MODELING DECISIONS IN COMPLEX PROJECTS

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Abstract

The upstream business of oil and gas industry is decision intense. The selection of a resource sensitive and economically designed concept is critical to the project success and requires making good decisions on time. Using an industrial example, this paper proposes a systematic modelling approach to identify and map decisions and options in complex projects. The approach applies a Dependency Structure Matrix (DSM), building on expertise of the application of DSMs to major capital project in industry over the past 10 years, and has demonstrably enabled clarity and alignment on project scope.

Keywords: Early design phases, Conceptual design, Design methodology, DSM

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1 INTRODUCTION

Timely decision making is key to the successful early planning of projects in the upstream sector of the oil and gas industry where project delays can destroy value yet rushed or incomplete decision making can miss the most valuable realisations. The scale of all the possible decisions to be addressed and their supporting activities can result in the development team being overwhelmed resulting in loss of efficiency in the concept development execution. This paper documents the continuous improvement process that BP has been using based on applying DSMs (dependency structure matrices) to drive projects efficiently through the concept selection phase whilst at the same time maximising value and minimising rework activities.

In the past BP has applied DSMs to the output of FAST (functional analysis systems technique) mapping of the concept development activities from integrated planning workshops. However, the number and scale of activities and complexity of the feedbacks identified was found to sometimes hinder the timely progressing of projects through concept selection. Consequently, an improved approach has evolved focusing on the creation of decision based planning, rather than activity based planning, supported by DSMs to deliver a much more tangible and manageable work plan. This application of DSMs has increased focus, clarity and team alignment during the conceptual design stage leading to an increased efficiency in schedule whilst increasing project value. This paper describes our current thinking on the value of decision mapping in front end project design and highlights opportunities for further improvement.

2 LITERATURE AND INDUSTRY PRACTICE

Product development is an inherently iterative process. Particularly during the conceptual design phase, dependencies between design activities, system elements, and people lead to an initial design being reworked, refined and optimised to a point where the concept design is frozen and detailed development of individual product components can finally take place. In the *Harvard Business Review,* Eppinger (2001) contrasts the traditional means of product development planning using the critical path method (CPM) to sequence activities and the reality of information exchange between tasks driving iteration in product development. Using this as motivation, he proposes using DSMs to model and optimise interdependencies and, subsequently, eliminate unnecessary iteration or rework in the design process.

Building on this perspective, Browning et al. (2006) provide a comprehensive compilation of the variety of potential purposes of process modelling, including planning and managing work and rework, codifying an approach to a project for project team members, and decision-making. Out of the range of modelling frameworks discussed, DSMs are cited as a type of model for capturing and analysing networks with "substantial and cyclical dependencies." By the same token, Yassin and Braha (2003) discuss the linkage between the modelling of relationships in DSMs to decision making within the iterative, concurrent engineering practice context. Through displaying the relationships among activities, product components, and people, a richer understanding of dependencies can be obtained, enabling tacit knowledge of these product development elements to become explicit and overcoming limitations in information processing by designers to make better decisions.

As such, these publications, as well as other seminal works (Eppinger, 1991; Levardy and Browning, 2009), place DSMs as a technique to employ during an iterative product development process to aid decision making. Based on this foundation, in 2012, Eppinger and Browning detailed DSM methods for complex system design and provided numerous example applications of DSMs within industry. DSM models are classified into 3 types: static architecture (product and organization DSMs), temporal flow (process or activity DSMs), and multi-domain. A key theme throughout this work is that by decomposing system process/product/people elements and identifying their dependencies, DSMs can be used to analyse a system and guide decisions taken to action improvements to the system under assessment.

Consequentially, using a DSM approach has been grounded as a reasonable and feasible means to overcome the challenges, which have been observed and documented within industry, in planning iterative processes and decision making. Over a decade ago, Eckert and Clarkson (2003) describe such challenges, namely lack of overview and communication problems, by drawing from 4 case studies across 3 industry sectors. Specifically, they identify the observed impact on decision making by having a multitude of separate, standalone plans to deal with different facets of design understanding and communication required to make development decisions. In recent years, publications have repeatedly recognized similar complications associated with decision making during iterative design processes within industry and discussed the application of activity, product, and people DSMs to support these challenges (Bhaskara, 2010; Ruzzo, 2015).

Equally recognising the symptoms of challenges associated with planning complex design processes and drawing from the DSM community's research base, BP has been applying process/product/people DSMs to major capital projects within the oil and gas sector during the conceptual design phase. The application of these primary types of DSMs has yielded project insights for planning and system architecture and given teams a basis to draw a common understanding of the project work, aiding decision making within projects by making team members consciously aware of the range of dependencies within the project environment. However, due to the inherent iterative nature of system design, further targeted improvements in decision making support have been identified and are currently being employed, as reported by Robinson during the keynote presentation at the *International Dependency and Structure Modelling Conference* in 2015. Subsequent sections of this paper document and detail the motivation for and approach to decision DSMs.

3 MOTIVATION AND REQUIREMENTS

In the past, BP has applied process/product/people DSMs with most experience implementing process/people DSMs to model project plans and project team / stakeholder interactions during the conceptual design phase (Feng et al., 2010). In 2010, BP operationalised the implementation of DSMs within the upstream business and applied a rigorous, systematic approach to using activity and organisational DSMs over a 3-year period on over 10 major upstream capital projects. After the ground work for the concept development project phase was completed via business framing and concept identification steps, the DSMs were constructed using information captured via a FAST map in a workshop / breakout session setting with 10 to 50 project team members (Figure 1). All project disciplines were represented and the agenda structured to gather input on all interfaces. The activity DSMs developed ranged from approximately 150 to over 400 activity items (including tasks and sub-tasks associated with decision making), while the organisational DSMs included approximately 50 to over 100 elements (Figure 2). Activity DSMs were analysed to remove rework loops and led to the development of an integrated concept development schedule.

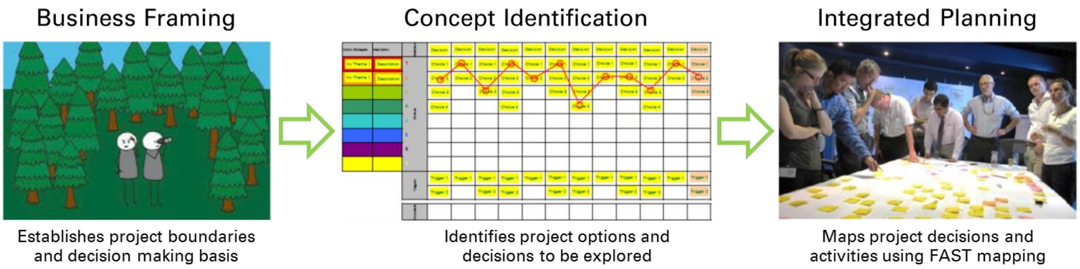

Figure 1. Business framing and concept identification stages in the concept development preceded the integrated planning FAST workshop

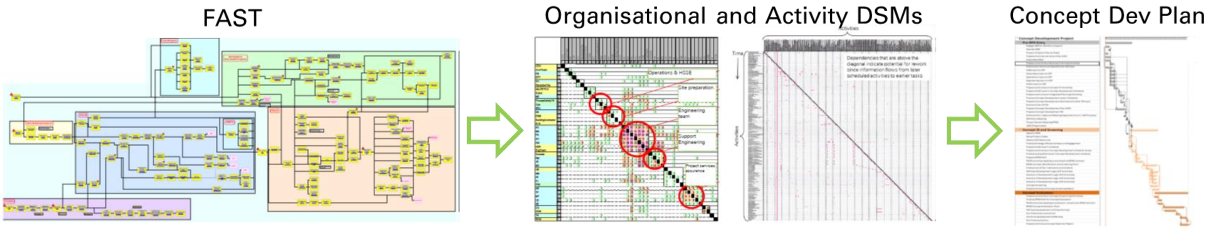

Figure 2. Information captured in integrated planning workshop via FAST diagram was mapped to organisational / activity DSMs, leading to concept development schedule

Based on this DSM implementation experience, learnings and areas for improvement were identified, and, consequentially, a refined, targeted application of DSMs to support decision making has been developed and implemented over the past 3 years. Specifically, 5 key learnings have motivated BP to move towards decision instead of activity DSMs:

1. **Failing to see the wood for the trees.** During the business framing and concept identification stages, key decisions and their interdependencies are identified. Given the iterative nature of the concept development process, decisions are crucial to assess and re-assess design trade-offs as design work progresses. In turn, during the detailing of activity DSMs and related schedule development (both which included decision tasks and sub-tasks), it was recognised that the relationships between decisions could become overshadowed and less visible to the project team, leading to the potential risks of (1) increased design iteration and (2) suboptimal design solutions.
2. **Time taken destroys value.** The time to complete concept development is driven by the decision-making process to narrow down project options and hone a design to move into the detailed design phase. As such, poor or slow decision making, leading to unnecessary iteration loops, potentially causes delays in concept development and potentially affects the project delivery timeline and, therefore, bottom-line economics for the project.
3. **Single discipline bias.** Coordinating work across discipline interfaces is another component of efficient decision making. Disciplines tend to focus on decisions that have the fewest interfaces to demonstrate early progress. Thus, driving alignment on the prioritisation of decisions across disciplines is essential to efficient project delivery and de-risk the potential for destroying project value.
4. **Bias concepts.** Developing a conceptual design relies on systematically evaluating a range of options and not prematurely focusing on a single concept. Disciplines can fixate on familiar design elements that are proven, simple, and require less effort to develop. Decreased visibility to the full decision-making process can limit investigation of trade-offs, resulting in a suboptimal solution.
5. **Rework risk.** The sequence of decisions directly impacts the number of design iterations required during concept development. Mapping dependencies among decisions and sequencing decisions to minimise the risk of unnecessary iterations and rework leads to efficient project delivery.

Considering the learnings outlined above, a decision-based approach to project development should recognize the importance of:

- Simplicity by improving the user interface, reducing the number of analysis steps, and team footprint,
- Being fast to apply by reducing the lead time to deliver results, and
- Reliability of results by ensuring appropriate sequencing of decisions that captures information flow.

4 PROPOSED METHOD

Business framing and concept identification workshops are a common practice in the oil and gas industry and proven method for a project team to (1) create clarity and alignment on the project boundary and (2) identify options and decisions that need to be made in the concept development phase. Driven by the learnings and requirements described in the previous section, the implemented process shown in

Figure 1 has been modified to replace the integrated planning session with a decision analysis session. In turn, the DSM methods in Figure 2 have been swapped out with a decision DSM approach. The following outlines the revised method that includes (1) framing and concept identification workshops and (2) decision analysis.

1. **Business Framing and Concept Identification Workshops**

The business framing workshop is a fundamental step as attendees discuss project context and scope boundaries. This enables the team to generate do-able and creative options within project scope during the concept identification workshop. During the latter workshop, attendees are divided into multidisciplinary workgroups and brainstorm on the elements of and options to consider for the system design. For example, an element identified may be *concept type* with the options of: adding a new offshore platform or modifying an existing platform. As another example, an element may be *processing capacity* with the options of: add a new process train, work within the capacity of an processing train, or debottleneck an existing processing train. Next, each workgroup is given an investment theme, such as lean engineering, minimum project cost, or maximum utilisation of existing infrastructure, and is asked to brainstorm distinctive realisations of how the system design options can be selected to meet the investment theme. This is followed by defining the differentiating decisions across these realisations. Returning to the above examples, decisions such as *concept type* and *processing capacity* are required. In turn, these steps define the concept options whereby not all investment themes can be accommodated and design trade-offs need to be considered.

2. **Decision Analysis**

Decision analysis follows on from the business framing and concept identification workshops. Specifically, a decision hierarchy is agreed, and decisions are prioritised and sequenced:

a) Decision Hierarchy - The differentiating decisions and related options from the concept identification workshop are summarised. The decision hierarchy may include up to 50 decisions, with multiple options under each.
b) Decision Priority - The decisions are classified based on priority and importance. This ensures that the team focus on major decisions that need to be made to select the project development concept. This limits the final decisions at this stage to 8-12 decisions rather than all decisions that have been identified. The decisions selected for immediate analysis are called *tier 1 decisions*. to be worked during concept selection and remaining *tier 2 decisions* can be deferred to later.
c) Decision Dependencies - For each *tier 1 decision*, input, output and single point of accountability are defined. Afterwards, a decision DSM is used to identify dependencies in terms of (1) direction (input/output/iterative) between two decisions and (2) the strength of the dependencies (i.e. make decision x to start decision y or finish decision x to finish decision y).
d) Decision Sequencing - Using the decision DSM, rework loops are highlighted and decisions are re-sequenced to minimise iterations.

5 CASE STUDY

The following case study for an offshore development in the North Sea, United Kingdom is an example of the proposed method. The project team in a business framing and concept identification workshop identified some 47 decisions. For each decision, options were summarised and linked to the investment theme as shown in the decision hierarchy (Figure 3).

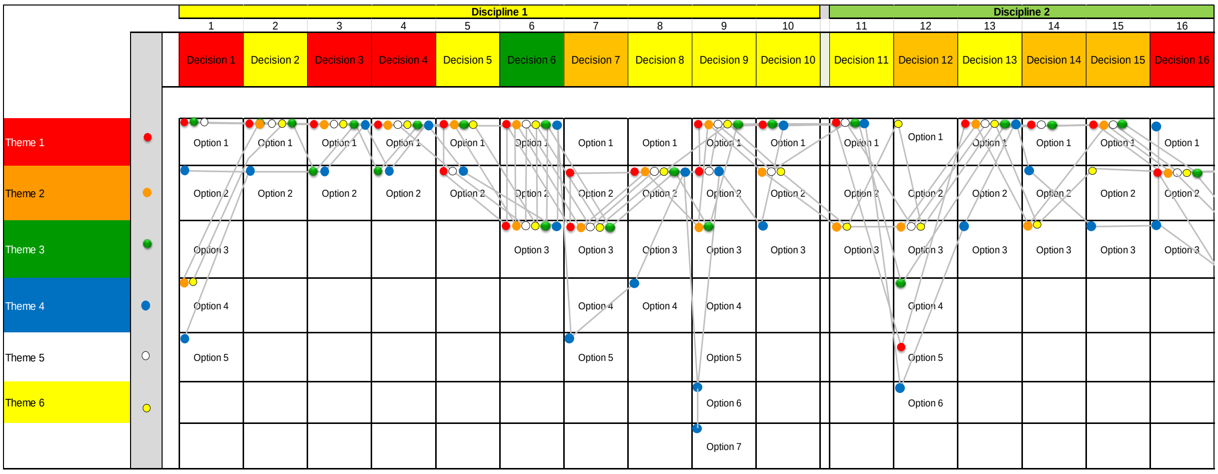

Figure 3. The decision hierarchy diagram used to map decisions and options during the concept identification workshop

From the decision map 8 *tier 1 decisions* were shortlisted for immediate working. Decisions dependencies between these were next mapped in a DSM by team members in interview sessions. Dependencies are marked as 'H' for a finish-to-start relationship or 'M' for a finish-to-finish relationship. As suggested by Figure 4, decisions around recovery method, artificial lift requirements, well types and their dependencies were captured.

	Input	Resources Targetted	Recovery mechanism	Artificial lift requirements	Wet or dry trees	Host Facility selection	Hydrocarbon Liquids handling	Concept Selection drivers	Pace, phasing and preinvestment levels
		T1a	T1a	T1a	T1a	T1a	T1a	T1a	T1a
1 Resources Targetted									H
2 Recovery Mechanism				H	M (partial info)	H			
3 Artificial lift requirements			H		M (partial info)	H			
4 Wet or dry trees			M (Partial info)	M (Partial info)					M (Partial info)
5 Host Facility selection		H	H	H	M (Partial info)		H	H	H
6 Hydrocarbon Liquids handling		H				H			
7 Concept Selection drivers		H	M (Partial info)			H	H		H
8 Pace, phasing and preinvestment levels		H				H	H	H	

Figure 4. A decision DSM is used map tier 1 decision dependencies

Finally, the results were presented as a flow diagram with sequence optimized to reduce rework. Figure 5 shows the initial flow diagram, which was then re-sequenced to reduce rework. Decisions are color coded based on the discipline that need to make the decision. Moreover, decisions are clustered into themes, such as 'Strategic Decisions' and 'Drilling Strategy', which are later used as a label for decisions grouping.

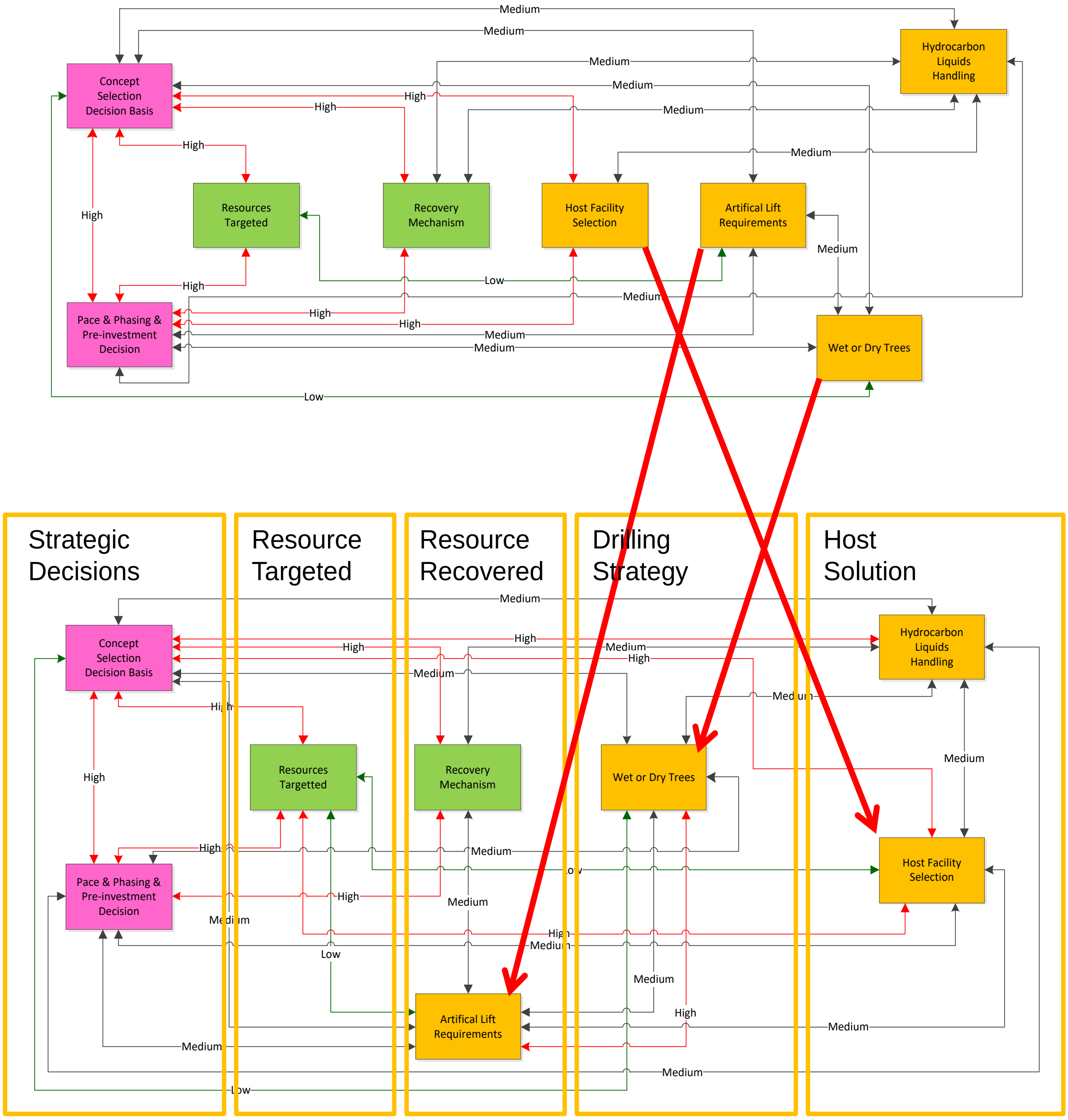

Figure 5. Decision flow diagrams illustrate the re-sequencing and clustering of decisions

The final step was to display the decision sequence in a simple decision map to be used subsequently to provide a framework to develop the integrated activity plan (see Figure 6). Links of activities that have a forward flow, such as between the *resource targeted* and *tree type* decision, were not shown for simplicity. When possible, decisions that are highly iterative, such as *recovery method* and *artificial lift requirement*, were coupled as decisions that need to be made in parallel and shown in the same column to reduce rework. Remaining decisions with rework loops are highlighted in the top triangle matrix. For example, based on which choice is selected to make the *host solution* decision, the *recovery method* decision may be revised. This can impact subsequently affect the *resources targeted* and *tree type* decisions.

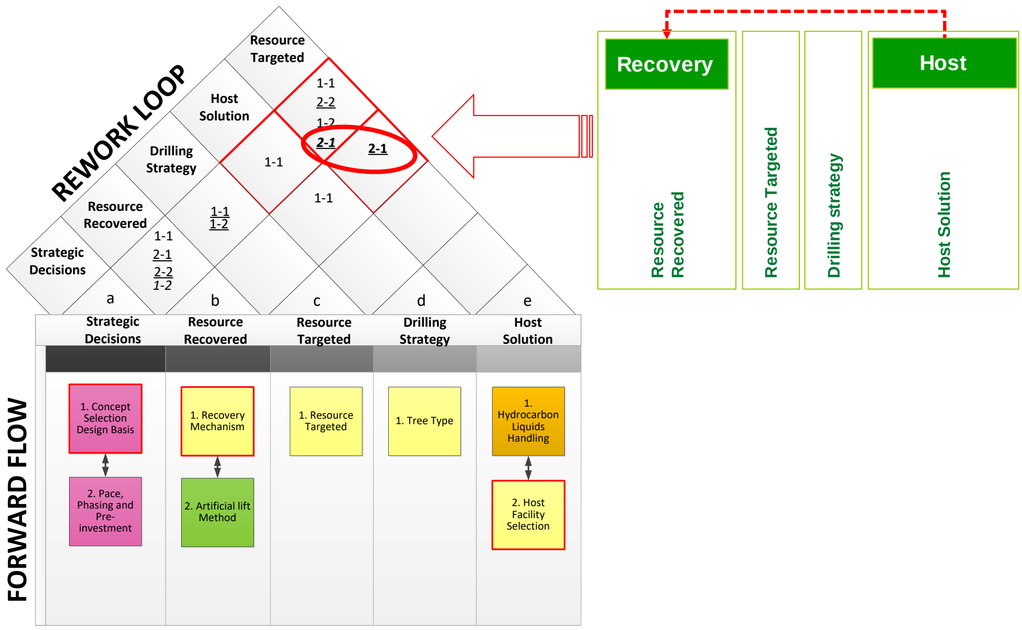

Figure 6. A decision map visualises the decision sequence and rework loop

Since 2014, this method has been implemented across a number of BP operated projects in the concept development phase with the following benefits realised:

- Focus - project teams now focus on a manageable number of up to 12 key decisions instead of more than 200 activities.
- Simplification - the concept selection programme is simplified by tracking important decision information, such as coupled decision status, rework, and forward flow as well as discipline ownership.
- Tracking and Communication - the decision map is used as part of a dashboard which provides clarity on project progress by decision status giving greater management visibility.
- Decision Quality Management - the method delivers logically sequenced decisions, which allows us now to put greater emphasis on decision quality.

Based on this method and the learning from the application of decision DSMs, a number of development and implementation opportunities are under further development. Firstly, the analysis methods of mapping decision dependencies and optimising rework is being further improved. Secondly, use of a decision map is being linked more effectively with other existing industry processes or tools, such as adoption of decision quality management and use of a project dashboard, to drive future delivery improvement. Finally, reviews of projects in concept development are being assessed to help further quantify the impact of a decision mapping approach and the introduction of decision quality on project pace, value and development planning costs.

6 CONCLUSION

Due to the historically complex, iterative nature of concept development within the upstream oil and gas industry, focus on and prioritisation of activities to enable effective decision making via a simple, standardised method is key to setting up a project for execution success. While a number of approaches, methods and practices have been applied within BP, such as FAST mapping and organisational/activity DSMs, the value of a new approach based on decision making has now been recognised. This paper reports on a structured methodology of decision mapping supported by DSM building on the well-established business framing and concept identification workshop processes. Since 2014, this method has been implemented across a number of BP operated projects in the concept development phase with the following benefits:

- Focus - project teams now focus on a manageable number of up to 12 key decisions instead of more than 200 activities.
- Simplification - the concept selection programme is simplified by tracking important decision information, such as coupled decision status, rework, and forward flow as well as discipline ownership.
- Tracking and Communication - the decision map is used as part of a dashboard which provides clarity on project progress by decision status giving greater management visibility.
- Decision Quality Management - the method delivers logically sequenced decisions, which allows us now to put greater emphasis on decision quality.

Significant benefits have been achieved in shifting from activity-based planning to decision-based planning as a means of driving focus on to priority tasks and achieving a level of simplicity into concept thinking which allows us to deliver complex project concepts.

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