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WBS-Based Work Processes: The Missing Component in Stage Gate Processes

Richard P. Helper, PSP

Abstract–As stage gate management systems become more widely developed and implemented, it may be time to consider whether these systems will provide significant improvements in project results. The stage gate process is generally described as a project management technique in which a project is divided into distinct stages, or gates, separated by decision points known as gates. Each gate has objectives, or requirements which must be met to pass the gate. These requirements are broadly defined, which subjects them to wide interpretation. Stage gate checklists provide more detailed requirements, but they still do not provide the granularity needed to properly manage and execute complex projects. What is missing? Well-defined work processes based on WBS accounts that interconnect disciplines and stakeholders and provides qualitatively defined acceptance criteria for technical and managerial deliverables. These processes can be logically connected to create a roadmap to follow between stage gates. This roadmap becomes a methodology that proactively supports meeting project objectives. This paper will demonstrate how to develop and use WBS work processes and why they should be the foundational element of a stage gate process.

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1. Introduction

Some of the construction industry's most significant improvements in the past several decades can be credited to adaptations of improvements implemented in manufacturing. Quality assurance/quality control is one example. The integration of quality assurance and quality control have made a significant improvement in the capital effectiveness of projects.

The stage gate process, which can be described as a quality assurance system, is a systematic approach to developing a product, in which the development process is broken down into several stages, each with a gate that must be passed to continue development. A principle of the stage gate process is that a manager and steering committee, separate from the development team review the development deliverables at progressive decision points and make the decisions of whether to pass through the gate.

However, there is very little industry support available to those wanting to implement a stage gate process. What is available is not nearly robust enough for use in the development and execution of large capital projects. This paper will demonstrate why WBS-based work processes are a necessary component when creating and implementing a stage gate process for the EPC industry.

2. The Stage Gate Process

A stage gate process is a sequenced step approach to making investment decisions. It is particularly beneficial where large investments are needed to develop products or projects. In 1958, the American Association of Cost Engineers created four cost estimate classifications, which reflect the stepped approach to developing estimates [1]. Today, that work is known as RP18-97 "Cost Estimate Classification As Applied in the EPC Industry."

The stage gate process as currently referenced is credited to Dr. Robert G. Cooper. Dr Cooper did research in the 1980s on how to improve the outcomes of product development initiatives. His book "Winning at New Products", published in 1987, introduces a process of sorting out bad product ideas before significant resources were expended. The process also improved the focus and development of the remaining good ideas to improve the chances of achieving their objectives.

Most implementations of the stage gate process in the capital project industry show a sequence of stages and gates focusing on what is commonly referred to as front end planning (FEP). FEP generally refers to the development of process engineering and CAPEX-related information. However, the owner organization typically performs additional activities related to the development of "pre-FEP" information and other functions logically belonging to the owner (e.g., financial modeling, real estate transactions, permitting, etc.).

However, the stage gate process can be adapted and applied to other phases of the project life cycle, including the proposal phase and the execution phases. This paper will focus on the development and FEP phases to highlight advocated changes against stage gate process information readily available.

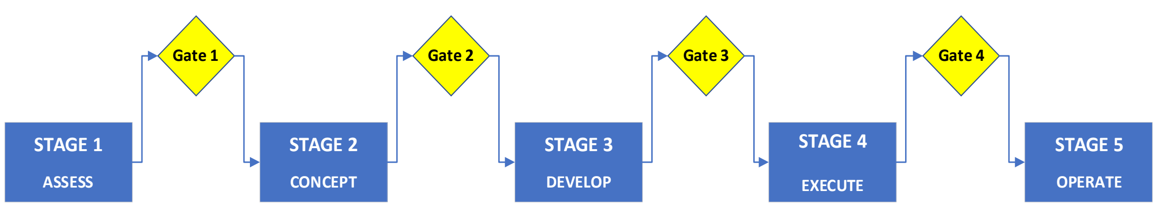

Figure 1–Sample Stage Gate Process

Figure 1 depicts a common stage gate process that is found using an internet browser search. It shows development of a project from initiation through completion of the project and handover to operations. They are usually accompanied by a list of major objectives or deliverables that must be completed to pass the gate. Stage gate checklists are used in some stage gate processes to formally document completion of deliverables, which in turn

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provide the documentation that the stage gate objectives have been met. Section 3 describes the stage gate components in more detail..

The Construction Industry Institute (CII) published Research Summary 213-1 “Front End Planning: Break the Rules, Pay the Price” in 2006, which included a graphical tool that represents three stages of front-end planning (FEP) [2]. Figure 2 shows the alignment of the CII research with the stage gate process.

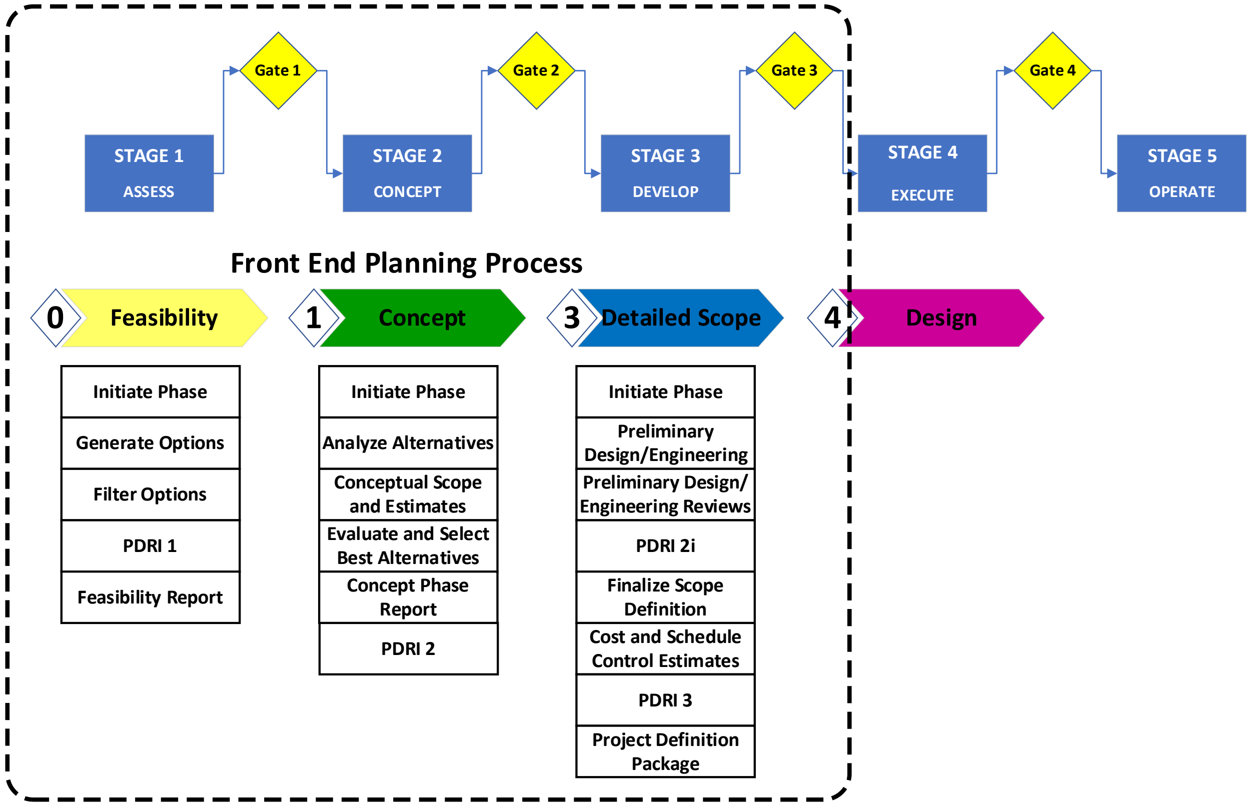

Figure 2–CII RS 213-1 Front End Process

Figure 3 shows the generic stage gate process adapted into a representation much more aligned to the EPC industry. The CII publication and accompanying tool provide much more detail to support the high-level graphic shown here. However, the granularity of deliverables and definitions of deliverables in CII RS 213-1 are still insufficient for most? companies to use “out of the box”. CII acknowledges that this publication is to serve as a primer for each company to develop their own process and checklists.

In some cases, the owner outsources the development of technical documents to a consultant. This could be because they lack the in-house competence, or they need to obtain proprietary technology. Figure 3 depicts an owner’s development phase in relationship with a consultant’s FEP phase. In this example, the owner integrates the consultant’s technical information into a comprehensive package of management and technical documents used to support project authorization.

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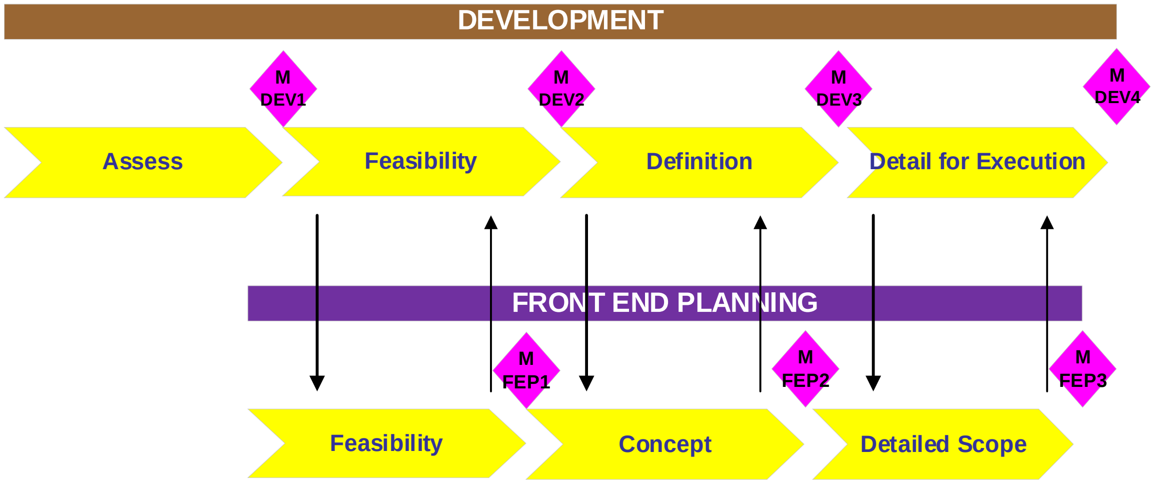

Figure 2–Owner's Development and Consultant's FEP Stages

The development and FEP stages are where the owner converts their business case to an engineered solution. This solution is expected to add value to the business. Accordingly, this is where the most significant risk/reward decisions need to be made to achieve the project objectives. While stage gate process was originally developed to shepherd the development of a product to production, it is easily adapted to shepherd the development of a project to execution.

The EPC contractor often provides a proposal, or tender offer to win a contract award. If the contract includes a "full wrap," more than likely it is for a fixed or lump sum price. To minimize risk and maximize added value, a formal stage-gate process is used to make progressive "go /no go" decisions leading to submission of the tender offer. There are similarities in how the EPC contractor prepares their proposal to how an owner prepares their development. Figure 4 below shows what a stage gate process might look like for an EPC contractor's proposal, or tendering phase.

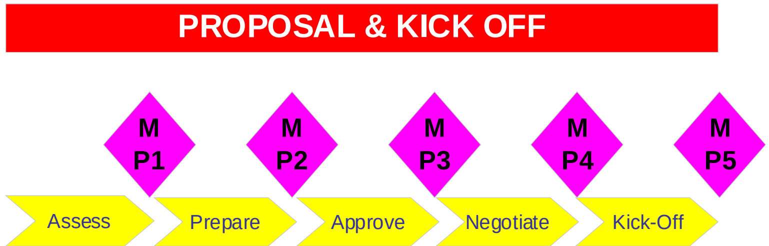

Figure 3–Proposal Stage Gate Process

While the stage gate process is most often associated with project development and FEP, as stated earlier, it can be adapted to manage the project execution stages. The execution stages are expected to maintain the value added in the development and FEP stages. For the EPC contractor, the execution stages are where their risk lies. The EPC contractor's goal is to have predictable project outcomes. Robust risk management supports this goal and is supported by multiple project reviews throughout the project execution phase.

Figure 5 below shows a stage gate process for the contractor's execution (EPC) phases. It is apparent that there are many more stage gates than have been seen for development. The reason is that the risks during project execution are related to engineering and supplier information developed during detailed design. The amount of detailed information, or deliverables developed during the execution phases is enormous. All the engineering deliverables subsequently drive the development of supply, construction, installation, and commissioning deliverables. This multitude of deliverables must be tracked and managed.

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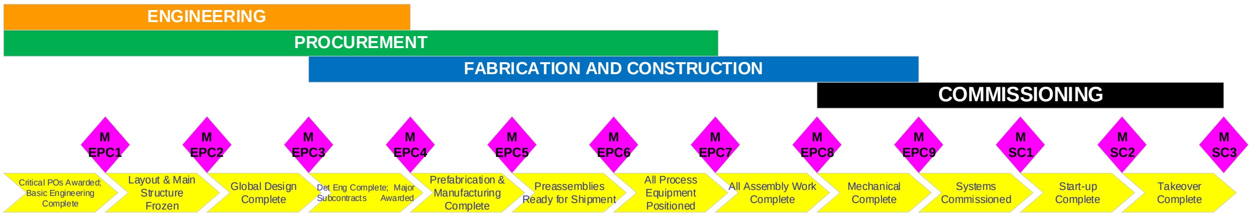

Figure 4–Project Execution Stage Gate Process

The stage gate process principles are the same for all phases of the project life cycle. The enterprise, or company establishes the stage gate requirements to ensure consistency in project execution across the portfolio of projects. The team develops deliverables required for the stage gate, there is a review of those deliverables at the end of the stage gate, and a "go/no go" decision is taken before moving to the next stage. However, the effectiveness of any stage gate process is largely dependent on the robustness of the deliverables required to pass a stage gate.

3. The Stage Gate Process Components

The basic principle of the stage gate process has been reviewed. The project life cycle is broken down into stages, which have requirements that are evaluated to pass the stage gate. The next area to unpack involves the requirements needed to pass through the stage gate.

An internet search of stage gate processes will provide limited insight on what these requirements might be. Typically, they are high-level and general in description. The following is an example of a stage-gate process developing downstream oil and gas projects. It was included in a paper by Cisco IBSG "Oil and Gas Megaprojects Using Technology and Collaboration to Drive a Step Change in Project Management"[3]:

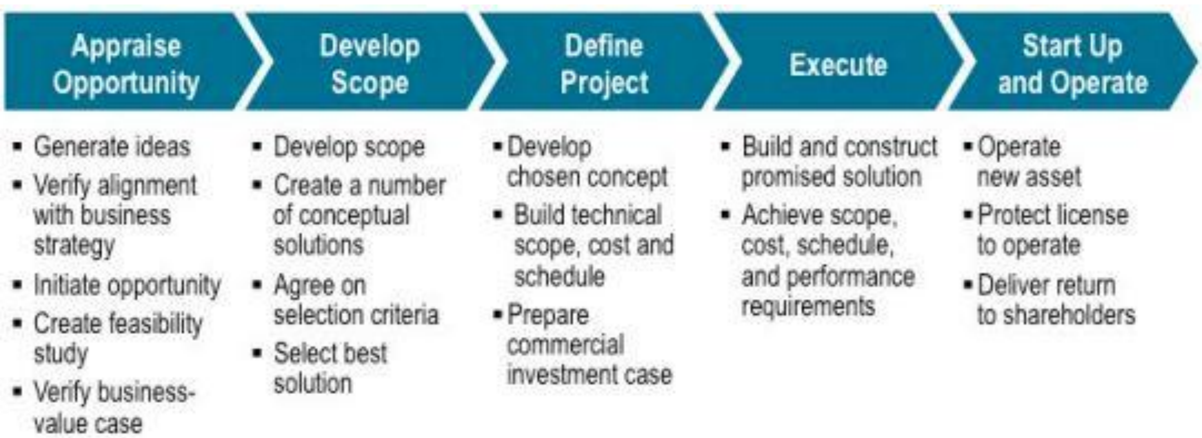

Figure 5–Example of Stage Gate Objectives

The stage names are different from those in Figure 1, however the requirements for each stage are substantially the same. The bullet items under each stage represent the requirements or stage gate objectives which must be met to pass through the respective gate.

As previously stated, the company establishes the stage gate objectives, or requirements to achieve project development and project execution consistency across the portfolio of projects. For companies that do not have the maturity usually reflected in governance policies, work processes or defined roles and responsibilities, the establishment of stage gate requirements comes from external sources. These sources nclude consultants, which are the source for the examples in this paper. The challenge is that these requirements, as shown as bullet items in Figure 6 are so vague, there is no qualitative or quantitative way to evaluate whether the requirements have been met.

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Referencing Figure 6, under the "Define Project" stage is the requirement to "Build technical scope, cost and schedule". To those in project management, this requirement would result in significantly different deliverables depending on who gets to interpret this requirement. If one were to define the cost and schedule part of the deliverable using AACE RP18-97[4], this might refer to a Class 5, Class 4 or Class 3 estimate and schedule, which is still somewhat limited guidance. For those not familiar with the AACE estimate and schedule classifications, , there's little industry guidance for establishing clear and consistent requirements for estimates and schedules .

Stage gate checklists provide a longer list of validation items, which are intended to provide better confirmation of meeting stage gate objectives. The checklists are replications of the major objectives or deliverables with perhaps some additional items to validate. Without a significant amount of deliverable definition and granularity, what can be found on the internet does not provide useful information for those in the heavy process industry. Figure 7 below shows a stage gate checklist that can be downloaded for free from a template library site called Modeloe. The third entry, "The project benefits from the project outweigh the estimated costs/effort" highlights the problem this paper is intended to solve. There is no qualitative or quantitative basis to provide guidance on whether or not this objective has been achieved. What is a project benefit? How is it measured?

Area	Criterion - all projects	Evidence	Met?	Comments
Strategic alignment	The Bus Case records how the proposed project aligns to a recognised strategy			
Business need & benefits	The Bus Case states at least one quantified target metric (benefit), and provides indicative			
	The projected benefits from the project outweigh the estimated costs/effort			
	The project is included in the Capital Plan, OR the portfolio board (or equivalent) has approved its inclusion as an additional project, and can show how the project will be funded			
Governance & sponsorship	The project has a Sponsor who has approved the Bus Case			
	The Sponsor understands his/her role, i.e. to authorise the project and funding, to chair the Steering Group, to approve Stage Gates and to champion the project			
Organisation & team	A project manager has been identified who will develop the Project Charter and associated documents in the Development Stage (this role may be performed by a Business Partner)			
Objectives, scope and deliverables	The high-level objective of the project is stated in the Bus Case			
	The Bus Case defines departments, markets/locations, processes and systems in and out of scope			
	The Bus Case lists the main project deliverables in terms that describe a physical output			
Planning and estimating	The Bus Case states an indicative timescale for the project			
	The Bus Case states any fixed or important dates such as regulatory deadlines			

SG0 checklist | SG1 checklist | SG2 checklist | SG2a checklist | SG3 checklist | SG4 checklist | Guidance | Change control

Figure 6–Sample Stage Gate Checklist

To summarize, the components of a stage gate process commonly found are the named stages, high-level objectives for each stage, and in some cases checklists for each stage.

4. The Missing Component

To better harness the potential of the stage gate process, an organization needs to develop clear, qualitative, and quantitative deliverables. Further, these deliverables must be interlocked with each other to reflect how technical and management information is relied upon beginning with an opportunity and ending with a completed project.

Deliverables are produced by using input information, processing that information, thereby adding, or retaining value, resulting in an output, which is the deliverable. This is the definition of a work process. A project's scope can be broken down into a hierarchical structure called the work breakdown structure (WBS). For purposes of this paper, the WBS structure at level 3 is the work process level. Therefore, each WBS level 3 account is a work process.

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Before further investigation of the WBS-based work processes, it is helpful to provide a vertical structure of the stage gate system. While stages provide the horizontal breakdown of the stage gate process; key activities provide the vertical breakdown. The following graphic lists key activities that could be used in a stage gate process during development and front-end planning. The key activities designated DEV01 through DEV08 represent development, which are owner activities. The PE01 front end planning key activity is commonly performed by a third-party consultant.

DEV01 Development Management
DEV02 Development Engineering
DEV03 Commercial
DEV04 Financial
DEV05 Environmental
DEV06 Legal and Regulatory
DEV07 Real Estate
DEV08 Technical
PE01 FRONT END PLANNING

Figure 7–Key Activities for Development and FEP

The graphic below identifies key activities that could be used by the EPC Contractor during FEP and execution phases.

PROJECT MANAGEMENT KEY ACTIVITIES	PROJECT EXECUTION KEY ACTIVITIES
PM01 FRONT END PLANNING MANAGEMENT	PE01 FRONT END PLANNING EXECUTION
PM02 PROJECT EXECUTION MANAGEMENT	PE02 HSE IN DESIGN
PM03 CONTRACT MANAGEMENT	PE03 SYSTEM ENGINEERING
PM04 RISK MANAGEMENT	PE04 LAYOUT, 3D MODELING AND DISCIPLINE DESIGN
PM05 QUANTITY MANAGEMENT	PE05 PROCUREMENT
PM06 ESTIMATING AND COST CONTROL	PE06 SUBCONTRACTING
PM07 PLANNING AND SCHEDULING	PE07 FABRICATION AND CONSTRUCTION
PM08 CHANGE MANAGEMENT	PE08 COMMISSIONING
PM09 HSE MANAGEMENT	
PM10 QUALITY MANAGEMENT	
PM11 INFORMATION MANAGEMENT	

Figure 8–Key Activities for Execution

AACE PM-2337[5] provides further guidance on how to structure a stage gate process for the execution, or EPC phases.

Figure 10 below shows the WBS-based work processes for the first, or "Assess" stage of the development stage gate process from Figure 6. The work processes are grouped by their key activities as shown in Figure 7. The WBS-based work processes in Figure 9 were defined to reflect the development process of a renewable energy project.

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There are no work processes in this stage for the key activities Legal and Regulator, Real Estate, Technical and Front-End Planning (see Figure 8). Those processes would begin in the next stage.

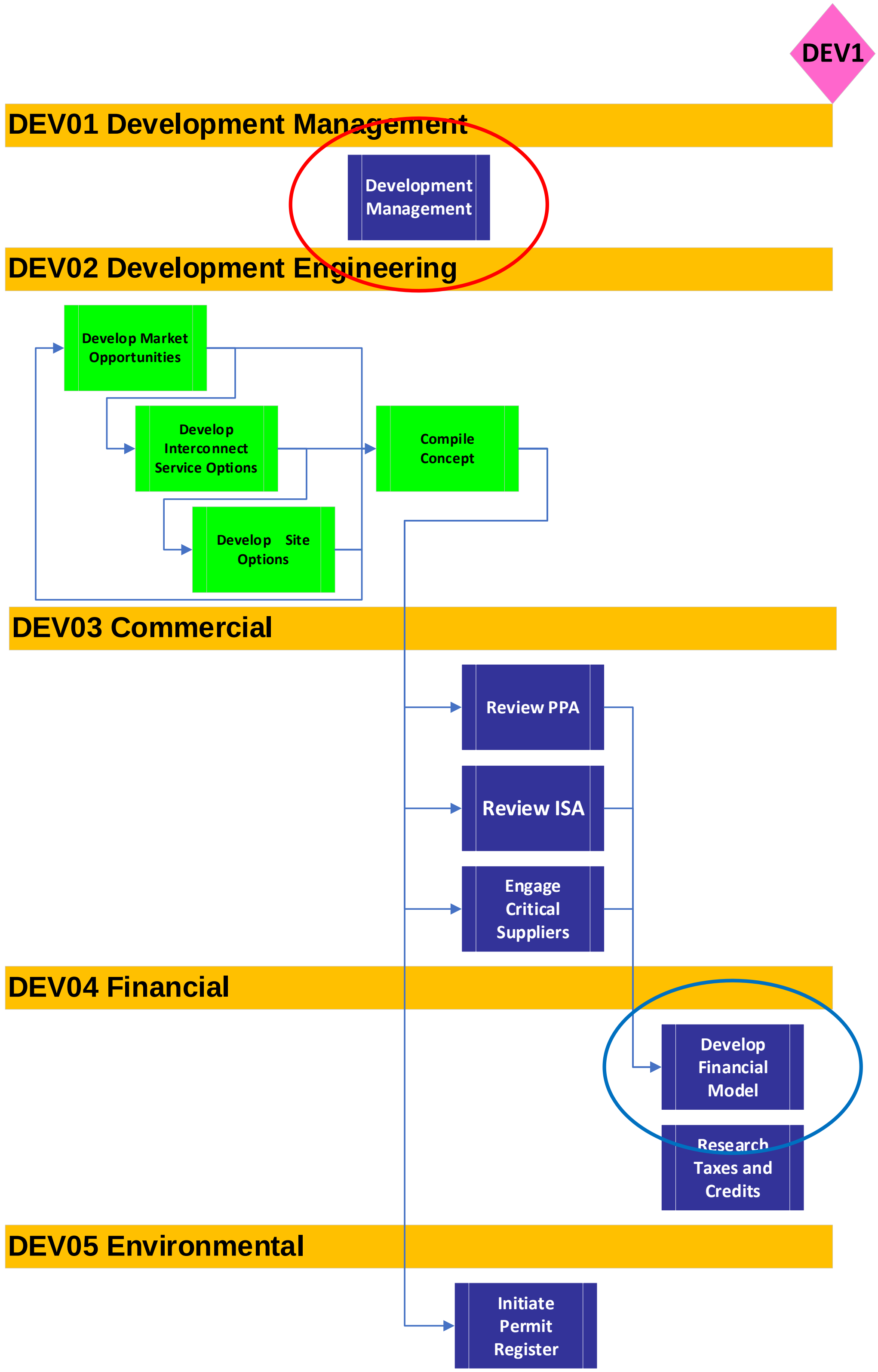

Figure 9–WBS Based Work Process Map

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5. Work Process Diagrams

Work process diagrams graphically depict the individual WBS-based work processes. Each WBS-based work process will have inputs and outputs. Figure 10 below is the "exploded view" of the work process highlighted by the red ellipse in Figure 11. The figure show that Development Management starts before other work processes and completes after the other work processes in stage 1 have been completed. Inputs to commence development management include the Pipeline (database of all potential projects), Governance and Policies, and the Business Plan. This is important because the diagram graphically shows precedence and succession; in other words, downstream work is dependent on upstream work.

Once the project passes the screens for conformance with governance, policies and business plan, the development team applies time and costs to create the stage 1 deliverables. This is done by performing the other work processes shown in Figure 10. Each one of these work processes has its own work process diagram, which in turn has inputs and outputs. All these work processes must be completed before the Development Management work process can be completed.

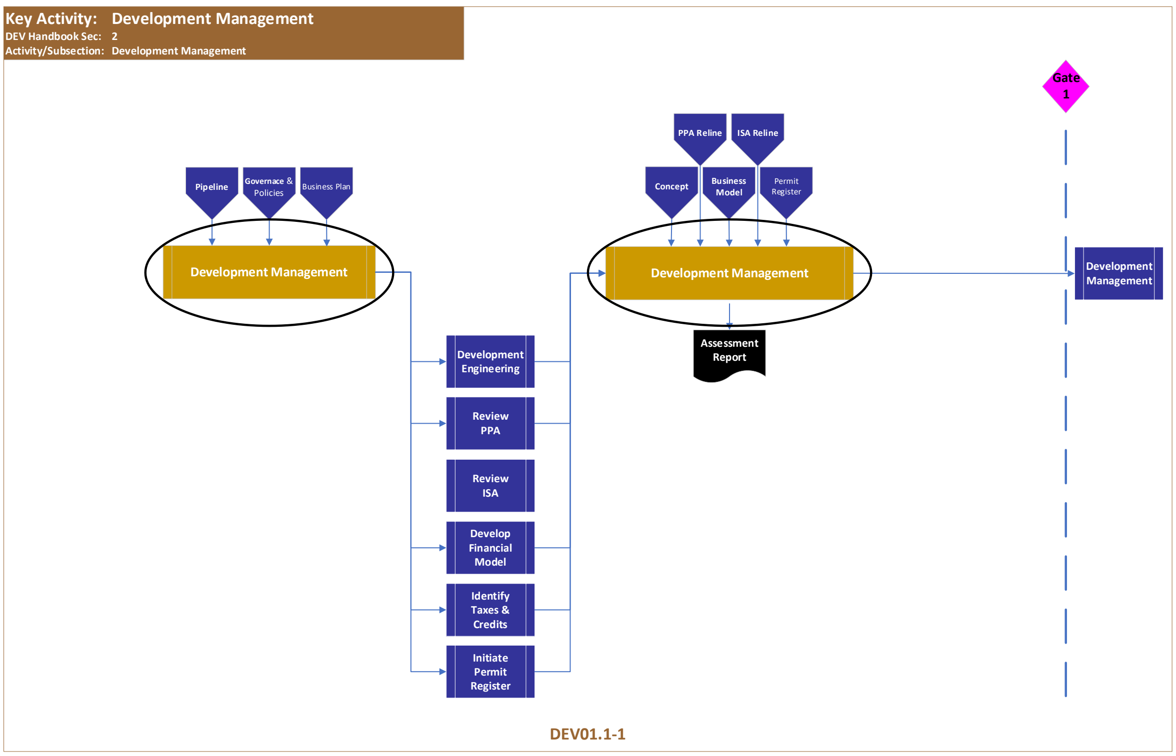

Figure 10–Work Process Diagram

6. Activity Descriptions

While Figure 11 graphically shows the inputs and output of the Development Management work process, Figure 12 provides more detail and narrative for the actual work process, which is depicted in the two brown rectangles.

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ACTIVITY DESCRIPTION

DEVELOPMENT

DEV01 DEVELOPMENT MANAGEMENT

Activity Title	Process
Development Management	**DEV01.1-DEV1**

ACTIVITY DESCRIPTION:	REF. DOC
Before starting, verify project includes: Market opportunity (PPA or Spec Build); product mix/capacity Interconnect capacity and location Potential site(s)	Development Handbook Section 2.1
Review current corporate policies; identify "deal killer" items Review current business plan for match to product mix, capacity, location, milestone dates	Development Handbook Section 2.2
Ongoing project management functions to include: Weekly development team meetings; publish minutes and Actions List Issue Project Manager's Report weekly	Development Handbook Section 2.3
Review development team deliverables and compile Assessment Report for Exec Mgt/Board Assessment Report to include: Executive Summary Project Description Commercial Summary (Ts and Cs from PPA, ISA) Financial Summary Development timeline and costs Attachments (Concept, Financial Model, Permit Register, Estimate, Schedule)	Development Handbook Section 2.4
Stage Gate 1 Review Ensure all Activity Descriptions are signed off by team leads Ensure all Stage Gate deliverables are compiled, organized and available to review team	Development Handbook Section 2.5

INPUT REQUIREMENTS:	ISSUE:	STATUS:
(Opportunity) Pipeline		Latest issue
Corporate Policies		Current approved version
Current Business Plan		Current approved version
PPA		DEV1
ISA		DEV1
Financial Model		DEV1
Permit List		DEV1

OUTPUTS:	ISSUE:	STATUS:
Action Lists		
Meeting Minutes		
Assessment Report		DEV1

The work performed and managed in this activity has been checked and verified to have relied upon the prerequisite quality of information required.

Project Manager　　　　Date

Figure 11–Development Management Activity Description

Within the Activity Descriptions shown in Figure 12, the prerequisite information is reiterated. There is guidance on what information must be included in the "Assessment Report," which is the primary output or deliverable for this work process. Note that one of the inputs is the Financial Model.

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Figure 13 below is the Activity Description for the Develop Financial Model work process. Consistent with other activity descriptions, it reiterates prerequisite deliverables and information needed prior to starting the work. It also provides qualitative requirements for the financial model output, or deliverable. Specifically, the financial model is to be a monthly Excel spreadsheet, showing specific income and expense line items over a 15-year period. Within the financial model is the return on investment (ROI) calculation. The ROI at various periods is presumably required to meet the requirement in the business plan. This information provides quantitative support for decision making than the "verify business-value case" stage gate objective shown in Figure 6. Additionally, the reviewer has confidence in the reliability of that quantitative value because it is supported by a documented process.

ACTIVITY DESCRIPTION

DEVELOPMENT

DEV04 FINANCIAL

Activity Title	Process
Develop Financial Model	**DEV04.1-DEV1**

ACTIVITY DESCRIPTION:	REF. DOC
Before starting, verify external dependency inputs including: Clearly defined revenue stream from PPA (or Spec) LDs/Penalties from PPA and ISA CAPEX from Class 5 Estimate Commercial milestones from Class 5 Schedule Internal CAPEX costs (development costs) OPEX costs (SG&A)	Development Handbook Section 4.0
Develop Excel based financial model, which includes a monthly income projection and cash flow for 15 years. Income projection to include rows for: Revenue Streams CAPEX Major Maintenance; Recurring capitalization Decommissioning (if applicable) OPEX (Salaries, Benefits, Administrative costs, fees, etc.) EBITDA Amortization Depreciation Income Taxes (Federal, State, Local, Tax Credits) Net Income ROI ROE	Development Handbook Section 4.0

INPUT REQUIREMENTS:	ISSUE:	STATUS:
Corporate Policies		Current approved version
Current Business Plan		Current approved version
PPA	Red Lined	DEV1
ISA	Red Lined	DEV1
Class 5 Estimate		DEV1
Class 5 Schedule		DEV1

OUTPUTS:	ISSUE:	STATUS:
Financial Model		DEV1

The work performed and managed in this activity has been checked and verified to have relied upon the prerequisite quality of information required.

Finance Manager   Date

Figure 12–Financial Model Activity Description

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To make a complete stage gate process, the remaining WBS based work processes for all the stages need to be defined and placed on the process map within their key activities and between their applicable stage gates. The information provided in this paper provides the guidance for developing the remaining processes for a company's development stage gate process.

7. Stage Gate Checklists

There are several definitions for a checklist. A checklist is a document that itemizes things to get done; that is actions are not forgotten, or a process has been followed. In some cases, the checklist is to ensure that things get done in the right order.

The work processes and activity descriptions provide a far more granular basis for developing checklists than simply expanding off a short bullet list of stage gate objectives. With documented processes, the checklist is a tool used to verify the process has been followed. Checklist items can be grouped to their respective work process and subsequently to their key activity to support the stage gate review. Figure 14 below shows a checklist for the WBS process shown in Figure 12, Development Management. Note that responsibility delegations are identified as are company policies and forms. Remarks are intended to provide further clarify acceptance criteria.

Project Title:	
Project No.:	
Client:	
Stage Gate:	DEV1 | Sign | Date
Auditee:	
Auditor:	

STAGE GATE REVIEW CHECKLIST

Key Activity / Activity / Checklist Item	Responsibility	Process	Form No.	Complete	Remarks
DEVELOPMENT					
Development Management					
"Assessment" Charter Issued?	Proj Mgr		DEV-01		
Includes budget for DEV1 work?					
Includes schedule for DEV1 work?					
Identifies scope of work for DEV1?					
Identifies deliverables due at completion of DEV1?					
PPA RFQ Received, processed; response returned?	Proj Mgr				
Functional requirements established (abssent PPA RFQ)?	Comm Mgr				
Interconnect Source identified, capabilities assessed?	Comm Mgr				
Transmission route identified?	Eng Mgr				
Interconnect Requirements identified?	Eng Mgr				
Site location evaluated?	PMO Mgr				Location, size, availability, inordinate conditions
Governance and Policies compliance					
Is project risk classification within approved limits?	Proj Mgr		RM-01		
Will pro					
Core ca					
Project su					
Product					
COD?					
Locatio					
"Assessment" Report Completed; Ready for Go / No Go Review?	Proj Mgr		DEV-02		
Concept Package Engineering deliverables included?	Proj Mgr				
Functional Requirements	Comm Mgr				
Business Model included?	CFO				
Milestone Schedule included?	Scheduler				DEV2, DEV3, DEV4, Financial Close, NTP, COD
Permit Matrix	Env Mgr				
Development Engineering					
Interconnect Services Feasibility Study completed?					

Governance and Policies compliance				
Is project risk classification within approved limits?	Proj Mgr		RM-01	
Will project development and execution comply with corporate policies?	Proj Mgr		GOV-203	
Core capabilities and strategy profile?	Proj Mgr		RM-02	

Figure 13–Stage Gate Checklist

Without work processes, the checklist is simply an extension, or expansion of the stage gate objectives. If unsupported by work processes or something else that is qualitative or quantitative, they are at best reactive; at worst unreliable.

8. Stage Gate Objectives – Revisited

The stage gate objectives are the foundational elements of stage gate processes commonly found. Those shown in the stage gate process, Figure 6 as previously stated are vague.

Referencing Figure 6, under the "Define Project" stage is the requirement to "Build technical scope, cost and schedule". Using the principles from this paper, that requirement would expand into multiple requirements:

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- Complete Basis of Design and Detailed Scope of Work
- Complete AACE Class 3 Cost Estimate
- Complete AACE Class 3 Schedule

Each of these objectives would be backed up with multiple check list items validating an approved process was followed.

9. Conclusion

A stage gate process that utilizes WBS-based work processes become a comprehensive management tool that provides improved predictability in project outcomes, ensures commercial compliance, reduces risk, and becomes a framework for collaboration and communication. The project controls benefits are the subject of AACE TCM-3747, Better Project Controls through Better Project Execution [6].

As a project progresses through the life cycle, the expectations are clear and communicated before the work is performed. As each project team member performs their respective work, they understand how their work fits into the entire project. They also know what information or deliverables they require before they perform their work and what deliverables are required by them for others to continue work. Each work process is self-audited and signed off upon completion of the requirements. Subsequent work processes verify prerequisite inputs are signed off before proceeding. As stage gates approach, checklists become a simple audit tool backed up by documentation of process compliance. A key paradigm shift is that WBS-based work processes shift the stage gate process from being reactive to being proactive. The acceptance criteria are clear and known at commencement by both the project team and audit team. Figure 13 illustrates the structural difference between a commonly found stage gate process and one that includes WBS-based work processes.

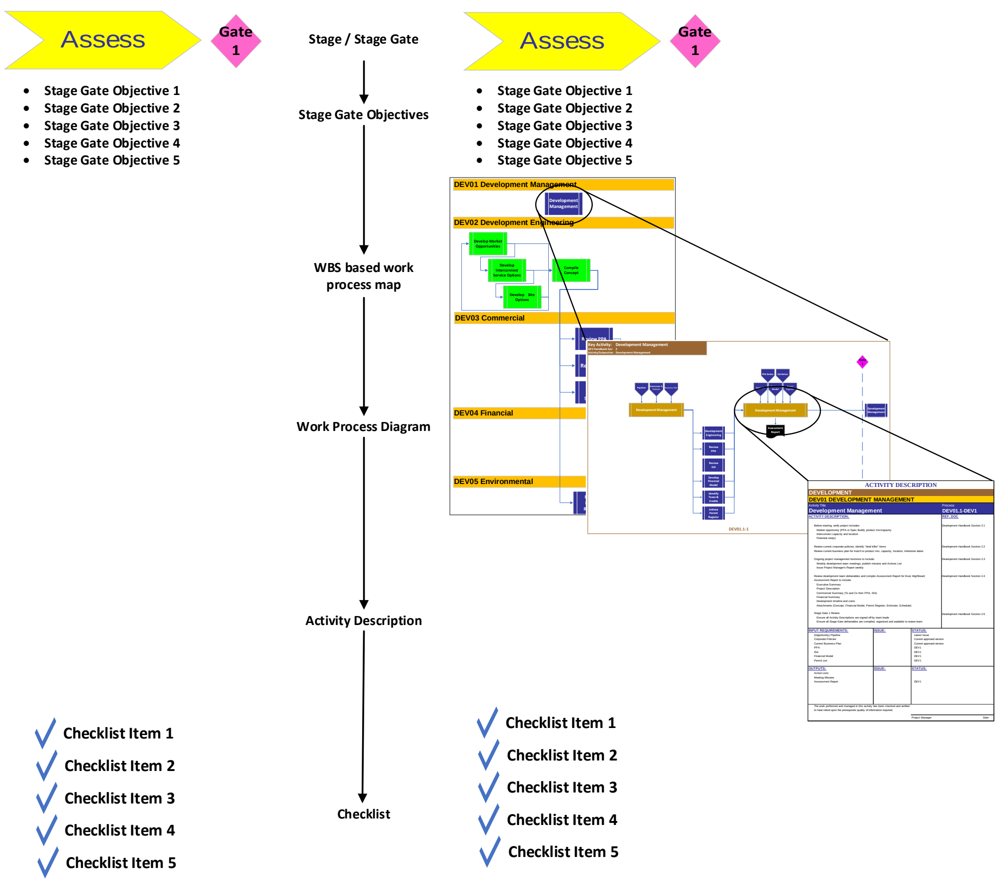

Figure 14- Stage Gate Process Comparison

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A stage gate process that utilizes objectives and checklists reactive because they are the only validation criteria and only reviewed at the end of a stage to determine whether the project passes the gate. And without clear acceptance criteria known to both the project team and review team, this exposes the project to delays if significant shortcomings are identified when months elapse between stage gate reviews.

The purpose of this paper is to demonstrate why a WBS-based work processes are a necessary component in a stage gate process. There are additional, complementary components that can be added onto this system.

1. RACI Requirements – for each work process, RACI assignments for performing, assisting, contributing, and approving work.
2. Forms and Reports Register – a catalog of standardized forms and reports associated with key activities and processes in a consolidated register for reference and quick access.
3. Stage Gate Punch lists – stage gate reviews are performed by reviewing the project documentation. It is recommended that they be performed by a separate team that is not the project team. Their findings are memorialized on a punch list, which assigns remedial work to a named individual with a planned completion date. This form allows for the periodic follow-up by senior management or the review team to ensure all follow-up actions are completed.

To be sure, there is a work effort to create a stage gate system. However, once it is created, it is reusable. As the organization gains experience from implementation, the stage gate system becomes the media where continuous improvement is captured (for immediate re-use). The most difficult part for owner organizations is the culture change required to work more formally. The development stage gate model is small and simple. For contractors, the most difficult part is having the resources to build out the execution phases as they are quite comprehensive. However, a complete template structure with guidance on developing work processes is provided in AACE PM-2337.

In closing, it has been demonstrated that an effective stage gate process cannot rely on vague milestone objectives. It must rely on WBS-based work processes which have defined inputs and outputs. The work processes must be interlocked so that all disciplines of work are integrated to produce a predictable project outcome. This paper provides the thought process and examples one can use to develop one's own WBS-based work processes and subsequently a complete stage gate process.

The key component for a robust stage gate process, which is missing from current systems, is the WBS-based work process.

References

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Richard P. Helper, PSP
RPH Consulting, Ltd.
Rick.Helper@RPHConsultingLtd.com

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