.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1
	Tool R&C.20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Tool R&C.21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1
	Tool R&C.23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Tool R&C.24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Tool R&C.25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tool R&C.26	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool R&C.29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool R&C.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool R&C.31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Tool R&C.32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
	Tool R&C.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Tool R&C.34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
Content Definition	Tool CD.1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool CD.2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool CD.3	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Tool CD.4	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
	Tool CD.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Tool CD.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool CD.7	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Tool CD.8	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Tool CD.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Tool CD.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Test and Validate	Tool T&V.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool T&V.2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool T&V.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
	Tool T&V.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Tool T&V.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Tool T&V.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool T&V.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool T&V.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Tool T&V.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool T&V.10	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
I*	Tool I&T.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0
PB**	Tool PB.1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1
	Tool PB.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Tool PB.3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Quality	Tool Q.1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Tool Q.3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
	Tool Q.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0
	Tool Q.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1
	Tool Q.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
Issues	Tool I.1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
	Tool I.2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
	Tool I.3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
	Tool I.4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	Tool I.5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1
Process	Tool P.1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	Tool P.2	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Tool P.3	0	0	0	0	1	0	0	0	0	0	1	1	0	1	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	0	0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
	Tool P.4	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	1
	Tool P.5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Tool P.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 23. EDS Inputs-Outputs matrix (Deliverables to Tools merged)[12]

---

[12] *=Market Research; BPS*= Build Phase Support; OPD*=Ongoing Product Development.
Green cells references to merged tools.



	- C.1	- C.2	- C.3	- C.4	- C.5	- C.6	- C.7	- C.8	- C.9	- C.10	- C.11	- C.12	- C.13	- C.14	- C.15	- C.16	- C.17	- SLD.1	- SLD.2	- SLD.3	- SLD.4	- SLD.5	- SLD.6	- SLD.7	- SLD.8	- SLD.9	- DD.1	- DD.2	- DD.3	- DD.4	- DD.5	- DD.6	- DD.7	- DD.8	- DD.9	- DD.10	- DD.11	- DD.12	- DD.13	- DD.14	- DD.15	- DD.16	- T&R.1	- T&R.2	- T&R.3	- T&R.4	- T&R.5	- T&R.6	- T&R.7	- T&R.8	- T&R.9	- T&R.10	- T&R.11	- T&R.12	- T&R.13	- T&R.14	- T&R.15	- T&R.16	- T&R.17	- T&R.18	- T&R.19	- PR.1	- PR.2	- PR.3	- PR.4	- PR.5	- PR.6	- PR.7	- PR.8	- PR.9	- PR.10	- PR.11	- PR.12	- PR.13	- PR.14	- PR.15	- PR.16	- PR.17	- PR.18	- PR.19	- PR.20	- PR.21
I.D.- C.3	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
I.D.- C.4	6	1	1	1	11	7	3	0	0	1	3	3	2	4	1	1	2	3	5	7	9	9	2	0	0	2	5	0	1	1	0	1	0	0	0	6	2	0	0	0	0	1	1	1	0	0	2	0	3	0	2	1	3	0	0	7	4	5	4	5	6	1	4	0	0	3	0	0	3	1	0	0	5	4	0	0	0	0	1	2	14	12
I.D.- C.5	7	1	1	11	1	5	2	0	0	1	4	4	2	5	1	3	1	3	4	8	11	8	2	0	0	2	9	0	1	1	0	1	0	0	1	3	0	0	0	0	0	1	1	1	0	0	2	0	1	0	2	1	4	0	0	8	5	6	5	6	5	1	6	0	0	5	0	0	5	1	0	0	4	6	0	0	0	0	1	2	11	10
I.D.- C.6	2	1	1	7	5	1	4	0	0	1	1	1	1	1	1	0	3	0	3	6	8	8	2	1	0	2	5	1	0	0	0	1	0	0	0	1	1	0	0	0	0	4	0	0	0	0	2	0	3	1	3	1	5	1	2	3	3	3	3	3	3	1	2	1	1	2	0	0	2	2	0	0	3	2	0	0	0	0	3	4	9	8
I.D.- C.7	1	1	1	3	2	4	1	0	0	1	1	1	1	1	1	0	3	0	3	2	2	2	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	0	0	0	2	0	2	1	3	1	2	0	1	2	1	2	1	1	1	0	0	1	1	0	0	0	0	2	0	0	1	1	0	0	0	0	2	3	3	3
I.D.- C.8	0	0	0	0	0	0	0	1	1	0	1	1	0	1	0	0	0	2	0	1	6	3	2	0	0	0	0	0	0	0	3	0	0	0	3	4	5	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	1	1	0	0	0	1	0	0	0	0	0	3	5	5
I.D.- C.9	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
I.D.- C.10	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
I.D.- C.11	2	1	1	3	4	1	1	1	0	1	1	5	2	7	1	1	0	4	2	2	3	2	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	1	0	0	2	2	2	2	2	1	0	4	0	0	3	0	0	4	0	0	0	0	1	0	0	0	0	0	1	5	1
I.D.- C.12	3	1	1	3	4	1	1	1	0	1	5	1	2	6	1	1	0	4	3	3	3	1	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	1	1	1	1	1	0	0	3	0	0	2	0	0	2	0	0	0	0	1	0	0	0	0	0	1	4	2
I.D.- C.13	2	1	1	2	2	1	1	0	0	1	2	2	1	2	1	0	0	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
I.D.- C.14	3	1	1	4	5	1	1	1	0	1	7	6	2	1	1	1	0	5	3	3	4	2	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	1	0	0	2	2	2	2	2	1	0	5	0	0	3	0	0	4	0	0	0	0	1	0	0	0	0	0	1	6	2
I.D.- C.15	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
I.D.- C.16	6	1	0	1	3	0	0	0	0	0	1	1	0	1	0	1	0	1	0	0	3	0	4	0	0	0	5	0	0	0	1	0	1	1	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5
I.D.- C.17	0	0	0	2	1	3	3	0	0	0	0	0	0	0	0	0	1	0	2	1	1	1	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	2	1	2	1	1	0	0	1	1	1	1	1	1	0	0	1	1	0	0	0	0	2	0	0	1	0	0	0	0	0	2	2	2	2
SLD.1	2	0	0	3	3	0	0	2	0	0	4	4	1	5	0	1	0	1	2	3	5	3	0	0	0	0	2	0	1	1	2	0	0	0	1	5	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	0	1	0	0	2	1	0	0	1	2	0	0	0	0	0	0	8	3
SLD.2	4	1	1	5	4	3	3	0	0	1	2	3	2	3	1	0	2	2	1	4	3	1	1	1	0	0	1	0	0	0	0	1	0	0	0	3	1	1	1	1	1	2	1	1	0	0	2	0	2	1	3	1	1	0	0	1	1	1	1	1	1	0	1	1	1	0	0	0	0	2	1	1	3	0	0	0	1	0	2	3	5	6
SLD.3	2	0	0	7	8	6	2	1	0	0	2	3	1	3	0	0	1	3	4	1	15	13	2	0	0	2	6	0	0	0	1	1	0	0	2	5	3	0	0	0	0	7	1	1	0	0	1	0	2	0	1	2	8	1	4	9	5	6	5	5	5	1	5	0	0	4	0	0	4	4	1	1	5	7	1	0	1	0	2	2	15	8
SLD.4	5	0	0	9	11	8	2	6	0	0	3	3	0	4	0	3	1	5	3	15	1	27	12	0	1	2	17	1	1	1	11	2	1	1	12	17	16	0	0	0	1	14	0	0	1	1	2	1	2	0	1	4	12	1	4	14	6	8	6	7	6	1	10	1	1	9	0	0	7	5	1	1	6	19	2	0	1	0	2	5	39	30
SLD.5	1	0	0	9	8	8	2	3	0	0	2	1	0	2	0	0	1	3	1	13	27	1	4	0	2	2	13	1	1	1	7	2	0	0	4	10	10	0	0	0	0	10	0	0	0	1	2	0	3	0	1	5	13	1	4	13	6	8	6	7	7	1	5	0	0	6	0	0	5	4	0	0	6	14	1	0	0	0	2	4	27	20
SLD.6	4	0	0	2	2	2	1	2	0	0	0	0	0	0	0	4	1	0	1	2	12	4	1	0	0	0	6	0	0	0	4	2	1	1	5	9	7	0	0	0	1	5	0	0	0	0	1	0	2	0	1	1	1	0	0	2	1	1	1	1	1	0	0	0	0	1	0	0	0	2	0	0	1	2	1	0	0	0	1	2	12	9
SLD.7	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	1
SLD.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	1	0	0	0	0	0	3	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3
SLD.9	0	0	0	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	0	1	1	0	0	0	0	0	0	2	2
I.D. - DD.1	5	0	0	5	9	5	1	0	0	0	1	1	0	1	0	5	1	2	1	6	17	13	6	0	0	2	1	1	1	1	6	2	1	1	4	4	2	0	0	0	0	2	0	0	0	1	1	0	1	0	1	1	4	0	0	7	5	5	5	5	4	1	4	0	0	5	0	0	4	1	0	0	5	10	0	0	0	0	1	1	15	14
I.D. - DD.2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
I.D. - DD.3	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
I.D. - DD.4	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
I.D. - DD.5	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0	2	0	1	11	7	4	0	3	0	6	0	0	0	1	0	1	1	8	11	14	0	0	0	1	8	0	0	0	0	0	0	0	0	0	6	4	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	0	0	1	3	0	1	1	0	0	1	17	14
I.D. - DD.6	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	2	2	2	1	0	0	2	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	1	1	1	0	1	2	1	1	1	1	1	0	0	0	0	1	0	0	0	1	0	0	1	1	0	0	0	0	1	1	2	2
I.D. - DD.7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
I.D. - DD.8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
I.D. - DD.9	0	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	1	0	2	12	4	5	0	0	0	4	0	0	0	8	1	0	0	1	5	9	0	0	0	1	6	0	0	0	1	0	0	0	0	0	2	2	0	0	3	0	0	0	0	0	0	3	1	1	4	0	0	2	1	0	0	1	7	0	0	1	0	0	1	13	8
DD.10	7	0	0	6	3	1	0	4	0	0	2	3	1	3	0	3	0	5	3	5	17	10	9	0	3	0	4	0	1	1	11	0	1	1	5	1	20	0	0	1	1	10	1	1	0	0	0	0	2	0	0	4	5	0	1	2	0	0	0	0	0	0	1	0	0	0	0	0	0	4	1	0	1	3	1	0	1	0	0	3	25	20
DD.11	3	0	0	2	0	1	0	5	0	0	0	0	0	0	0	1	0	1	1	3	16	10	7	0	3	0	2	0	0	0	14	0	0	0	9	20	1	1	1	2	2	13	0	0	0	0	0	0	2	0	0	7	8	0	1	3	0	0	0	0	1	0	0	0	0	0	0	0	0	4	1	0	2	3	0	0	2	0	0	4	24	18
DD.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
DD.13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
DD.14	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1
DD.15	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	1	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1
DD.16	0	0	0	1	1	4	3	4	0	0	0	0	0	0	0	0	2	1	2	7	14	10	5	1	0	0	2	0	0	0	8	1	0	0	6	10	13	0	0	0	1	1	0	0	0	0	2	0	2	1	2	4	10	1	4	4	1	2	1	1	1	0	0	1	1	0	0	0	0	6	0	0	1	3	1	0	1	0	3	5	18	9
T&R.1	1	0	0	1	1	0	0	0	0	0	1	1	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
T&R.2	1	0	0	1	1	0	0	0	0	0	1	1	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
T&R.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
T&R.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1
T&R.5	0	0	0	2	2	2	2	0	0	0	1	0	0	1	0	0	2	0	2	1	2	2	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	2	1	2	1	1	0	0	2	2	2	2	2	2	0	1	1	1	1	0	0	1	2	0	0	1	0	0	0	0	0	2	2	2	2
T&R.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	2	1
T&R.7	1	0	0	3	1	3	2	0	0	0	0	0	0	0	0	0	2	0	2	2	2	3	2	1	0	0	1	0	0	0	0	1	0	0	0	2	2	0	0	0	0	2	0	0	0	0	2	0	1	1	2	1	1	0	0	2	1	1	1	1	2	0	0	1	1	0	0	0	0	2	0	0	2	0	0	0	0	0	2	2	3	5
T&R.8	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	1
T&R.9	1	1	1	2	2	3	3	0	0	1	1	1	1	1	1	0	2	0	3	1	1	1	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	2	1	1	1	1	0	0	1	1	1	1	1	1	0	0	1	1	0	0	0	0	2	0	0	1	0	0	0	0	0	2	3	1	3
T&R.10	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	1	2	4	5	1	0	2	0	1	0	0	0	6	1	0	0	2	4	7	0	0	0	0	4	0	0	0	0	1	0	1	0	1	1	5	0	1	2	1	1	1	1	1	0	0	0	0	0	0	0	0	2	0	0	1	1	0	0	1	0	1	1	7	6
T&R.11	0	0	0	3	4	5	2	2	0	0	1	1	0	1	0	0	1	0	1	8	12	13	1	0	1	1	4	0	0	0	4	1	0	0	2	5	8	0	0	0	0	10	0	0	0	0	1	0	1	0	1	5	1	1	4	7	4	5	4	4	3	1	2	0	0	2	0	0	2	2	0	0	3	6	0	0	1	0	2	4	13	8
T&R.12	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
T&R.13	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	4	4	4	0	1	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	4	0	0	0	0	0	0	0	0	0	1	4	1	1	2	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	1	1	4	2
T&R.14	0	0	0	7	8	3	2	1	0	0	2	1	0	2	0	0	1	1	1	9	14	13	2	0	0	1	7	0	1	1	0	2	0	0	3	2	3	0	0	0	0	4	0	0	0	0	2	0	2	0	1	2	7	0	2	1	6	8	6	7	7	1	5	1	1	6	0	0	4	2	0	0	5	12	0	0	0	0	1	2	12	8
T&R.15	0	0	0	4	5	3	1	0	0	0	2	1	0	2	0	0	1	0	1	5	6	6	1	0	0	1	5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	1	0	1	1	4	0	0	6	1	7	7	7	6	2	4	0	0	4	0	0	4	1	0	0	3	4	0	0	0	0	1	1	6	3
T&R.16	0	0	0	5	6	3	2	0	0	0	2	1	0	2	0	0	1	0	1	6	8	8	1	0	0	1	5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	1	0	1	1	5	0	1	8	7	1	7	8	7	2	4	0	0	4	0	0	4	1	0	0	3	6	0	0	0	0	1	1	8	4
T&R.17	0	0	0	4	5	3	1	0	0	0	2	1	0	2	0	0	1	0	1	5	6	6	1	0	0	1	5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	1	0	1	1	4	0	0	6	7	7	1	7	6	2	4	0	0	4	0	0	4	1	0	0	3	4	0	0	0	0	1	1	6	3
T&R.18	0	0	0	5	6	3	1	0	0	0	2	1	0	2	0	0	1	0	1	5	7	7	1	0	0	1	5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	1	0	1	1	4	0	0	7	7	8	7	1	7	2	4	0	0	4	0	0	4	1	0	0	3	5	0	0	0	0	1	1	7	4
T&R.19	0	0	0	6	5	3	1	0	0	0	1	0	0	1	0	0	1	0	1	5	6	7	1	0	0	1	4	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	2	0	2	0	1	1	3	0	0	7	6	7	6	7	1	2	3	0	0	3	0	0	3	1	0	0	4	4	0	0	0	0	1	1	8	5
I.D. - PR.1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2	2	2	2	2	1	2	0	0	2	0	0	2	0	0	0	1	2	0	0	0	0	0	0	3	3
I.D. - PR.2	1	0	0	4	6	2	0	1	0	0	4	3	0	5	0	0	0	3	1	5	10	5	0	0	0	2	4	0	0	0	1	0	0	0	3	1	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	2	0	0	5	4	4	4	4	3	2	1	1	1	9	0	0	9	0	0	0	2	5	0	0	0	0	0	0	9	6
I.D. - PR.3	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	1	1	2	1	0	0	0	1	0	0	0	1	0	0	0	0	1	1	0	1
I.D. - PR.4	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	1	2	1	1	0	0	0	1	0	0	0	1	0	0	0	0	1	1	0	1
I.D. - PR.5	0	0	0	3	5	2	0	1	0	0	3	2	0	3	0	0	0	1	0	4	9	6	1	0	0	2	5	0	0	0	1	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	6	4	4	4	4	3	2	9	1	1	1	0	0	8	0	0	0	2	6	0	0	0	0	0	0	7	5
I.D. - PR.6	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
I.D. - PR.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I.D. - PR.8	0	0	0	3	5	2	0	1	0	0	4	2	0	4	0	0	0	2	0	4	7	5	0	0	0	2	4	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2	0	0	4	4	4	4	4	3	2	9	0	0	8	0	0	1	0	1	0	2	4	0	0	0	0	0	0	8	4
I.D. - PR.9	0	0	0	1	1	2	2	1	0	0	0	0	0	0	0	0	2	1	2	4	5	4	2	1	0	0	1	0	0	0	1	1	0	0	1	4	4	0	0	0	0	6	0	0	0	0	2	0	2	1	2	2	2	0	1	2	1	1	1	1	1	0	0	1	1	0	0	0	0	1	1	0	1	1	1	0	1	0	2	2	6	4
PR.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	2	0	0	0	3	0
PR.11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	0	0	1	0
PR.12	0	0	0	5	4	3	1	0	0	0	0	0	0	0	0	0	1	1	3	5	6	6	1	0	0	1	5	0	1	1	1	1	0	0	1	1	2	1	1	1	1	1	0	0	0	0	1	0	2	0	1	1	3	0	0	5	3	3	3	3	4	1	2	0	0	2	0	0	2	1	1	1	1	4	0	0	1	0	1	1	7	6
PR.13	0	0	0	4	6	2	1	1	0	0	1	1	0	1	0	0	0	2	0	7	19	14	2	0	0	1	10	0	1	1	3	1	0	0	7	3	3	0	0	0	0	3	0	0	0	1	0	0	0	0	0	1	6	0	2	12	4	6	4	5	4	2	5	1	1	6	0	0	4	1	0	0	4	1	1	0	0	0	0	1	15	13
PR.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	2	1
PR.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
PR.16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	1	0	0	0	1	0	0	0	3	0
PR.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
PR.18	0	0	0	1	1	3	2	0	0	0	0	0	0	0	0	0	2	0	2	2	2	2	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	0	0	0	2	0	2	1	2	1	2	1	1	1	1	1	1	1	1	0	0	1	1	0	0	0	0	2	0	0	1	0	0	0	0	0	1	2	2	3
PR.19	2	1	1	2	2	4	3	3	0	1	1	1	1	1	1	0	2	0	3	2	5	4	2	1	0	0	1	0	0	0	1	1	0	0	1	3	4	0	0	1	1	5	0	0	0	0	2	0	2	1	3	1	4	0	1	2	1	1	1	1	1	0	0	1	1	0	0	0	0	2	0	0	1	1	0	0	0	0	2	1	5	5
PR.20	9	1	0	14	11	9	3	5	0	0	5	4	1	6	0	5	2	8	5	15	39	27	12	0	2	2	15	1	1	1	17	2	1	1	13	25	24	0	0	1	1	18	1	1	1	1	2	2	3	0	1	7	13	1	4	12	6	8	6	7	8	3	9	0	0	7	0	0	8	6	3	1	7	15	2	1	3	1	2	5	1	36
PR.21	9	2	1	12	10	8	3	5	1	1	1	2	1	2	1	5	2	3	6	8	30	20	9	1	3	2	14	1	1	1	14	2	1	1	8	20	18	1	1	1	1	9	0	0	1	1	2	1	5	1	3	6	8	1	2	8	3	4	3	4	5	3	6	1	1	5	1	0	4	4	0	0	6	13	1	1	0	1	3	5	36	1

Figure 24. EDS DSM(5): Deliverable Interaction by the utilization of merged tools

Appendix c. MATLAB code routines to obtain network properties (Bounova 2014)

```
>> numnodes(adj)

>> numedges(adj)

>> link_density(adj)

>> issymmetric(adj)

>> average_degree(adj)

>> diameter(adj)

>> isconnected(adj)

>> num_conn_comp(adj)

>> find_conn_comp(adj)

>> clust_coeff(adj)
```

Bibliography

3M. (2012). *A culture of innovation* . St. Paul: 3M.

Ackoff, P. R. (2010). 15.965 - Leaders for Manufacturing Program Seminar.

BMWgroup. (n.d.). Retrieved from BMWgroup.com

Bounova, G. (2014, November 23). *Octave routines for network analysis.* Retrieved from DOI: 10.5281/zenodo.10778: https://zenodo.org/ record/10778

Brown, B., & Anthony, S. D. (2011). *How P&G tripled its innovation success rate.* Boston: Harvard Business Review.

Chesbrough, H. (2012). *GE's ecomagination Challenge: An Experiment in Open Innovation.* California: University of California, Berkeley, Haas School of Business.

Christensen, C. (1997). *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail.* Harvard Business School Press.

Dori, D. (2002). *Object-Process Methodology: A Holistic Systems Paradigm.* Berlin: Springer-Verlag.

Ebert, C. (Jul2013). Improving engineering efficiency with PLM/ALM. *Software & Systems Modeling,* Vol. 12 Issue 3, p443-449.

Edward Crawley, B. C. (2016). *System architecture : strategy and product development for complex systems.* NJ: Pearson Higher Education, Inc.

Eppinger, S., & Browning, T. (2012). *Design Structure Matrix Methods and Applications.*

Forsberg, K., Mooz, H., & Cotterman, H. (2005). *Visualizing Project Management, p. 358.* J. Wiley & Sons.

Grieves, M. (2006). *Product Lifecycle Management. ISBN 0071452303.* McGraw-Hill.

Hoffer, J. A., George, J. F., & Valacich, J. S. (2014). *Modern systems analysis and design.* Iowa: Pearson.

Hommes, Q. D. (2008). Comparison and application of metrics that define the components modularity in complex products. *Proceedings of the ASME 2008 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference.* New York, USA: ASME.

Hommes, Q. V. (2014). ESD.411 Systems Engineering Lecture Slides.

INCOSE. (2011). *SYSTEMS ENGINEERING HANDBOOK. A GUIDE FOR SYSTEM LIFE CYCLE PROCESSES AND ACTIVITIES.* International Council on Systems Engineering.

Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013. (n.d.). Retrieved from https://www3.epa.gov/

J, N. (2013). *The structure and function of complex networks.* Soc Ind Appl Math .

Lutters, E., van Houten, F. J., Bernard, A., Mermoz, E., & Schutte, C. S. (2014). *Tools and techniques for product design.* In CIRP Annals - Manufacturing Technology.

Michael C. Pasqual, O. L. (2011). Multilayer network model for analysis and management of change propagation. *Res Eng Design.* Springer-Verlag London Limit.

Morris, M. K. (2010). *Corporate Entrepreneurship and Innovation. (Chapter 12, Pages 331 & 337-347).* Cengage Learning.

Moser, B. (2014). ESD.411 PM Introduction Lecture slides.

OEM. (2016). "Time to Engineer" Internal survey.

Oisen, R. (1971). Can project management be defined? *Project Management Quarterly*, 12-14.

Olivier L. de Weck, A. M. (2012, June). Investigating Relationships and Semantic Sets amongst. *Third International Engineering Systems Symposium, Delft University of Technology.*

Saaksvuori, A. &. (2004). *Product Lifecycle Management. ISBN 3540403736.* Springer-Verlag.

Soderborg, N. R., Crawley, E. F., & Dori, D. (October 2003). System Function and Architecture: OPM-Based Definitions and Operational Templates. *Communications of the ACM*, Vol. 46 Issue 10, p67-72.

Stark, J. (2004). *Product Lifecycle Management: Paradigm for 21st Century Product Realisation. ISBN 1852338105.* Springer-Verlag.

Sterman, J. (2000). *Business Dynamics: Systems Thinking and Modeling for a Complex World.*

Steward, D. V. (1981). *Systems Analysis and Management:Structure, Strategy, and Desing.* New York: Petrocelli Books.

Suh, N. (2001). *Axiomaric Design: Advances and Applications.* New York: Oxford University Press.

Thebeau, R. E. (2001). *Knowledge management of system interfaces and interactions from product development processes.* MIT.

Ulrich, K., & Eppinger, S. (2012). *Product design and development.* New York: McGraw-Hill/Irwin.

University, D. A. (1993).

Utterback, J. M. (1996). *Mastering the dynamics of innovation.* Boston: Harvard Business School Press.