The Primacy of the Scope Baseline in Engineering & Construction Projects[1]

Bob Prieto

Chairman & CEO
Strategic Program Management LLC

In the management of engineering & construction projects it is accepted that a project can be described and best controlled against three baselines – scope, schedule and budget[2]. Together they define the project's performance measurement baseline. This paper focuses on the scope baseline and suggests its primacy among the three baselines. An incomplete scope will, by definition, result in incomplete or inaccurate schedules and estimates.

What is scope?

Scope is the detailed set of deliverables and/or features for a project derived from the project's requirements. Scope must clearly identify the work required to successfully deliver a given project. A more detailed description of the elements of scope is provided later in this paper and, while focused on engineering & construction projects, is more generally applicable.

Why is scope definition and management important?

Inadequate scope definition and management has been identified as a major source of degraded project performance. The International Association for Contract & Commercial

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[2] Quality is a baseline parameter defined as meeting customer's requirements, i.e., scope, schedule, budget

Management (IACCM) has identified 10 common pitfalls for contract management. First among these is "lack of clarity on scope and goals"[3]. Others[4,5,6,7] have identified that when scope is not clearly and accurately defined, overruns become systemic and scope creep is a consequence and the second highest rework indicator.

In addition to cost overruns arising from poor scope definition we also often see delayed completion and disputes, often extended in time. Poor scope definition affects all of the project's baselines.

Inadequate scope definition and management is also a source of owner's risk, referred to as 'Spearin risk'[8,9] in the US, for which no effective transfer or warranty mechanisms currently exists.

Spearin Doctrine
A legal principle that holds that when a contractor follows the plans and specifications furnished by the owner, and those plans and specifications turn out to be defective or insufficient, the contractor is not liable to the owner for any loss or damage resulting from the defective plans and specifications. The courts in virtually all states have adopted this rule

What creates scope problems?

There are many potential contributors to scope challenges with business and/or project complexity and uncertainty being the principle source of scope and goals issues. This inescapable challenge is exacerbated by[10]:

- Inadequate project definition and agreement during the pre-contract phase reflecting
  - Ambiguity
  - Incomplete definition
  - Lack of stakeholder engagement and agreement

[3] Excellence in Contract Management; Common pitfalls from a practitioner's perspective; IACCM; CPA Global 2016
[4] Scope Creep; Stephanie Gurlen; University of Missouri–St. Louis; 2003
[5] Investigation and Analysis of the Rework Leading Indicators in Construction Projects: State-of-the-Art Review; University of Texas Arlington; Elnaz Safapour; Sharareh Kermanshachi; Piyush Taneja; 2019
[6] Hollmann, John K. 2016. Project Risk Quantification: A Practitioner's Guide to Realistic Cost and Schedule Risk Management (Probabilistic Publishing: Gainesville, FL, USA).
[7] Guidance Note 1 Project Scope; Australian Government Department of Infrastructure and Regional Development; March 2017
[8] United States v. Spearin (248 US 132)
[9] The implicit warranty an Owner makes at contract to the Constructor, is the source of Scope/Spearin Risk that Owners retain regardless of the contracting transfer method. Spearin Risk remains with the owner as uninsured risk associated with the completeness and accuracy of the project scope.
[10] Opinions about Project Scope Management; NYU; Henry Zhou; 2016

- Failure to manage change and maintain and update scope post award leading to scope creep

Scope change in and of itself is not bad as along as it is driven by factors which necessitate it to meet strategic business objectives or reflect changing capabilities. Scope change is often driven by the natural refinement of the initial scope statement and such changes best occur at the earliest stages of the project lifecycle[11]. Change must be agreed to, proactively and aggressively managed, and well documented and communicated.

Scope development process

The scope development process begins in the owner's organization and must be directly linked to the Strategic Business Outcomes (SBOs)[12] the organization wants to achieve (Why). From this, the earliest identification of the 'needs' that the project must satisfy are developed (What). The 'Why' and 'What' allow the owner to articulate a set of specific goals and objectives often memorialized in the Owner's Project Requirements (OPR)[13].

The project requirements[14] should encompass:

- Business requirements
- Stakeholder requirements
- Solution requirements
- Project requirements
- Transition requirements (brownfield projects)
- Assumptions, dependencies and constraints[15,16]

The owner's project requirements are then translated into a definitive scope of work (SOW) and an accompanying basis of design (BOD)[17,18]. The SOW confirms the objectives and goals laid out in the OPR and ensure that they are specific, clearly laying out what, why and how they will be achieved. Challenges and constraints the project will

[11] Scope Development to Support Estimating; National Academy of Construction Executive Insight; Stu Anderson; 2018
[12] Strategic Program Management; published by the Construction Management Association of America (CMAA); ISBN 978-0-9815612-1-9; July 24, 2008
[13] The Owner's project requirements (OPR) detail the high level functional requirements of a project and the expectations of how it will be used, achieve user needs, and operated for its entire lifecycle. The Owner Project Requirements will form the basis from which all design, construction, acceptance and operational decisions are made.
[14] Requirements Documents: Do You Know What Should Be Included? Master of Project Academy
[15] These should be memorialized and tracked throughout the project
[16] Prieto (2016); Management of Assumption Infatuation in Large Complex Projects; PM World Journal; Vol. V, Issue IV–April 2016
[17] The Basis of Design is a functional or performance based narrative description of what the designer will do to meet OPR; finalized at end of construction; includes assumptions and criteria used. The author has recommended an expanded basis of design encompassing construction and O&M considerations.
[18] Prieto (2014) Addressing Project Capital Efficiency through a Business Basis of Design; PM World Journal Vol. III, Issue IV –April 2014

face are also laid out and initial iteration between scope, schedule and budget development occurs, ultimately leading to a comprehensive project baseline.

The SOW and associated BOD[19] clearly establish detailed project requirements that must be met and their linkage to the OPR. Table 1 highlights some of the major challenges faced in defining project goals and scope[20].

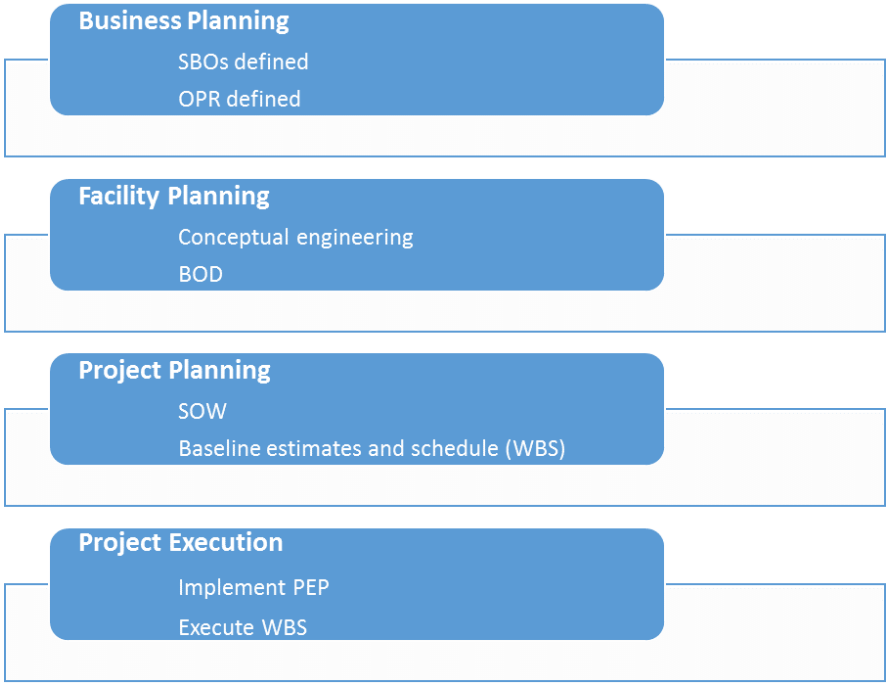

Table 1
Major Challenges in Defining Goals and Scope

- Business complexity
- Articulation of client's strategic business outcomes
- Weak client processes
- Stakeholder clarity
- Inadequate time allowed
- Weak provider staff and processes
- Rapid change affecting project
- Metrics drive wrong behaviors
- Inflexible contracting terms and processes

[19] Addressing Project Capital Efficiency through a Business Basis of Design; PM World Journal; Vol. III, Issue IV – April 2014
[20] Adopted from Tackling the weaknesses in Contract Management; Pitfall #1: Lack of clarity in scope and goals; IACCM; 2016

The CII developed Project Definition Rating Index (PDRI)[21] provides a scoring tool for measuring the adequacy of project scope definition and identifies area requiring improvement.

Developing artificial intelligence efforts hold the potential of more robustly identifying scope gaps and residual scope risk retained by owners through the Spearin doctrine.

Elements of Scope of Work (SOW)[22]

The scope of work consists of two principle elements, a scope of facilities and a scope of services. These are usually accompanied by an executive summary providing an overview of the project, ideally linking back to the 'Why' and 'What' memorialized in the owner's project requirements. The SOW should consider and include, as appropriate, information related to the project's cost estimate and schedule. In addition, commercial and risk aspects should be considered.

Development of the SOW is aided by development of a project work breakdown structure (WBS) and the two activities typically go hand in hand.

Other elements addressed in the SOW include:

- Project organization
- Project approvals
- Reporting requirements
- Project control policy
- Change management policy
- Intellectual property rights (including non-disclosure and confidential information)

Scope of facilities

The purpose of the Scope of Facilities is to present the physical and functional description of the final constructed and delivered facility. The scope of facilities typically encompasses the design basis and assumptions and clarifications.

Design Basis

This provides a general introduction and an overview of the project's Scope of Facilities. It addresses the following aspects of the project:

- Introduction (who, what, when and where)
- Type of project[23] (E, EP, EPC, EPCM, etc.)
- Type of contract (cost plus, lump sum, etc.)

[21] CII 1994, Pre-project planning: Beginning a project the right way; Construction Industry Institute; The University of Texas at Austin
[22] This may also be referred to as a statement of work.
[23] Engineering (E); engineering and procurement (EP); engineering, procurement and construction (EPC); engineering, procurement and construction management (EPCM)

- Brief overview of client
- Purpose and overview of Project Facilities
- Design basis overview (linked to the more detailed Basis of Design document)
- Project specification List
- Work Breakdown Structure
- Site location and battery limits

Items that describe the design approach, activities, and deliverables for the project should be discussed in the Scope of Services section.

Assumptions and Clarifications

This focuses on the general project assumptions[24], clarifications, and exclusions (for the providing firm, the client or others) associated with the physical and functional description of the facilities that are applicable to the project. Exclusions should be clearly detailed and presented in a positive manner. Discussion with all project stakeholders should ensure that any potential "white space" risks have been addressed. Uncertainties and "soft" issues should be addressed, reviewed with the client and documented for clarity and to minimize liabilities.

Assumptions, clarifications, and exclusions regarding design approaches, activities, and deliverables should be addressed in the Scope of Services section.

Typical concerns include:

- Is future expansion of the facility to be considered in the design?
- Adequacy of existing plant utility (or other) systems to be used for the proposed project facilities.
- Presence of hazardous wastes, asbestos or volatile organic carbon materials in the work areas.

Scope of services

The Scope of Services should include:

- Project execution approach, activities and deliverables
- Activities and deliverables to be provided by the client, suppliers, subcontractors, etc.
  - Interfaces should be detailed and tracked
- Activities and deliverables normally provided that will not be provided by anyone
  - These represent potential "white space risks"[25]

[24] Assumptions should be documented and regularly tracked.
[25] PMR (2019). Program Management Is Anything but Simple: Interview with Robert Prieto; *Project Management Review*; republished in the *PM World Journal*, Vol. VIII, Issue VI, July

Project Approach

Provides a general introduction and an overview of the project's Scope of Services. The company execution plan and methods, activities, and tools that will be provided and/or used for the project are addressed. Specific roles and responsibilities, activities, and tools of the client and other parties for the project are also presented.

The project approach covers the following aspects of the project (if applicable):

- Project type (E, EPC, EPCM, CM, etc.).
- Type of contract (cost plus, lump sum, etc.)
- Identification of engineering or construction companies if performing only partial services
- Project roles and responsibilities
  - Project services responsibility matrix may be prepared or included with a project execution plan
  - Roles and responsibilities of the company engineering, procurement, construction and project management team.
  - Roles and responsibilities of the client
  - Roles and responsibilities of other engineers, contractors and/or companies
- General description of how the project will be executed
  - Detailed further in the project execution plan
- Equipment and area numbering systems
- Units that work will be performed in (e.g., English, metric)
- Language the work will be delivered in
- Types of project reviews (P&IDs, safety, constructability, operability, etc.)
- Permit responsibilities (construction, building, environmental, etc.)
- Intellectual property; non-disclosure and/or secrecy agreement
  - Data ownership and usage rights
- Brief overview of BIM/CAD systems to be used
- General description of any special design aids that will be used including any proprietary company tools
- General description of any planned use of Artificial Intelligence (AI) and validation and verification for intended use
- Brief overview of how company will add value to the project

General information about the physical and functional description of the facility should be discussed in the Scope of Facilities section.

References and Standards

This SOW should contain a list of all currently adopted Codes and Standards that are common to most engineering disciplines for the project. The codes and standards may be the company's, the client's, or applicable industry standards. Any standards related to acceptance of materials, components, systems and equipment should also be explicitly

stated and accepted by the client. Confirm consistency with proposal, cost and pricing basis. It is important to note applicable revision date to be used where possible and to avoid citing “latest applicable standards” which open up a potential disparity between the version used in furnishing and installing and ultimate acceptance testing.

Codes and standards applicable to only one or two engineering disciplines should be listed in the individual discipline's References and Standards section of the Scope of Services. A general description of any special design aids to be used should also be discussed in this section.

Typical standards include:

- ANSI – American National Standards Institute
- ASME – American Society of Mechanical Engineers
- ASTM – American Society for Testing Material
- FM – Factory Mutual
- NEC – National Electrical Code
- NEMA – National Electrical Manufacturers Association
- NFPA – National Fire Protection Association
- OSHA – Occupational Safety and Health Administration
- UL – Underwriter's Laboratories Inc.
- State and local codes and regulations having jurisdiction.
- Client Standards
- Company Standards
- Project Specification List

Any approvals required by codes should be clearly indicated as being obtained by the supplier, such as certification required by local inspecting authorities on foreign supplied equipment, and should be reflected in their respective statements of work.

Particular attention must be paid to new and emerging technologies where standards may not yet exist or are evolving quickly.

Performance based standards should be noted, ensuring recognized acceptance tests exist or detailing how acceptance will be ascertained.

Special attention is required when artificial intelligence is incorporated in analysis or final system performance and control. This is an emerging area warranting special attention.

Special Resources

Any special resources that are of a general nature which will be used to implement the project should be called out addressing the specific task of the resource and the timing of their involvement. Special types of computer simulation and software should also be addressed, together with any planned use of AI.

Deliverables to Client and Construction

The general types of project documents to be provided to the client and construction during or at the end of the project should be described. A more definitive listing of engineering deliverables is typically included as part of the project execution plan (PEP). This list should include, but should not be limited to:

- Deliverables to Client:
  - Scope of Work for project
  - Project Estimates
  - Schedules
  - Monthly project report
  - Project procedure manual
  - Project distribution list
  - Final BIM Model/CAD files (containing only contractually required info)
  - CAD file index
  - Drawing list
  - Specification list
  - Special reports
  - Close-out report
  - PE stamped documents (if specifically required by client)
- Deliverables to Construction:
  - Scope of work
  - Project estimates
  - Schedules
  - BIM Model/CAD files (as required)

Client Interface

A general overview of the review and approval of project documents and the level of client involvement in the project should be described, reflecting agreement with the client. All major client representatives involved in the interface should be identified along with their roles and responsibilities. Indicate the process and frequency for the various reviews for the project ensuring consistency with any client approval matrix typically included in the PEP.

Inter-discipline Coordination

How the project team will interface and coordinate work should be described including methods and procedures to formally review engineering and supplier documents (drawings, specifications, etc.). Reference the development of any project activity model (PAM) as a means of documenting interface requirements.

Assumptions and Clarifications

This SOW should lay out the general assumptions, clarifications, and exclusions (for company, client and others) associated with the general design approach, activities and deliverables for the project. Exclusions should be presented in a positive manner. Uncertainties and "soft" issues should be documented in order to promote review and discussion with the client and to minimize liabilities.

This section should address:

- Location of engineering taskforce, including work to be performed in offshore engineering centers
- Estimated trips to job site, suppliers and others by Project Management
- Reliability of client documentation
- As-built drawings
- Permits (construction, building, environmental, etc.)
- State and local approval of construction documents
- Construction support
- Commissioning and startup support
- Training of plant personnel
- Operating manuals

Assumptions, clarifications, and exclusions regarding the physical and functional description of the facility should be addressed in the Scope of Facilities section.

Engineering & Construction Industry Challenge

An assessment made on readiness of various industries to ensure that project requirements are well defined and understood ranked engineering and construction lowest of six industries[26]. Accountability for goal clarity and completeness of requirements begins with the owner but engineering and construction require strong and regularly implemented scope processes that ensure these goals and requirements have been clearly and comprehensively defined. Requirements should be tracked throughout the project, cascading down into the various structures, systems and components. A requirements traceability matrix is one tool that can be used and it serves to enhance the scope management process.

Assurance that goals and requirements have been clearly and comprehensively defined must include consideration of both the internal and external stakeholder ecosystems. From personal experience, failing mega-projects suffered from lack of articulation of strategic business objectives; agreement on them and continuous communication.

[26] Industries, in order of readiness included technology/software; telecommunications; aerospace/defense; services; oil/gas/minerals/utilities; engineering/construction. Tackling the weaknesses in Contract Management; Pitfall #1: Lack of clarity in scope and goals; IACCM; 2016

Measurement systems need to focus on project execution, closely managing the prime contract and its associated scope, not just cost and schedule performance. Weaknesses in scope definition and completeness are a predictor of overall negative project performance. Scope, or more appropriately, scope creep needs to be key components of rigorous monthly project reviews[27].

Scope documents must reflect the full range of risks that projects may face, avoiding artificially screening out low probability, high consequence risks[28]. Uncertainty and complexity[29] warrant special attention.

The cascading of project scope throughout a complex supply chain needs to better ensure that unseen 'white space' risks are not being created.

Role of Work Breakdown Structure (WBS)

The WBS serves to both further refine the project's scope as well as to break the work down into manageable, executable tasks. The lowest level in a WBS is the work package level[30]. Advanced Work Packaging (AWP)[31] creates small, well-defined Engineering, Construction or Installation Work Packages (EWP, CWP, IWP) for the construction workforce. This paper is not focused on the WBS but several cautions are worth noting.

First, the process of refining and defining the project's scope must avoid tendencies to create scope growth through the addition of 'wants' vs the project's 'needs' defined in the scope document. These 'wants' can include new requirements, nice to have features, or personal preferences of members of the WBS team. The developed WBS must be thoroughly reviewed against the SOW for both gaps as well as extraneous items.

Second, the theory behind WBS development rests on an initial premise of conventional project management theory that says that projects are well bounded and decomposable into smaller tasks. In the world of large complex projects[32], projects are not well bounded, being susceptible to a wide range of external factors that create 'project flows' that modify task activities and more significantly the flows or work reflected in the connecting arrows in a WBS. For large complex projects these arrows are no longer dimensionless and 'white space' risks can be created as the result of project flows.

[27] Effective Project Review Meetings; National Academy of Construction Executive Insight; Bob Prieto; June 5, 2019
[28] Prieto (2018); Rethinking the Mathematics of Large Complex Projects; LinkedIn November 28, 2018
[29] Prieto (2017); *PM World Journal*; Complexity in Large Engineering & Construction Programs; Vol. VI, Issue XI – November 2017 - https://pmworldlibrary.net/wp-content/uploads/2017/11/pmwj64-Nov2017-Prieto-complexity-in-large-engineering-construction-programs.pdf
[30] What is a work package? The AWP Institute; April 23, 2018
[31] Advanced Work Packaging (AWP) is a construction-driven planning and collaboration system for building capital projects
[32] Theory of Management of Large Complex Projects; Construction Management Association of America (2015); ISBN 580-0-111776-07-9

Scope Creep

Scope creep, or at least the tendency, is a reality of project execution. Scope change, effectively managed, is not necessarily bad. Scope creep, ineffectively managed, creates project problems and drives cost and schedule overruns. Table 2[33] identifies some indicators of potential scope creep risk.

Table 2
Scope Creep Indicators

- Communication within owners
- Number of oversight entities
- Impact of project location
- Alignment of internal entities
- Number of owner organizations
- Number of funding phases
- Clarity of project goals
- Project population density
- Target project schedule
- Number of joint venture entities
- Number of active internal entities

Front end planning and alignment strategies are effective means of reducing the risk of scope creep. Strong change management practices complemented by effective dispute resolution practices also contribute to better scope management.

KPIs

All items of scope must be quantifiable and measurable. These in turn must be linked to the baseline cost and schedule. Project deliverables need to be confirmed by all relevant stakeholders and the effort to create and maintain these deliverables needs to be considered.

KPIs should be linked to acceptance criteria for each deliverable.

[33] Identifying Manageable Scope Creep Indicators and Selecting Best Practice Strategies for Construction Projects; Safapour, Kermanshachi; 2019

Summary

In this paper we have covered several key points with respect to the scope baseline in engineering & construction projects. These include:

- Scope baseline has primacy among the baseline documents (scope, schedule, budget)
- Lack of clarity of scope and goals is the number 1 project pitfall for contract management
- Inadequate scope definition and management is source of 'Spearin' risk, retained by owner
- Scope of work and basis of design must be tightly linked to owner's project requirements
- Principle elements of scope of work are scope of facilities and scope of services
- All items of scope must be quantifiable and measurable

About the Author

Bob Prieto

Chairman & CEO
Strategic Program Management LLC
Jupiter, Florida, USA

Bob Prieto is a senior executive effective in shaping and executing business strategy and a recognized leader within the infrastructure, engineering and construction industries. Currently Bob heads his own management consulting practice, Strategic Program Management LLC. He previously served as a senior vice president of Fluor, one of the largest engineering and construction companies in the world. He focuses on the development and delivery of large, complex projects worldwide and consults with owners across all market sectors in the development of programmatic delivery strategies. He is author of nine books including “Strategic Program Management”, “The Giga Factor: Program Management in the Engineering and Construction Industry”, “Application of Life Cycle Analysis in the Capital Assets Industry”, “Capital Efficiency: Pull All the Levers” and, most recently, “Theory of Management of Large Complex Projects” published by the Construction Management Association of America (CMAA) as well as over 600 other papers and presentations.

Bob is an Independent Member of the Shareholder Committee of Mott MacDonald. He is a member of the ASCE Industry Leaders Council, National Academy of Construction, a Fellow of the Construction Management Association of America and member of several university departmental and campus advisory boards. Bob served until 2006 as a U.S. presidential appointee to the Asia Pacific Economic Cooperation (APEC) Business Advisory Council (ABAC), working with U.S. and Asia-Pacific business leaders to shape the framework for trade and economic growth. He had previously served as both as Chairman of the Engineering and Construction Governors of the World Economic Forum and co-chair of the infrastructure task force formed after September 11th by the New York City Chamber of Commerce. Previously, he served as Chairman at Parsons Brinckerhoff (PB) and a non-executive director of Cardn0 (ASX)

Bob can be contacted at rpstrategic@comcast.net.