2024 NDIA MICHIGAN CHAPTER
GROUND VEHICLE SYSTEMS ENGINEERING
AND TECHNOLOGY SYMPOSIUM
DIGITAL ENGINEERING/SYSTEMS ENGINEERING (DE/SE) TECHNICAL SESSION
AUGUST 13-15, 2024 - NOVI, MICHIGAN

Strategic Decision Intelligence: Safeguarding Product Development Success in Complex Engineering Landscapes

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ABSTRACT

Product design and development (PDD) in complex and highly engineered programs, whether in the U.S. Department of Defense (DoD) or commercial sectors, faces significant challenges due to rapidly changing operational landscapes, budget constraints, and aggressive schedules. The current Digital Engineering Strategy blueprint, advocated by the DoD, underscores the difficulty of balancing design, delivery, and sustainment of intricate systems within such constraints. Traditional approaches characterized by linear processes and siloed operations often lead to prolonged cycle times and solutions ill-prepared to adapt to technological advancements and shifting threats. Despite efforts to modernize acquisition processes, core PDD practices remain entrenched in conventional methodologies, resulting in program breaches and financial losses. This paper advocates for the adoption of decision intelligence and analytics platforms to enhance decision-making capabilities in PDD. Leveraging advanced analytics, machine learning algorithms, and decision support systems, these platforms aim to streamline workflows, mitigate decision-making biases, improve decision confidence/timeliness, and knowledge management. By integrating these platforms, organizations can effectively address the challenges of complexity and uncertainty, fostering innovation, efficiency, and sustained success in an ever-evolving global landscape.

Citation: A. Murat, R.B. Chinnam, S. Rana, S. Rapp, A. Dunn, R. Renke, J. Bechtel, and K. Hansen, "Strategic Decision Intelligence: Safeguarding Product Development Success in Complex Engineering Landscapes," In Proceedings of the Ground Vehicle Systems Engineering and Technology Symposium (GVSETS), NDIA, Novi, MI, Aug. 13-15, 2024.

1. INTRODUCTION

Product design and development (PDD) presents a myriad of challenges, particularly within the highly engineered and complex programs of both the U.S. Department of Defense (DoD) and commercial sectors. The complexity, uncertainty, and risks associated with the DoD acquisition process are well documented (Bond et al., 2015). These challenges are exacerbated by rapidly evolving operational landscapes, stringent budgetary constraints, and aggressive schedules. The current Digital Engineering

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Strategy blueprint, advocated by the DoD, underscores the struggle in harmonizing design, delivery, and sustainment of intricate systems within such constraints (DoD, 2018). Traditional approaches, characterized by linear processes, document-centric methods, and siloed operations, often lead to prolonged cycle times and solutions ill-prepared to adapt to exponential technological advancements and shifting threats. Despite commendable efforts to modernize acquisition processes (e.g., the introduction of DoDI 5000.02 "Operation of the Adaptive Acquisition Framework"), extensions into rapid/streamlined acquistion and embrace Digital Engineering methodologies, the core PDD practice remains entrenched in conventional, ad hoc methodologies, resulting in significant financial losses from canceled programs and terminations (Clowney et al., 2016). These challenges are not unique to the defense sector; they also afflict commercial industries grappling with analogous complexities and uncertainties in PDD.

In an era defined by rapid technological advancements and dynamic operational landscapes, the need for agility, adaptability, and resilience transcends organizational boundaries (McCann and Skesky, 2012). The ability to navigate ambiguity and make informed decisions amid complexity is paramount. Responding to the recurring pattern of program failures necessitates a sophisticated approach to decision intelligence and analytics. This involves leveraging advanced tools and platforms capable of discerning intricate variables and evolving threats, fostering a culture of informed decision-making and strategic foresight (Heilig and Scheer, 2023).

This paper advocates for enhanced decision-making capabilities in product design and development (PDD) through the adoption of strategic decision intelligence and analytics platforms. By leveraging advanced analytics, machine learning algorithms, and decision support systems, these platforms are poised to revolutionize PDD processes and program management. Streamlining workflows, mitigating biases, and improving decision accuracy and timeliness, they serve as instrumental tools in navigating the intricate terrain of PDD for advanced engineering systems. Through their integration, organizations, whether in the

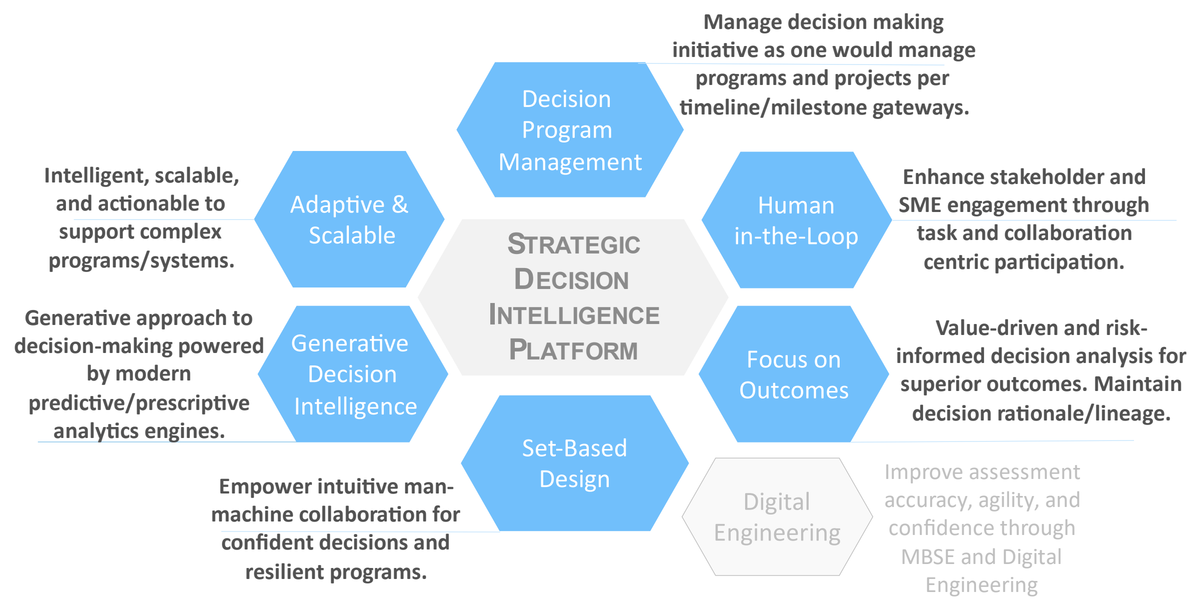

Fig. 1. Key requirements for strategic decision intelligence platforms.

defense sector or commercial industries, can effectively address the challenges of complexity and uncertainty, ultimately fostering innovation, efficiency, and sustained success.

2. DECISION INTELLIGENCE PLATFORMS

Effective decision intelligence platforms are crucial for successful decision-making in Product Design and Development (PDD) processes (Heilig and Scheer, 2023). The following key requirements outline the necessary functionalities of these platforms:

Decision Program Management: Traditionally, analytics and decision support studies are treated as standalone activities, often conducted manually with ad hoc planning, data collection, and analysis. This fragmented approach can lead to inefficiencies, errors, and hindered knowledge management (Khan *et al*., 2023). Decision intelligence platforms should enable the planning and orchestration of decision-making initiatives akin to managing programs and projects. This involves establishing reliable processes, milestones, and gateways aligned with project objectives. Real-time access to project status and intervention capabilities for management are essential features. The programmatic decision impact on Program Executive Offices (PEO(s)) and their interactions with government developmental organizations and support contractors are very real. DE efforts need to include the decision process itself.

Human in-the-Loop: Stakeholder and Subject Matter Expert (SME) engagement is critical for effective decision-making. Decision intelligence platforms should facilitate seamless interaction and collaboration between human decision-makers and machine-generated insights (Gorman, 2019). These platforms should allow participants to work in their preferred modes and intervals, ensuring maximal involvement throughout the decision-making process.

Focus on Outcomes: Prioritizing value-driven decision-making is essential. Decision intelligence platforms should incorporate risk-informed analysis methodologies to assess and mitigate potential risks associated with decision outcomes. Maintaining decision rationale and lineage is crucial for transparency and accountability in decision-making processes (Zimmerman *et al.*, 2019).

Set-Based Design: Supporting set-based design approaches is imperative for facilitating collaborative exploration of decision alternatives (Rapp *et al*., 2018). Decision intelligence platforms should empower intuitive man-machine collaboration, enabling confident decision-making based on comprehensive analysis and evaluation of multiple options.

Generative Decision Intelligence: Leveraging advanced predictive and prescriptive analytics techniques is essential for generating decision alternatives dynamically (O'Callaghan, 2023). Decision intelligence platforms should harness the power of generative decision intelligence to facilitate the discovery of innovative solutions and enhance decision-making efficacy.

Adaptive & Scalable: Decision intelligence platforms must be adaptable to evolving project requirements and scalable to accommodate the complexity of large-scale programs and systems (Pratt *et al.*, 2023). Providing actionable insights enables decision-makers to implement decisions effectively and efficiently.

Digital Engineering: Integration with model-based systems engineering (MBSE) methodologies and digital engineering processes enhances assessment accuracy, agility, and confidence in decision-making processes (Bone *et al.*, 2019). Decision intelligence platforms should seamlessly integrate with digital engineering pathways to optimize decision-making outcomes.

These requirements are indispensable for enabling informed, agile, and resilient decision-making in complex strategic environments.

Furthermore, the technical requirements for strategic decision intelligence platforms include:

Framing of Decision Problems: Translating high-level mission intentions into structured representations aligned with organizational objectives is crucial. The platform should address mission requirements comprehensively, resolve discrepancies among stakeholders, and provide intelligent assistance to facilitate collaborative deliberation and refinement.

Decision Space Modeling: Enabling comprehensive exploration of decision alternatives is essential. The platform should support the generation of viable decision choices, ensure compatibility with evaluation measures, and offer a structured representation of the decision space based on domain knowledge.

Outcome Risk Modeling: Facilitating informed decision-making in uncertain environments requires effective outcome risk modeling. The platform should enable the understanding of various risk types, assess the likelihood and impact of potential events, and support the development of risk mitigation strategies.

Stakeholder Preference Elicitation: Capturing valid preferences from stakeholders is critical. The platform should employ appropriate methods to ensure stakeholder understanding and adaptability to individual differences.

Trade Space Exploration: Evaluating design alternatives and making informed trade-offs is essential. The platform should represent the entire range of design choices, enable trade-off analysis, and support risk management and optimization techniques.

Decision Program Management: Planning, managing, and tracking decision-making processes across initiatives are essential for success. The platform should identify critical decisions, establish decision sequencing, and provide management support for program stakeholders.

By meeting these technical requirements, decision intelligence platforms can enhance organizations' ability to address complex challenges and achieve their desired outcomes effectively.

3. INTEGRATED RISK MANAGEMENT

According to a study sponsored by the U.S. Army, standard practice across the Army (and to a lesser extent DoD) is to treat technological performance, schedule, and cost estimation and risk as virtually independent dimensions in trade-space analyses (Bond et al., 2015). For example, the Army does not have a robust quantitative framework to link the outcomes of risk (cost, schedule, and technical) and performance assessments in evaluating alternatives. This delayed consideration of risk can expose the program to various vulnerabilities. The requirements for robust risk management, emphasizing integration, adaptability, and optimization, include:

1. **Upfront Consideration of Risk along with Performance:** Embedding decision-critical risk considerations along with performance metrics during up-front evaluation of concepts is likely to ensure better outcomes in the end. By intertwining risk assessment with performance objectives, decision-makers achieve a balanced perspective, enhancing the likelihood of achieving desired outcomes while mitigating potential hazards.
2. **Enhanced Risk Assessment and Management:** Information critical for risk assessment often evolves and improves over the course of product development. Increased fidelity of risk

assessment allows for dynamic adjustments as new information emerges. Initial exploration of the decision space with preliminary risk measures enables iterative refinement, empowering organizations to adapt strategies and allocate resources effectively in response to evolving challenges and opportunities.

3. **Risk-Informed Sequential Decision Making:** By modeling decision-making as a sequential process with probabilistic outcomes (e.g., using Markov Decision Processes), organizations can identify optimal strategies that balance performance objectives with risk tolerance (Rapp *et al*., 2018).
4. **Management of Technology Options and Objectives:** Maintaining a diverse portfolio of technological solutions and continuously reassessing project objectives enables organizations to remain agile and responsive to evolving circumstances. This proactive approach enhances adaptability and resilience in the face of changing dynamics and emerging risks.
5. **Fidelity of Performance and Risk Assessments:** Ensuring the accuracy and relevance of performance and risk assessments over time is critical for program success. Continuous monitoring and validation of metrics and indicators of assessment uncertainty enable early identification of discrepancies or deviations, facilitating timely corrective action to mitigate potential impacts on outcomes.

4. SET-BASED DESIGN (SBD)

Traditional design methods, also known as "point-based" design approaches, typically involve defining the problem, generating multiple solutions, ranking those solutions, and ultimately selecting the most promising

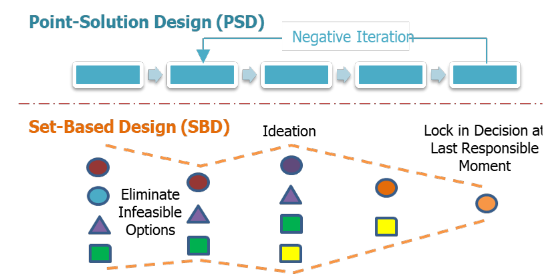

Fig. 2. Point-solution design vs set-based design.

one. However, since the selection of a single point in the design space is made in the initial stages of development with limited understanding of the problem, the chosen solution may become infeasible or suboptimal, leading to the need for additional work or modifications (Gumina, 2019). In the past two decades, set-based design (SBD) practices have emerged as a promising alternative to the traditional linear development process for complex

Risk Exploration: *SBD advocates early exploration of diverse design options to identify and mitigate potential risks before committing resources.*

Flexibility: *SBD maintains multiple design options, enabling swift responses to changing requirements, tech, or external factors to avoid obsolescence.*

Uncertainty Reduction: *SBD reduces uncertainty by exploring various design alternatives simultaneously, providing insights into benefits, costs, and risks.*

Trade-off Analysis: *SBD facilitates comparing performance, cost, and schedule among design alternatives, aiding decision-makers in identifying optimal solutions.*

Early Risk Mitigation: *SBD promotes rapid prototyping and testing to identify and address risks early, preventing escalation in later stages.*

Collaboration and Learning: *SBD fosters collaboration and knowledge sharing, leveraging collective expertise to innovate and manage risks effectively.*

Fig. 3. Mitigating risks through set-based design.

engineering systems to reduce risk (refer to Fig. 2).

SBD practices are inspired by Toyota's automotive development process and the principles of concurrent engineering (CE). Toche et al. (2020) notes that there is a need for holistic models and platforms to support cross-domain communication, overlapping, narrowing, and refinement of sets to enable SBD. Although there have been some successful pilot efforts to apply SBD within the DoD, such as the Ship to Shore Connector and Amphibious Combat Vehicle, as examined by Chan et al. (2016), the process cannot be easily scaled to the broader DoD enterprise due to the tedious reliance on manpower and the absence of trained SBD professionals (Doerry, 2022). The risk mitigation benefits of SBD can be substantial (refer to Fig. 3). However, to formalize SBD development and support consistent analysis and decision making, there is a need to orchestrate it within a digital decision support environment (Murat *et al*., 2022).

5. ENHANCED DECISION SUPPORT

A fundamental limitation today is that the approaches to decision support systems (DSS) predominantly focus on decision analysis (DA). Since the inception of DSS as a discipline in the 1960s, much progress has been made in the realm of developing DA methods (e.g., Analytic Hierarchy Process for multi-criteria decision making, Markov Decision Processes for sequential decision making, decision trees, influence diagrams, optimization) and IT technologies (e.g., databases and user-interface). However, there has been far less focus on structuring the actual support for decision makers (Shim et al., 2002). There is a need for fostering more structure and vigor in the very critical "decision framing" and the actual "deciding" phases of the entire decision-making process to ensure robust outcomes (refer to Fig. 4).

There is a need for more user-centered design, balancing customization with standardization, and increased multi-disciplinary stakeholder engagement (Laka et al., 2022). More broadly, in the intricate landscape of product development, intentional decision-making at various milestones is critical for project success. To ensure alignment with overarching objectives and constraints, organizations must employ a deliberate and iterative approach, considering the following requirements and strategies:

1. **Comprehensive Milestone Analysis:** Conduct thorough analyses of each milestone, identifying key objectives,

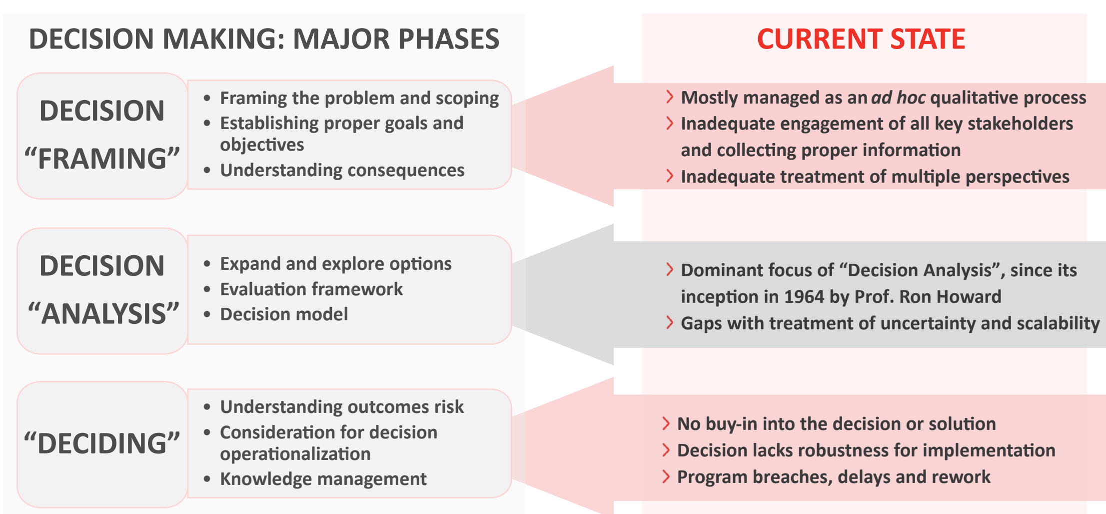

Fig. 4. "Framing" and "Deciding" aspects of decision making.

constraints, and associated risks. Evaluate alignment with project goals to strategically position milestones for progress while mitigating setbacks.

2. **Data-Driven Decision Making:** Embrace data-driven approaches, leveraging relevant metrics and analytics for informed decision-making. Establish robust data collection mechanisms to base decisions on empirical evidence rather than intuition.
3. **Scenario Planning and Contingency Management:** Anticipate potential scenarios and develop contingency plans to address unforeseen challenges. Implement flexible decision-making frameworks for agile responses to changing circumstances.
4. **Stakeholder Engagement and Collaboration:** Foster open communication and collaboration among stakeholders, soliciting input for informed decisions. Establish clear decision-making channels and empower stakeholders to contribute to strategic planning.
5. **Alignment with Evolving Objectives:** Regularly reassess project objectives considering market dynamics, technological advancements, and stakeholder expectations. Ensure milestone decisions align with project goals, adjusting course as necessary to maintain alignment.
6. **Iterative Feedback Loops:** Implement feedback loops to evaluate milestone decisions and identify opportunities for improvement. Solicit feedback from project team members, stakeholders, and end-users to optimize project outcomes.
7. **Documentation and Knowledge Management:** Maintain detailed documentation of milestone decisions and outcomes to facilitate organizational learning. Establish centralized repositories for easy access to relevant information and insights.

6. DYNAMIC WORKFLOW MANAGEMENT

In large organizations engaged in complex engineering product development, the utilization of workflow management software is imperative (DoD, 2018). The inability to actively engage all key stakeholders in a dynamic environment reduces engagement, trust, and confidence in the resulting decisions. This software plays a pivotal role in enabling distributed teams to collaborate effectively, regardless of their geographical locations. By providing a centralized platform, it facilitates real-time

***Integrated Engagement Platform**: Implement a centralized platform for stakeholder engagement, seamlessly integrating workflow automation to streamline communication and collaboration.*

***Automated Progress Tracking**: Utilize automation within the platform to track project progress and provide stakeholders with real-time updates on milestones and developments.*

***Role-Based Access Management**: Incorporate role-based access controls within the platform to ensure that stakeholders have access to relevant information and tasks.*

***Feedback Collection Features**: Integrate automated feedback collection features to gather input from stakeholders at various stages of the product design and development process.*

***Communication Streamlining**: Leverage automation to streamline communication within the platform, facilitating efficient exchange of information and decision-making.*

***Collaboration Tools Integration**: Integrate collaboration tools into the platform to enable seamless document sharing, discussion forums, and virtual meetings among participants.*

***Continuous Improvement Mechanisms**: Embed mechanisms for allowing ongoing optimization based on stakeholder feedback and evolving project requirements.*

Fig. 5. Requirements for enhancing workflows

communication, task tracking, and progress monitoring, thereby ensuring seamless coordination across interdisciplinary teams. Furthermore, workflow management software aids in visualizing and managing task dependencies, mitigating the risk of bottlenecks and delays. Its agility allows for swift adaptation to evolving project requirements, ensuring that teams can respond promptly to changes without compromising project timelines or quality. Overall, the integration of workflow management software is essential for optimizing productivity, enhancing collaboration, and facilitating the successful delivery of complex engineering products within large organizations. Refer to Fig. 5 for specific requirements.

7. GENERATIVE DECISION INTELLIGENCE

Generative Decision Intelligence (GDI) constitutes a sophisticated approach within the realm of product design and development, characterized by its dynamic generation of alternatives on demand (refer to Fig. 6).

This process is underpinned by a nuanced comprehension of the structural dynamics inherent in the decision space within a specified context. The decision space, a comprehensive domain encompassing all conceivable alternatives, necessitates meticulous representation to facilitate effective exploration and analysis. A critical facet of GDI lies in recognizing that a decision alternative is not a singular, monolithic concept but rather a composite entity comprised of structural building blocks. These building blocks, akin to design components or options, adhere to specific composition grammar guidelines governing their arrangement and interaction within the decision space. Central to this representation is the articulation of a comprehensive list of composable components alongside their associated composition rules. At the core of GDI's functionality are intelligent optimization and machine learning algorithms meticulously designed to navigate and exploit the intricacies of the decision space representation. These algorithms are engineered to systematically generate alternatives that not only meet predefined criteria but also exhibit superior feasibility and performance characteristics. By leveraging the structured representation of the decision space, GDI algorithms facilitate the discovery and synthesis of alternatives that are not only viable but also possess the potential to outperform conventional solutions.

Generating Alternatives*: Involves generating alternatives on demand, leveraging knowledge of the structural dynamics of the decision space within a specific context.*

Decision Composition*: Decision alternative is not a singular monolithic concept but rather a composition of structural building blocks (e.g., design components or options), following specific composition grammar.*

Decision Space Representation*: Decision space encompasses all possible alternatives and needs an effective representation. Consists of a list of composable components and the accompanying composition rules.*

Intelligent Algorithms*: Involves optimization and machine learning algorithms that generate viable and superior alternatives by exploiting the decision space representation.*

Fig. 6. Generative decision intelligence.

8. CASE STUDIES

The team is currently preparing two case studies for PEO GCS and PEO CS & CSS customers to support the DE effort for Program Protection and Automotive – Mobility modeling. Both use case implementations use the decision intelligence platform developed through US Army SBIR programs. In the Program Protection DE use case, the team will demonstrate the DE pathways for program risk assessment and mitigation using the decision intelligence platform. The Automotive-Mobility modeling use case will leverage the HPCMP CREATE™-GV (HPCMP CREATE, 2024) capabilities in physics-based mobility assessment, to demonstrate the DE pathways for model-based trade studies using the decision intelligence platform.

These DE efforts are based on protected information (controlled unclassified and classified). The case studies will be released, after approved by the PEO(s), and will also be documented in protected information journals.

9. CONCLUSION

In the intricate landscape of Department of Defense (DoD) product planning and program management, and commercial systems, the role of effective decision intelligence and analytics platforms cannot be overstated. These platforms can serve as indispensable tools for navigating the complexities inherent in defense initiatives, offering a systematic approach to addressing challenges and optimizing decision-making processes.

By leveraging advanced methodologies such as Generative Decision Intelligence (GDI), the DoD can significantly enhance its decision-making efficacy and mitigate risks associated with product planning and program management. GDI represents a transformative paradigm shift in decision-making, offering a dynamic and adaptive framework for generating alternatives finely tuned to specific contextual nuances. Through GDI, decision-makers gain deeper insights into complex decision spaces, enabling them to make informed, strategic choices that align with organizational objectives and constraints.

Moreover, effective decision intelligence platforms enable the DoD to address identified challenges, such as the absence of structured processes in early development phases, ineffective stakeholder engagement, and a lack of decision lineage impeding knowledge management. By providing tools and frameworks for comprehensive analysis and stakeholder collaboration, these platforms facilitate informed decision-making throughout the product lifecycle, from initial planning to execution and evaluation.

Embracing a holistic approach to decision intelligence is crucial for achieving operational excellence and mission readiness in today's dynamic security landscape. By integrating decision intelligence platforms into existing processes and workflows, the DoD can foster a culture of informed decision-making, adaptability, and resilience. Furthermore, these platforms enable the DoD to stay ahead of evolving threats and technological advancements, ensuring that defense initiatives remain agile and responsive to changing circumstances.

In conclusion, effective decision intelligence and analytics platforms are paramount for the success of DoD product planning and program management efforts. By embracing advanced methodologies and adopting a holistic approach to decision intelligence, the DoD can enhance its operational effectiveness, mitigate risks, and promote program success in an ever-changing security environment.

10. REFERENCES

Bond, C. A., Mayer, L. A., McMahon, M. E., Kallimani, J. G., & Sanchez, R. (2015). Developing a Methodology for Risk-Informed Trade-Space Analysis in Acquisition (No. RAN136454). Rand Corporation. Link

Bone, M. A., Blackburn, M. R., Rhodes, D. H., Cohen, D. N., & Guerrero, J. A. (2019). Transforming systems engineering through digital engineering. *The Journal of Defense Modeling and Simulation*, 16(4), 339-355.

Chan, J., Hays, A., Romas, L., Weaver, J., & Morrison, J. (2016). Implementing Set

Based Design into Department of Defense Acquisition. Naval Postgraduate School Monterey United States. Link

Clowney, P., Dever, J., & Stuban, S. (2016). Department of Defense Acquisition Program Terminations: Analysis of 11 Program Management Factors. *Defense Acquisition Research Journal*, *23*(3).

DoD (2018). Department of Defense: Digital Engineering Strategy. Link

Doerry, N. (2022). Dr. Norbert Doerry, a DoD SBD expert, in discussing adoption of SBD by the U.S. DoD with Agile Systems LLC team.

Gorman, R.R. (2019). Next Generation Intelligence Integration: Leveraging Artificial Intelligence to Facilitate Human-Machine Collaboration and Enhance Intelligence Collection and Analysis, MS Thesis, Marine Corps University.

Gumina, J. M. (2019). *A Set-Based Approach to Systems Design*. Dissertation, Naval Postgraduate School, Monterey, United States.

Heilig, T., & Scheer, I. (2023). *Decision Intelligence: Transform Your Team and Organization with AI-Driven Decision-Making*. John Wiley & Sons.

HPCMP CREATE (2024). *CREATE-GV*. Link

Keeney, R. L. (2004). Making better decision makers. Decision Analysis, 1, 193–204.

Khan, A., Ghose, A., Dam, H., & Syed, A. (2023). A Survey of Process-Oriented Data Science and Analytics for supporting Business Process Management. *arXiv preprint arXiv:2301.10398*.

Laka, M., Carter, D., Milazzo, A., & Merlin, T. (2022). Challenges and opportunities in implementing clinical decision support systems at scale: Interviews with Australian policymakers. *Health Policy and Technology*, 100652.

McCann, J., & Selsky, J. W. (2012). *Mastering turbulence: The essential capabilities of agile and resilient individuals, teams and organizations*. John Wiley & Sons.

Murat, A., Chinnam, R. B., Rana, S., Rapp, S., Hartman, G., Lamb, D., & Agusti, R. (2022). Combat Vehicle Program Management and Product Development Resilience through Set-Based Design. *In Proceedings of the Ground Vehicle Systems Engineering and Technology Symposium*, Novi (Michigan, USA).

O'Callaghan, M. (2023). Decision intelligence: human–machine integration for decision-making. CRC Press.

Pratt, L., Bisson, C., & Warin, T. (2023). Bringing advanced technology to strategic decision-making: The Decision Intelligence/Data Science (DI/DS) Integration framework. *Futures*, 152, 103217.

Rapp, S., Chinnam, R., Doerry, N., Murat, A., and Witus, G. (2018). Product Development Resilience Through Set-Based Design. *Systems Engineering Journal*. 21(5), 490-500.

Rapp, S., Doerry, N., Chinnam, R., Monplaisir, L., Murat, A., & Witus, G. (2018). Set-Based Design and Optimization.... Can They Live Together And Make Better Trade Space Decisions?. *In Proceedings of the NDIA Ground Vehicle Systems Engineering and Technology Symposium*, Novi (Michigan, USA).

Shim, J. P., Warkentin, M., Courtney, J. F., Power, D. J., Sharda, R., & Carlsson, C. (2002). Past, present, and future of decision support technology. *Decision support systems*, *33*(2), 111-126.

Toche, B., Pellerin, R., & Fortin, C. (2020). Set-based design: A review and new directions. *Design Science*, *6*, e18.

Zimmerman, P., Gilbert, T., & Salvatore, F. (2019). Digital engineering transformation across the Department of Defense. *The Journal of Defense Modeling and Simulation*, 16(4), 325-338.