Enhancing Workflow Efficiency in Innovative Automotive Processes: A Structured Approach Using DMM and DSM Matrices

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Abstract: This study analyzes an innovative production process in the automotive sector, specifically regarding the introduction of the SeatBridge patent during the assembly phase of front seats. By employing structured tools such as the Work Breakdown Structure (WBS), semi-structured questionnaires, and DMM matrices, a group of subject-matter experts (ESM) was guided through systematic data collection and processing. The adopted workflow enabled optimization of time and resources, ensuring active involvement of professionals throughout the project phases. The final output consisted of the construction of the process DSM matrix, a useful tool to understand and optimize interdependencies among activities. Despite the method's effectiveness, some critical aspects emerged, particularly regarding the need for further development of the DMM transformation algorithm and the strong reliance on active expert engagement. The results confirm the validity of the approach and open promising perspectives for future applications in complex production environments.

Keywords: Innovative process, Automotive, DMM and DSM matrices, Resource optimization, Structured analysis

1 Introduction

The implementation of theoretical and practical tools associated with the Design Structure Matrix (DSM) entails several well-documented challenges in industrial settings. Research has consistently identified critical barriers including the difficulty of obtaining reliable cross-domain dependency data from experts in complex production environments (Browning, 2016), the inadequacy of standardized data collection modules for DSM population (Qi Dong, 2002), and the absence of versatile, user-friendly software for DSM modeling and analysis (Browning, 2016). These implementation challenges are further compounded by the substantial volume of new data required to construct structurally rich system models and the tendency of engineers to provide excessive or inconsistent information when populating DSM matrices (Qi Dong, 2002).

Within this context of recognized methodological challenges, the effective management of project teams emerges as a critical task for Project Managers in achieving set objectives. The complexity inherent in product development (PD) projects stems not only from product design itself, but also from the development process, human resource organization, applied tools and technologies, and requirements to be satisfied (Lindemann et al., 2009). In each of these domains, complexity is generated by numerous elements and the multitude of their relationships - between product components, between activities necessary for their development, and between the people who perform these activities (Lindemann et al., 2009).

The literature emphasizes that cross-functional or interdisciplinary teams are essential for providing collective experience, information, and resources for effective model construction and problem-solving (Kreimeyer et al., 2007). However, this intensive interpersonal interaction often generates conflicts due to variations in experience, knowledge, organizational or professional loyalty, understanding of scope and objectives, and/or contradictory purposes and goals (Kreimeyer et al., 2007). Project Managers consequently face crucial questions: "How many teams should be formed? Who should be a member of one team or another? How can managers ensure that relevant information is exchanged between people in different teams?" (Kreimeyer et al., 2007).

These challenges highlight the need for Project Managers who not only understand DSM/DMM methodology but are also skilled in human resource management and group dynamics. The success of DSM-based approaches is closely tied to the active participation and expertise of involved professionals (Danilovic and Browning, 2007). Research has demonstrated that expert engagement quality significantly impacts the reliability of dependency data collection, with personal interviews with the most suitable experts being recommended over standardized questionnaires due to the tendency of different engineers to have conflicting opinions about how elements relate to each other and the importance of these relationships (Qi Dong, 2002).

This article aims to address these recognized challenges by highlighting the importance of constructing Domain Mapping Matrices (DMM) as key support for implementing process-based DSM through a structured expert engagement workflow. Building upon our previous research (Grazzini et al., 2024), this work focuses specifically on the role of DMMs as structured data collection tools and demonstrates how, when applied through the proposed workflow, this approach can lead to optimal results while effectively addressing the complex dimension of human resource management within organizational contexts.

This paper contributes to the DSM/DMM literature through three key innovations informed by the identified gaps in current practice:

First, we propose a novel methodological framework that positions DMM not as the end goal of analysis (as is common in existing literature), but as an intermediate structured data collection tool specifically designed to generate process-based DSM. This addresses the recognized challenge of direct DSM population methods in complex industrial settings (Browning, 2016) by introducing a systematic intermediate step that enhances data reliability while reducing expert time commitment.

Second, we introduce a specialized transformation algorithm that converts domain-crossing data (Activities-Parameters) collected through DMMs into a comprehensive activity-based DSM. Unlike traditional approaches where DSMs are populated directly through expert interviews - which can lead to inconsistencies and excessive demands on experts (Qi Dong, 2002) - our method introduces an intermediate analytical layer that structures the data collection process more effectively.

Third, we demonstrate how this approach can be operationalized through a structured expert engagement workflow that systematically guides subject matter experts through the data collection process. This methodology directly addresses the critical team management challenges identified in the literature (Kreimeyer et al., 2007) by providing clear roles, objectives, and structured interaction protocols that balance methodological rigor with practical time constraints in industrial settings.

The integration of these elements creates a comprehensive methodology that addresses the fundamental challenge recognized in DSM implementation literature: obtaining reliable cross-domain dependency data efficiently from experts working in complex production environments (Browning, 2016) (Qi Dong, 2002). By formalizing the data collection process through DMM construction before DSM derivation, we enable more structured expert contributions while simultaneously creating a reusable knowledge base for future analyses, thereby addressing both the technical and human resource management aspects of DSM implementation.

2 The Role and Construction of Domain Mapping Matrices (DMM) in Cross-Domain System Modeling

Domain Mapping Matrices (DMMs) represent a significant evolution of the Design Structure Matrix (DSM) theory, as they allow for modeling inter-domain relationships—overcoming the inherent limitations of the intra-domain nature of DSMs. While DSMs are square matrices used to explore interactions within a single domain (such as product, process, or organization), DMMs are rectangular matrices specifically designed to capture dependencies between elements from different domains. This cross-domain capability is essential for understanding the complex interactions that characterize many systems.

The concept of DMMs (Danilovic and Browning, 2007) highlights their potential applicability across five design domains - Product, Process, Organization, Tools, and Goals - emphasizing their versatility. In practice, DMMs are often used in conjunction with DSMs to gain deeper insights into system structures and to support the derivation of additional matrices. Constructing a DMM involves several fundamental steps: identifying the two distinct domains to be analyzed, defining the elements within each domain, and mapping the relationships between them. Rows and columns of the matrix represent elements from each domain respectively, with the matrix cells indicating the presence, strength, or type of relationship through binary values, numerical scales, or symbolic coding.

For instance, a DMM might link process activities to the organizational units responsible for them or connect functional requirements to design parameters. In the literature, DMMs have been applied to various domain pairs such as Process–Goals (Browning et al., 2002), Functional Flow–Design (Jankovic et al., 2012), and Component–Function (Flanagan et al., n.d.), with the aim of enhancing traceability, coordination, and cross-domain alignment. Analytical techniques such as clustering or the computation of Domain Analysis Criteria (DACs) have been applied directly to DMMs to uncover patterns or improve system understanding.

2.1 Repositioning DMMs: From Analytical Endpoints to Structured Data Collection Tools

In some cases (e.g., Jankovic et al., 2012), DMMs serve as a basis for deriving DSMs, reflecting a similar conceptual approach to the one adopted in this study. However, this work introduces a key distinction. Rather than using DMMs purely as tools for inter-domain analysis, we position them as a structured mechanism for expert-guided data collection, with the specific goal of supporting the construction of an activity-based DSM. This preparatory role makes the DMM a critical intermediary step in the modeling process (Grazzini et al., 2024), enabling a more reliable and organized transition toward standard DSM analyses such as sequencing, tearing, and simulation. While both traditional approaches (Qi Dong, 2002) and the one presented here rely on expert input to populate system matrices, our method innovates by explicitly integrating DMMs into the expert engagement workflow. Instead of relying solely on interviews or surveys to directly populate a DSM—which can lead to inconsistencies or impose excessive demands on experts—our approach leverages DMMs to structure and streamline the data collection process, supported by dedicated computational tools. Despite the growing interest in DMMs, the literature reveals three persistent limitations. First, DMMs are often treated as analytical endpoints rather than as tools within a broader methodological framework. Second, direct DSM population methods face practical challenges in complex industrial settings. Third, few studies offer a clear path for translating multi-domain analysis into actionable, domain-specific optimization. This paper addresses these gaps by redefining the role of DMMs within the DSM construction process and proposing a formalized methodology for expert involvement that improves both efficiency and data reliability.

3 Structured Workflow for DMM Construction through Expert Panel Involvement

The process of constructing the Domain Mapping Matrix (DMM) was developed through five progressive phases, as visually summarized in Figure 1, which outlines the structured workflow followed throughout the study. This diagram serves as a visual reference for the methodology adopted, highlighting the sequential logic and interdependence between phases. It also provides an at-a-glance view of the entire methodological architecture, helping to contextualize each stage within the broader research framework.

The first phase involved the formation of the expert group, selecting professionals with specific expertise relevant to the domains under analysis. At this stage, it was essential to clearly present the case study and explain the DSM/DMM methodology to ensure a comprehensive understanding of the framework. A detailed presentation was provided, including previous research applications, objectives, and the intended use of the matrices. This created a common ground of understanding among experts from different backgrounds. Coordination meetings and a preliminary Work Breakdown Structure (WBS) were used as key tools to structure the initial activities. The WBS was not only instrumental in mapping out the process steps, but also served as a communication bridge among team members. In the second phase, through brainstorming sessions and focus groups, the experts collaborated to identify the most relevant process activities along with their corresponding input/output parameters. These activities were then grouped according to each specialist's domain of expertise, enabling a thematic and functional organization of the content. The joint sessions allowed for iterative refinement and validation of proposed elements, promoting a participative environment where each expert's input contributed to shaping the process landscape. Special care was taken to avoid overlaps and ensure the traceability of each identified element to its respective domain.

The third phase focused on the presentation and explanation of the DMM framework. The experts were introduced to the concept and purpose of the matrix, specifically how it maps relationships between identified domains, such as activities and parameters. This stage was crucial for ensuring that all participants were aligned in their interpretation of the methodology and the significance of the resulting matrices. Real-world examples and simplified versions of DMMs were used to clarify the expected output and encourage consistent interpretations. To support this process, both focus groups and structured or semi-structured questionnaires were used to facilitate understanding and gather data. Experts were encouraged to express doubts and provide feedback, fostering a collaborative learning process.

3.1 Implementation and Validation: From Collaborative Construction to Expert Consensus

The fourth phase was dedicated to the construction of the DMMs, carried out through collaborative elaboration of the information collected in the previous phases. Inputs from the focus groups were integrated with the WBS structures and digital tools (such as spreadsheets or dedicated matrix editors) to systematically populate the matrices. Attention was paid to the type and strength of the relationships recorded in each matrix cell, based on shared criteria established beforehand. The ability to incorporate comments and justifications next to each input strengthened the reliability of the dataset and made the knowledge base auditable and replicable.

Finally, the fifth phase involved the review and validation of the DMMs by the expert group. In this concluding phase, the preliminary results were discussed collectively to verify their accuracy. Feedback loops were introduced to address inconsistencies or disagreements, and multiple validation sessions were sometimes required. A multidisciplinary consensus panel supported the process, ensuring a solid and shared knowledge base for the final interpretation of the data. This phase also included a reflection on the applicability of the generated matrix for downstream uses, such as the creation of the activity-based DSM or the computation of inter-domain metrics.

Overall, the five-phase methodology not only ensured the methodological rigor of the data collection and modeling process but also fostered a sense of ownership and shared responsibility among the participants. The structured nature of the workflow provided clarity and repeatability, making it suitable for adaptation in other industrial contexts.

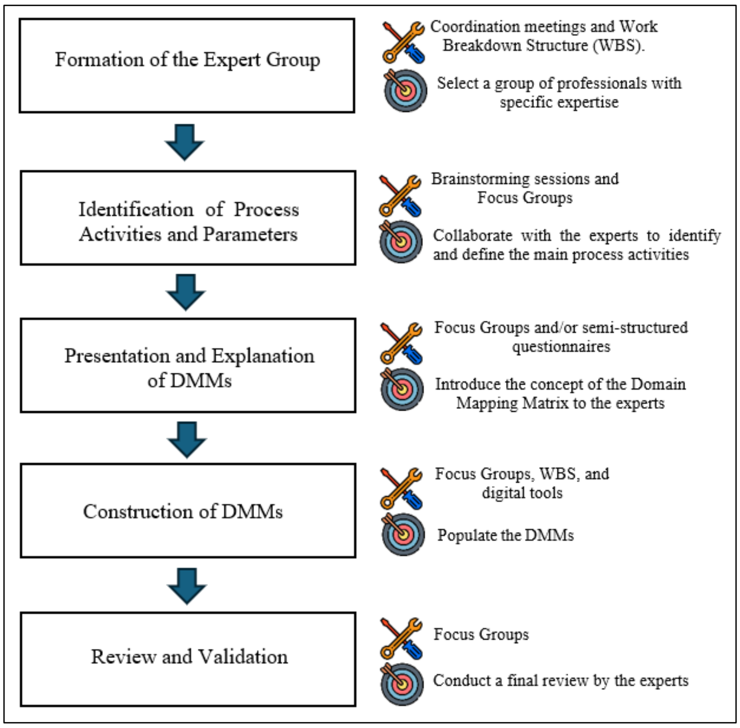


Figure 1. Workflow for DMMs construction

4 Methodological Approach and Contextual Adaptation

To support the identification of relevant activities and parameters connected to the SeatBridge innovation, a semi-structured questionnaire was designed and submitted to a selected group of Subject Matter Experts, as shown in Figure 3a. The tool was divided into four key sections:

1. A – personal and professional background;
2. B – selection of up to 12 critical process activities;
3. C – indication of 10 key parameters for the selected activities (input/output);
4. D – open-ended evaluation of the patent's innovative potential, strengths, and weaknesses.

The structure of the questionnaire encouraged a systematic yet flexible collection of expert knowledge, allowing for both quantitative aggregation and qualitative insights. In particular, Section D could optionally be adapted to suit the level of familiarity of experts with the production process: in place of the open-ended evaluation, respondents were invited to rate the strength of the relationships between activities and parameters using a three-point scale (1–weak, 2–moderate, 3–strong), with the possibility of adding specific comments. This alternative was especially useful in contexts where experts possessed a high level of operational knowledge and were motivated to enhance systemic understanding through precise feedback. Figure 3b shows the semi-structured questionnaire translated into English to illustrate its structure and components. This modular approach proved effective in capturing diverse perspectives while keeping the input aligned with the project's analytical needs.

Before deploying the questionnaire, a brainstorming session was held with a multidisciplinary team to define the preliminary structure of the car seat system, as shown in Figure 2. The session resulted in a categorized breakdown of components, teams, and associated activities, grouped by area of expertise (mechanical, materials, safety, electronics). The clarity and coherence of the resulting table allowed it to serve as a shared reference point throughout the entire study. Furthermore, the use of this table not only facilitated a common language among experts from different disciplines but also helped ensure a traceable link between early conceptualization and the subsequent analytical models. It promoted alignment among participants during focus groups and fostered a collective understanding of process interdependencies. As the research progressed, this foundational material was revisited and refined, reinforcing its role as a living document rather than a static artifact.

Together, these two tools—questionnaire and initial classification—provided a coherent methodological foundation and promoted consistency across the research stages, from data collection to modeling. They also enabled the validation of assumptions through iterative feedback, improving the robustness of the constructed Domain Mapping Matrices and ensuring higher fidelity in the final DSM analyses.

4.1 Parameter Definition and Classification

Within the context of this study, "parameters" are defined as measurable characteristics, variables, or attributes that serve as inputs to or outputs from specific process activities. These parameters represent the tangible and intangible elements that flow between activities, creating the interdependencies that the DMM matrices are designed to capture. Parameters encompass physical components (seat frames, bolts, fabric), informational elements (assembly instructions, quality standards, design drawings), operational conditions (torque specifications, temperature requirements, timing constraints), and quality criteria (dimensional tolerances, strength requirements, aesthetic standards). In the SeatBridge case study, typical input parameters included seat frame assemblies, mounting bracket specifications, and quality inspection checklists, while output parameters comprised assembled seat units, assembly time documentation, and quality verification reports. This systematic parameter classification enabled experts to identify and categorize the various elements flowing through the assembly process, facilitating the structured population of the Activities-Parameters DMM matrices.

LEVEL	TEAM	COMPONENTS	ACTIVITY LIST	ID
CAR SEAT (S)	MECHANIC	Seat structure	Assembly of the basic seat structure	S1
		Regulatory mechanisms	Electric motor adjustment to adjust seat height, tilt and distance	S2
		Heating and ventilation	Application of accessory structures	S3
		Frame and tipping mechanisms	Basic structure installation	S4
	MATERIALS	Padding material	Application of padding	S5
		covering	Application of coatings	S6
	SAFETY	Security systems	Application of accessory structures	S7
		Seat belts	Seat belt installation	S8
	ELECTRONIC	Electrical and regulation system	Installation of additional systems	S9

Figure 2. Initial Brainstorming

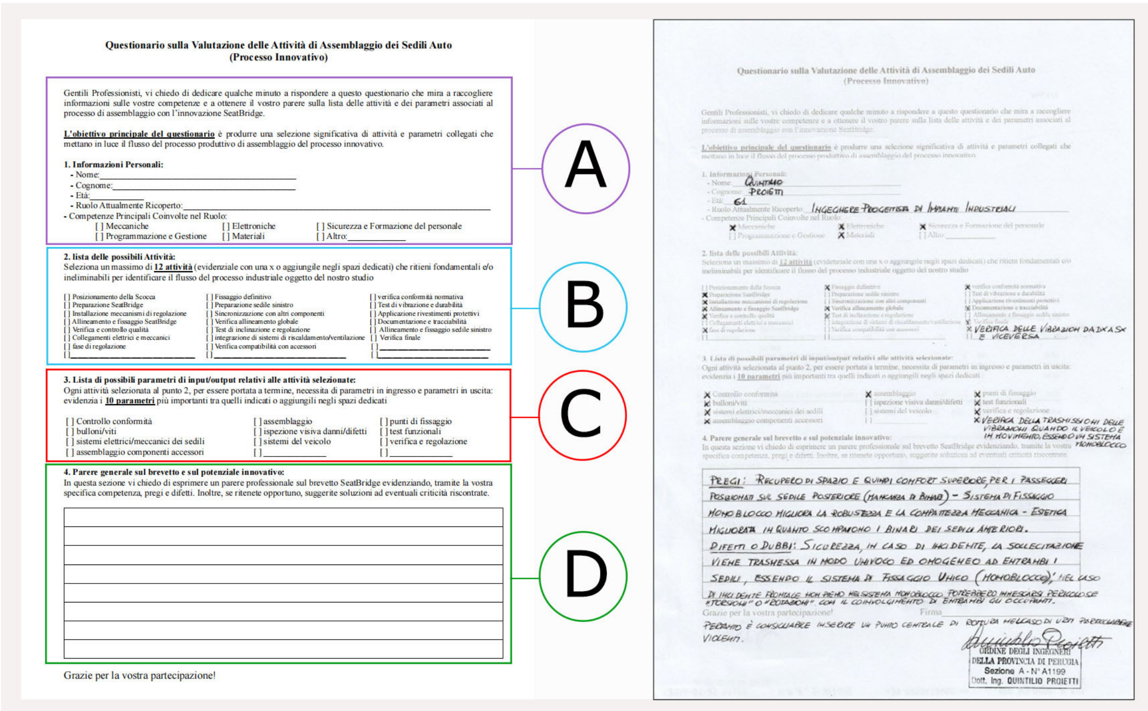
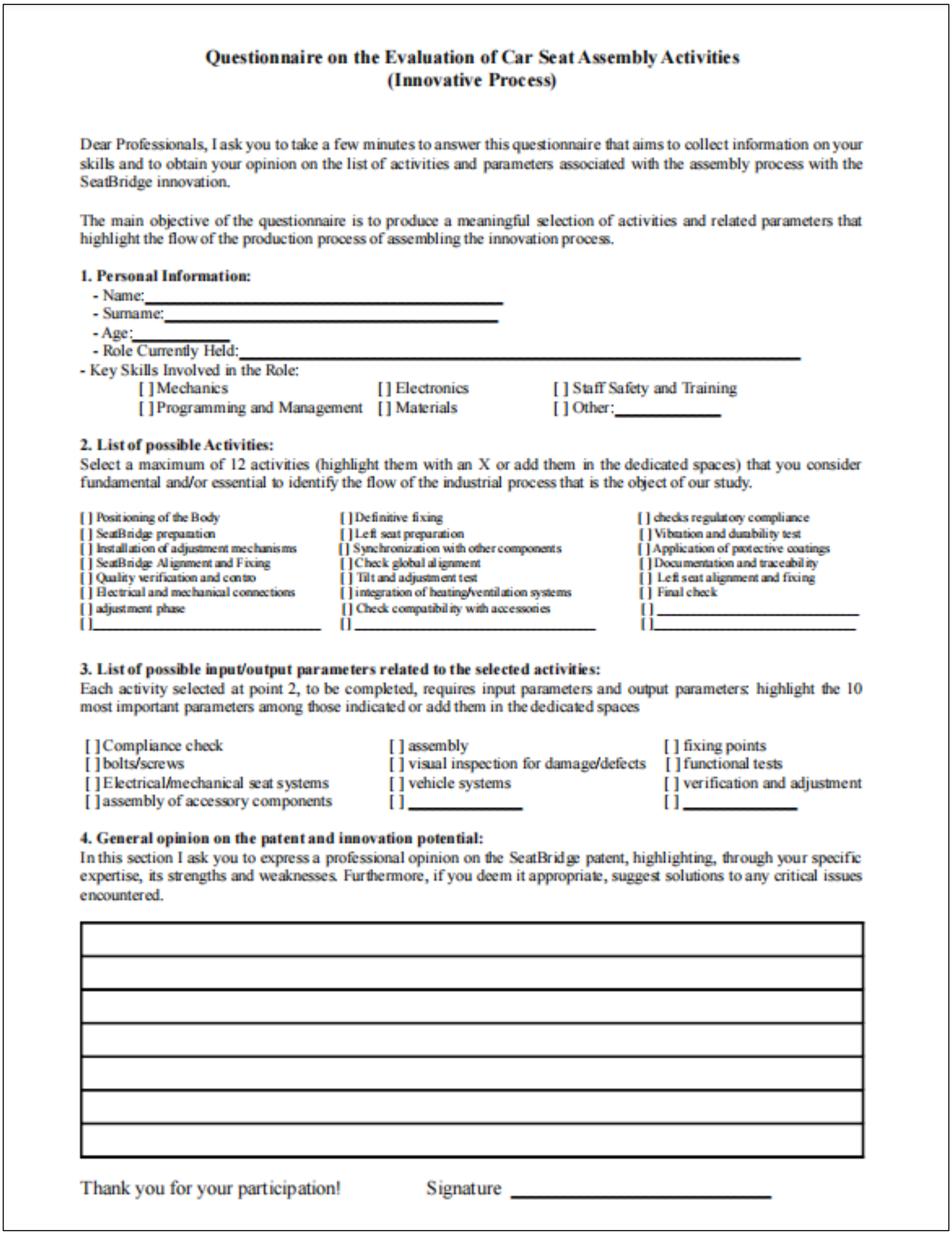


Figure 3a. Modularity of the semi-structured questionnaire divided into component parts with example of compilation



Questionnaire on the Evaluation of Car Seat Assembly Activities
(Innovative Process)

Dear Professionals, I ask you to take a few minutes to answer this questionnaire that aims to collect information on your skills and to obtain your opinion on the list of activities and parameters associated with the assembly process with the SeatBridge innovation.

The main objective of the questionnaire is to produce a meaningful selection of activities and related parameters that highlight the flow of the production process of assembling the innovation process.

1. Personal Information:

- Name:____________________
- Surname:____________________
- Age:__________
- Role Currently Held:____________________
- Key Skills Involved in the Role:

[ ] Mechanics
[ ] Electronics
[ ] Staff Safety and Training
[ ] Programming and Management
[ ] Materials
[ ] Other:__________

2. List of possible Activities:

Select a maximum of 12 activities (highlight them with an X or add them in the dedicated spaces) that you consider fundamental and/or essential to identify the flow of the industrial process that is the object of our study.

[ ] Positioning of the Body
[ ] SeatBridge preparation
[ ] Installation of adjustment mechanisms
[ ] SeatBridge Alignment and Fixing
[ ] Quality verification and contro
[ ] Electrical and mechanical connections
[ ] adjustment phase
[ ]____________________
[ ] Definitive fixing
[ ] Left seat preparation
[ ] Synchronization with other components
[ ] Check global alignment
[ ] Tilt and adjustment test
[ ] integration of heating/ventilation systems
[ ] Check compatibility with accessories
[ ]____________________
[ ] checks regulatory compliance
[ ] Vibration and durability test
[ ] Application of protective coatings
[ ] Documentation and traceability
[ ] Left seat alignment and fixing
[ ] Final check
[ ]____________________
[ ]____________________

3. List of possible input/output parameters related to the selected activities:

Each activity selected at point 2, to be completed, requires input parameters and output parameters: highlight the 10 most important parameters among those indicated or add them in the dedicated spaces

[ ] Compliance check
[ ] bolts/screws
[ ] Electrical/mechanical seat systems
[ ] assembly of accessory components
[ ] assembly
[ ] visual inspection for damage/defects
[ ] vehicle systems
[ ] __________
[ ] fixing points
[ ] functional tests
[ ] verification and adjustment
[ ] __________

4. General opinion on the patent and innovation potential:

In this section I ask you to express a professional opinion on the SeatBridge patent, highlighting, through your specific expertise, its strengths and weaknesses. Furthermore, if you deem it appropriate, suggest solutions to any critical issues encountered.

Thank you for your participation!   Signature ____________________

Figure 3b. Semi-structured questionnaire used during the research

5 The case study

The case study focused on analyzing the front seat assembly process in the automotive sector, specifically evaluating the impact of introducing the SeatBridge patent. The primary objectives were: - Quantify process time reduction potential - Evaluate cost optimization opportunities - Identify critical dependencies affecting implementation - Develop an optimized process sequence. The innovative SeatBridge patent promised a significant reduction in assembly time based on preliminary estimates but required systematic analysis to validate this claim and identify potential implementation challenges. The study employed the structured DMM-to-DSM workflow described in Section 3, with specific adaptations for the automotive manufacturing context: a panel of eight professionals was assembled, including - 1 senior manufacturing manager with 12+ years of experience - 3 process engineers specializing in seat assembly - 2 design engineers familiar with the SeatBridge patent - 2 quality assurance specialists. Each expert contributed an average of 8.5 hours to the study, distributed across five structured sessions over a three-week period.

LEVEL	TEAM	COMPONENTS	ACTIVITY LIST	ID
SEATBRIDGE ASSEMBLY PROCESS, INNOVATIVE PROCESS (IPS)	MECHANIC	Seat backrest	Tilt and adjustment test	PI1
		SeatBridge	Basic structure installation	PI2
		SeatBridge	SeatBridge preparation	PI3
		SeatBridge, Car body	SeatBridge alignment and fixing	PI4
		Car body floor, SeatBridge	Definitive fixing	PI5
		Seat sitting	Integration of heating/ventilation systems	PI6
		Car model	Check compatibility with accessories	PI7
	MATERIALS	Car body, Car model	Car body positioning	PI8
	SAFETY	SeatBridge	Quality verification and control	PI9
		SeatBridge	Preparation of components	PI10
		SeatBridge	Final check	PI11
		SeatBridge	Synchronization with other components	PI12
		SeatBridge	Check global alignment	PI13
		SeatBridge, Car model	Verification of regulatory compliance	PI14
		Car body, SeatBridge	Vibration and durability test	PI15
		SeatBridge	Application of protective coatings	PI16
		SeatBridge, Car body, Car model	Documentation and traceability	PI17
		SeatBridge, Car body, Car model	Adjustment phase	PI18
	ELECTRONIC	SeatBridge, Car model	Installation of the adjustment mechanisms	PI19
		SeatBridge, Car model	Electrical and mechanical connections	PI20

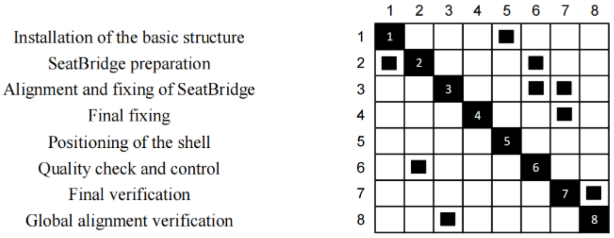
(a)

LEVEL	TEAM	ACTIVITY LIST	ID
SEATBRIDGE ASSEMBLY PROCESS, INNOVATIVE PROCESS (IPS)	MECHANIC	Installation of the basic structure	PI2
		SeatBridge preparation	PI3
		Alignment and fixing of SeatBridge	PI4
		Final fixing	PI5
	MATERIALS	Positioning of the shell	PI8
	SAFETY	Quality check and control	PI9
		Final verification	PI11
		Global alignment verification	PI13

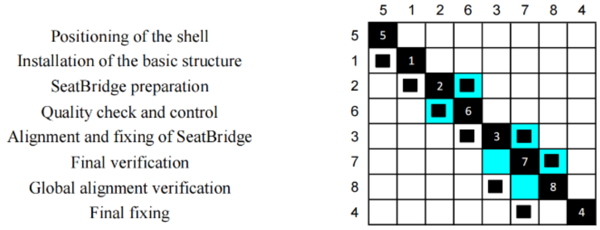
(b)

Figure 4. Activity decomposition (a), Optimized process (b)

Through the WBS approach, the assembly process was decomposed into 20 distinct activities (see figure 4 (a)), which were further consolidated into 8 primary activities (see figure 4 (b)) through expert consensus. These activities were then matched with critical parameters through the structured questionnaire process. The Activities-Parameters DMM was populated through a combination of: - 8 completed semi-structured questionnaires (100% response rate) - 3 facilitated focus group sessions (120 minutes each) - 2 technical validation workshops Inter-rater reliability was assessed using Fleiss' kappa coefficient, yielding a value of 0.76, indicating substantial agreement among experts. Disputed relationships (12% of all identified relationships) were resolved through a Delphi-like consensus process. The application of the transformation algorithm to the DMM data produced an activity-based DSM, as shown in figure 5 (a), with 9 dependencies (from a possible 64 in a 8×8 matrix), representing a 14% non-zero density. Analysis of this matrix revealed: - 3 critical feedback loops affecting sequential implementation - 5 high-leverage activities with disproportionate impact on overall process time - 2 clusters of tightly coupled activities (see figure 5 (b)) requiring concurrent engineering. The optimized process sequence was presented to the expert panel for verification. Using a 7-point Likert scale assessment, experts rated the results as follows: - Technical feasibility: 6.3/7 - Expected benefits realization: 5.8/7 - Implementation complexity: 3.2/7 (lower is better).



(a)



(b)

Figure 5. DSM of innovative process (a), Partitioned DSM (b)

Although we use the same case study as in our previous work (Grazzini et al., 2024), this choice enables a direct comparison of the proposed methodological advancements. Applying the approach to different industrial contexts represents the natural evolution of this research.

5.1 Consensus Processes and Reliability Assessment

Two complementary consensus processes were employed to ensure data reliability and expert agreement validation.

- Inter-rater Reliability Assessment through Fleiss' Kappa

Inter-rater reliability was assessed using Fleiss' kappa coefficient, a statistical measure specifically designed for evaluating agreement among multiple raters (Fleiss, 1971). Unlike Cohen's kappa, which is limited to two raters, Fleiss' kappa enables the assessment of agreement across multiple evaluators, making it particularly suitable for expert panel studies. The coefficient measures the degree of agreement in classification beyond what would be expected by chance, with values ranging from -1 to 1. Following Fleiss' guidelines, values above 0.75 are considered excellent, 0.40-0.75 as fair to good, and below 0.40 as poor agreement.

- Delphi-like Consensus Process

For disputed relationships (12% of all identified relationships), a Delphi-like consensus process was implemented. The Delphi method, originally developed by RAND Corporation in the 1950s, is a structured communication technique designed to achieve convergence of expert opinions through iterative rounds of questioning and feedback (Dalkey and Helmer, 1963). Our modified approach maintained the core principles of the Delphi method: structured feedback, controlled anonymity, and iterative refinement, while adapting the process to the specific context of DSM matrix population.

6 DSM Matrix Optimization: Development and Application of DMM Transformation Algorithm

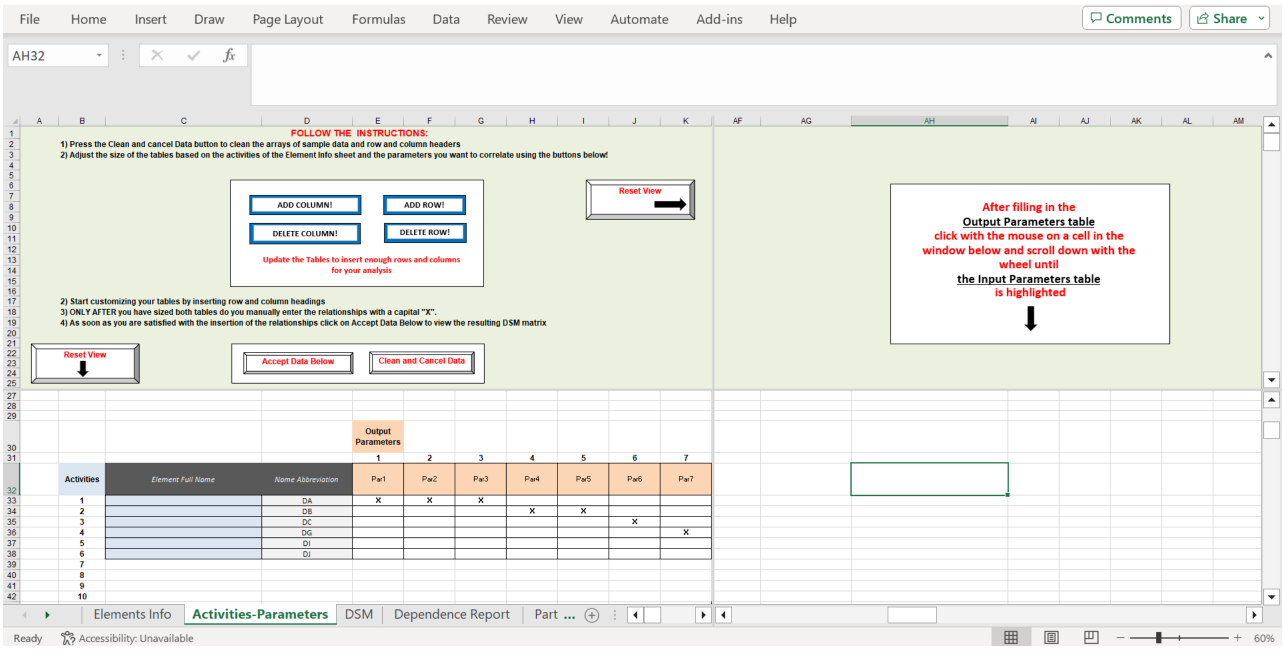


Figure 6. "Activities Parameters" worksheet display screen

The DMM transformation algorithm, integrated within the 'Activities-Parameters' worksheet shown in figure 6, enables the generation of a DSM matrix with a maximum size of 50x50, based on two DMM matrices with maximum dimensions of 50x20. The adopted method requires the insertion of relationships between activities and parameters through the use of uppercase 'X' characters in the input and output tables. The algorithm subsequently calculates the DSM matrix by scanning all the relationships within the DMM tables and placing the corresponding values in the DSM matrix. The dimensions of the tables can be modified using buttons located at the top of the worksheet, which allow the user to add columns ('add column') and rows ('add row') or delete them using the 'delete column' and 'delete row' buttons. Each modification is dynamically reflected in both tables. The correct use of the worksheet involves the execution of the following steps:

1. Macro Activation: Upon opening the file, it is necessary to enable macros by clicking the 'Enable Content' button. This step is essential to ensure the proper functioning of the VBA-integrated features within the worksheet.

2. Updating VBA Analysis Tools: Prior to using the worksheet, the VBA analysis tools must be updated. This can be done by selecting "Analysis ToolPak – VBA" from the Excel add-ins window.
3. Worksheet Setup: The 'Activities-Parameters' worksheet is divided into three main areas: the Activity-Parameter Output table, the Activity-Parameter Input table, and the DSM matrix. It is important to properly adjust the zoom level and split the window to facilitate data entry.
4. Data Entry: Data should first be entered into the Output table, adjusting its dimensions as needed. Relationships between activities and parameters are indicated using uppercase 'X' characters. Subsequently, data is entered into the Input table following the same procedure.
5. DSM Matrix Generation: Once the data has been entered into the DMM tables, the 'Accept Data Below' button is pressed to generate the DSM matrix. The system calculates the interrelationships between activities and appropriately positions them within the DSM matrix.

The DMM transformation algorithm follows a systematic procedure to compute the DSM matrix. Figure 7 provides an example by illustrating how the relationships in the first column are filled in, thereby demonstrating the calculation method. The following steps are automatically executed:

1. Scanning Relationships: The algorithm scans all relationships in the first row of the Activity-Parameter Output table and identifies matches within the Input table.
2. Value Placement: The identified relationships are placed in the DSM matrix by inserting the value '1' in the corresponding cells.
3. Process Repetition: This process is repeated for all columns in the DMM tables, thereby populating the DSM matrix with all interrelationships between activities.

Figure 7. Example of how the algorithm works for the population of relations in the first column

This innovative approach streamlines the work of experts by enabling efficient management of interdependencies between activities and parameters. The robustness of the algorithm is ensured by its ability to adapt to the specific requirements of the production process, while maintaining the accuracy and reliability of the collected data. However, it is important to emphasize that the algorithm requires further development and validation to ensure its applicability in broader and more diverse contexts.

7 Conclusions

This study represents a significant evolution from our previous research (Grazzini et al., 2024) on the SeatBridge case. While the earlier work focused primarily on applying the DSM methodology to compare industrial processes, the present study delves deeper into the methodological process itself, formalizing the expert engagement workflow and repositioning DMMs as structured data collection tools rather than mere analytical endpoints. The use of the same case study allows for a direct comparison of methodological improvements, although applying the approach to different industrial contexts remains an important objective for future research. The use of DMM matrices in the study of the innovative production process presented in the case study demonstrated the effectiveness of a streamlined and structured workflow, capable of generating the DSM matrix process as the final outcome. This approach proved to be particularly suitable for analyzing activities and sub-activities that require in-depth investigation through feasibility and applied research studies.

Among the main strengths identified are:

- Optimization of time and human resources: roles and objectives assigned to each participant were clear and well defined, enabling high operational efficiency.
- Modularity and effectiveness of data collection tools: the semi-structured questionnaires proved highly functional, gathering precise and high-quality information through the active and competent involvement of the ESM participants.
- Methodological flexibility: the modular structure of the questionnaires allowed for timely adaptation to the emerging needs of the research, confirming the value of these tools for future applications.

The group of experts involved expressed positive evaluations of the adopted approach, acknowledging the good balance between the complexity of the analyzed process and the clarity of the instruments used.

However, some weaknesses were also noted:

1. The need for further exploration of the DMM transformation algorithm: although promising, it requires additional validation to ensure full applicability in broader or more complex production contexts.
2. Dependence on the quality of ESM engagement: the success of the approach is closely tied to the active participation and expertise of the involved professionals, which could present a challenge in different contexts.

In conclusion, the method adopted proved to be robust and effective in achieving the intended objectives, opening promising perspectives for application in other areas of process design and innovation. Future developments may focus on enhancing the scalability and reliability of the algorithm, as well as refining data collection and analysis models.

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