NAC Executive Insights

Location Factors in Large Complex Projects

Key Points

- This Executive Insight looks at location factors from a nontraditional perspective.
- Location factors for six global scale projects are compared.
- Strategies and tactics suitable for location-challenged large complex projects are outlined.

Traditional Definition of Location Factors

In construction, according to AACE[1] International[2], "A location factor is an instantaneous (i.e., current—has no escalation or currency exchange projection) overall total project factor for translating the total cost of the project cost elements of a defined construction project scope of work from one geographic location to another. This factor recognizes differences in productivity and costs for labor, engineered equipment, commodities, freight, duties, taxes, procurement, engineering, design, and project administration. The cost of land, scope/design differences for local conditions and codes, and differences in operating philosophies are not included in a location factor."

"Location factors provide a way to evaluate relative cost differences between two geographic locations. They often are applied to conceptual estimates for identifying "go/no-go" projects at an early stage. The ability to produce meaningful data during the conceptual stage is critical to the efficient management of the funds and resources of owners. This is what drives location-factor developers toward methods that are accurate, flexible, easily managed, and allow a quick turnaround."

While the disciplined approach is useful, much more insight is required when dealing with large complex projects.

Nontraditional Look at Location Factors

Traditional considerations of location factors in projects are focused on estimate and budget development based on factoring or otherwise adjusting estimates or actual costs (or their components) from other similar projects to establish a budget for a new project. While this is a useful technique for many projects, this approach to employing location factors breaks down as scale and complexity grow in

[1] Association for the Advancement of Cost Engineering
[2] AACE International 28R-03, Developing Location Factors by Factoring – As Applied in Architecture, Engineering, Procurement and Construction, 2006

nonlinear ways. Large complex projects located in more extreme environments create even more of a challenge, because there may not be any relevant similar projects.

This Executive Insight provides a comparison of a half dozen location-challenged projects and identifies relevant strategies and tactics across this group. The enumeration represents useful guidance for addressing location factors faced in challenging environments. These strategies and tactics themselves each represent thinking and practices which were developed over many prior projects of similar character and scale. Table 1 provides a general recap of these location-challenged projects.

Confidentiality concerns prevent the projects' direct identification. The strategies and solutions laid out are, by design, not linked to any particular project. Rather, they are intended to provide the reader with an expanded range of possibilities.

Table 1 - Key Location Factors

	Canadian Energy	Mideast Industrial	Australian Mining	South American Mining	Desert Warzone	Asian Mining
Nominal Value ($B)	6	6	20	4	Undisclosed Multiple $B	6
Client Type	Private	Quasi-Government Corporation	Private	Private	Government	Government/ Private JV
			Environmental			
Climate	Arctic Cold	Desert	Desert	High Altitude	Desert	Cold with Arctic Cold sub-season
Summer Temperature	Moderate	Extreme Heat	Seasonal Extremes	Moderate	Seasonal Extremes	Seasonal Extremes
Winter Temperature	Extreme Cold	Moderate	Moderate	Moderate	Seasonal Extremes	Seasonal Extremes
Nighttime Temperature	Typical Diurnal	Clear Sky Temperature Drop	Clear Sky Temperature Drop	Clear Sky Temperature Drop	Typical Diurnal	Clear Sky Temperature Drop
Relative Humidity	Dry	Dry	Dry	Dry	Varied but generally dry	Dry
Precipitation	Heavy Winter Snowfall	Low Annual Rainfall	Low Annual Rainfall; Summer Monsoons	Low Annual Rainfall	Varied with seasonal extremes	Low Annual Rainfall
Altitude	Nominal	Nominal	Nominal	Above 10,000 ft	Varied	High desert
Wind	Seasonally Significant – Polar Blasts	Seasonally Significant – Sandstorms	Nominal	Nominal	Seasonal and Location Variation	Seasonal Extremes

Table 1 - Key Location Factors						
	Canadian Energy	**Mideast Industrial**	**Australian Mining**	**South American Mining**	**Desert Warzone**	**Asian Mining**
Health Protection	N/A	Typhoid	Varied	Health Protection	N/A	Typhoid
Execution Related						
Power Supply	Self-Provided	Seasonally Significant	Seasonally Significant	Seasonally Significant	Seasonally Significant	Seasonally Significant
Fuel Types	Diesel; Natural Gas	Diesel	Diesel	Diesel	Diesel	Diesel
Fuel Availability	Available	Available	Available	Available	Fuel Convoys Subject to Attack	Available
Renewables	N/A	N/A	Limited	Limited	Limited	N/A
Microgrids	N/A	N/A	N/A	N/A	Some use	N/A
Water	Local Availability	Local Availability; Supplemented	Local Availability; Supplemented	Local Availability	Local Availability; Supplemented	Local Availability
Labor Supply	Nationally Sourced	Multi-national	Nationally Sourced	Nationally Sourced	Nationally Sourced	Multi-national
Logistics	Typical for Large Industrial	Typical for Large Industrial	Remote Sites; Port Subject to Significant Tidal Swings	Challenged by Altitude	War Zone Challenges	Remote Site; No Ocean Access
Supply Chain	Global	Global	Global	Global	Varied by project; Local and Regional Sourcing Dominated	Global

Strategies and Tactics Considered in Location Challenged Projects of Scale

Strategies and tactics suitable to location-challenged large complex projects are outlined in this section. Not all solutions are available to all sites, but the range of possibilities helps address many of the common challenges faced. Strategies and tactics have been grouped by:

1. Management
2. Engineering
3. Procurement
4. Construction

The considerations set forth below were all present on one or more of the projects reflected in Table 1.

1. Management

The management of projects facing potentially significant location challenges requires added attention and considerations in addition to the rigorous management that large complex projects demand. Integration of the project's complete supply chain becomes more important given that location challenges may manifest anywhere along the traditional project logistics chain.

Project assumptions, constraints, and underlying management algorithms, like those used in AI-enabled project management, must be evaluated to ensure they reflect the challenged location of the project. This means looking deeper than normal into productivity challenges and rethinking the sequence of construction and increasing resilience in project execution methodologies and schedules to reflect the increased potential for environmental or supply chain logistical disruptions.

The overarching management challenges in location-challenged projects revolve around ready access to labor and the productivity challenges that management and the project face in these difficult environments; often longer but certainly more difficult supply chains with greater potential for logistical constraints or disruption from one or more location factors; and operating environments for equipment which may be well outside traditional operating envelopes.

Project Management

- Third party deliverables integrated into master schedule
- Location factor related constraints require particular attention and so must be closely tracked and the associated potential for constraint coupling[3] closely monitored. These constraints are those not traditionally present (and therefore not typically tracked) in non-location challenged projects. (Example: diurnal and seasonal variations for access by different draft vessels, but in the extreme.)
- AI-enabled project management[4] systems must reflect training data with comparable location factors. Typical training data will typically not parse the data set for location-challenged projects, resulting in predictive algorithms that do not reflect the special project management challenges of location-challenged projects.
- Minimize project execution and schedule precedence in project execution plans and master schedule, when possible, given the greater exposures created by a more highly constrained logistical chain or access to onsite resources to recover from schedule slippages.
- Recognize that increased granularity in planning and scheduling is required in location-challenged projects
    - Task mobilization, readiness,and demobilization warrant special attention. Planning and preparation must be robust since the opportunity for recovery from false starts or inadequate planning is limited.
- Ensure scope[5] completely reflects location specific challenges and work opportunities.

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[3] Executive Insight, Coupling in Large Complex Projects
[4] Executive Insight, Verification & Validation of Project Management AI
[5] Executive Insight, Know What You are Trying to Accomplish – The Primacy of the Scope Baseline

- Timely project startup[6] is essential for location-challenged projects in tight labor markets.
- Start staff recruitment should occur as early as possible, recognizing the timeframes needed to staff remote locations.
- Enhanced cross-cultural training should be established to ensure excellent staff morale (productivity factor) and teamwork.
- High-quality staff accommodations and amenities are a must for a location-challenged project workforce.

Project Services

- Elements of project controls will be based at other locations (for example, the mod yard, prefab facility, and major suppliers).
- Construction preassembly increasingly takes place away from the final plant location.
- Assess the anticipated business risks associated with executing the project in multiple intermediate locations (mod yard, prefab facility).
- Development of relevant and applicable progress measurement is increasingly important, for example, out-of-sequence loads to a zero lay down area urban site (impacts sequence of construction) or construction delays in creating an environmentally controlled workspace to allow construction to continue during weather extremes.
- Augmented supplier quality assurance is needed, given the more limited accessibility to the project site to correct deficiencies.

Systems & Tools

- Project systems and management should be stood up fully during FEL (front-end loading). Delayed stand up of onsite document management systems (drawings, purchase orders) threaten efficient execution in this more constrained environment and are more difficult to recover from. Similarly, inadequate or delayed material tracking increases the likelihood of improper storage of environmentally sensitive materials or equipment.
- Coordination of delivery of materials to individual modules and multiple construction sites increases the importance of the material management function.

Startup

- Startup readiness risk assessment and planning should start at the outset of the project.
- Strategies for vertical launch (highly integrated on-site acceptance testing, performance and operating procedure validation, pre-commissioning and commissioning, and vendor training for accelerated startup of the facility) must be assessed and supporting efforts identified early in the project execution process.

[6] Executive Insight, Project Startup

2. Engineering

The design of location-challenged projects changes from traditional projects in several fundamental ways. First, the design parameters and material specifications traditionally used must all be re-examined. Temperature extremes may require the specification of heating or cooling blankets on mass concrete pours. Poor quality local water supplies may require pre-treatment of water used in various construction operations with requirements beyond what would be normally be considered.

The anticipated difficulties in on-site construction must be recognized and additional considerations given to logical system interface points to manage the myriad of challenges along the logistical chain, including possible extremes of load limits and shipping envelopes.

Design must pay special attention to simplifying the supply chain and erection and ensuring that appropriate means and methods will work in the project environment.

Front End Loading (FEL)

- Utilize a strong construction basis of design[7].
- Maximize manual construction performed in protected locations (dynamic air shelter; protection from Artic wind; shade) through careful layout during FEL.
- Artic plant valves should be located on the south side of plant.
- High quality welding should be performed, to the extent possible, in a controlled environment.
- Controls and instrumentation should be designed to be plug and play installation on prefabricated assemblies.
- Be aware of a modified sequence of activities that modularization and development of strategic supplier relationships require.
- Use readily produced, standard member sizes in program-wide steel design.
- Specify standardized connection details, bolt sizes, and tools.
- Develop a dedicated module yard.
- Engineering activities should be focused on maximizing standardization[8] and modularization.
- Provide temporary floating "dormitory" facilities at ports to provide nearby housing for required labor force when onshore options are limited or labor will be seasonally constrained or require surges during certain periods.
- Include strategic suppliers into the FEL process[9].
- Design activities should be guided by the principle of facilitating project execution[10] while recognizing the specific location challenges the project will face. Examples include a degree of pre-assembly that would not be economical on a less location-challenged project or the incorporation of permanent platforms in facility design to eliminate the need for temporary scaffolding and improve worker safety during construction in extreme environments.

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[7] Executive Insight, Business Basis of Design
[8] Executive Insight, Nuts and Bolts of Engineering and Construction
[9] Executive Insight, Procurement Management in Large Complex Programs
[10] Executive Insight, Improving Large Project Delivery

- Common layouts that allow conveyance systems (conveyors; select piping) to be standardized to a high degree.
- Individual modules should include MCCs (motor control centers) for their systems.
- Utilize a temporary modular wharf (or roll-on, roll-off dock facility) for construction materials if ports are constrained.
- FEL process may be compressed in select incidences, recognizing overall project schedule impacts may be created by specific location factors. The quality of the FEL process must be maintained.

Engineering

- Deliver by utilizing modularization and achieve a higher degree of preassembly on non-module portions of the facility.
- Protect design integrity through additional quality control, recognizing the significant project execution impact.
- Modularized designs will utilize BIM (building information modeling).
- Focus on optimizing project execution, not project design.
- Identify opportunities for preassembly.
- Reduce the number of items of supply through standardization at the component level.

3. Procurement

Procurement in location-challenged projects must recognize the particular environmental and logistical challenges the project will face. Sourcing of indigenous materials may be highly constrained such that even routine construction materials may not be available in either the quantity or quality required. Packaging of materials must account for any environmental extremes as well since any shipping related forces will likely be encountered. In some environments, extremes of dust and moisture may also encountered.

The bottom line: traditional procurement specifications may have to be modified from more generic guidance to specific location-sensitive requirements. Such guidance needs to be provided as part of procurement specifications so that any challenges that may arise can be identified early and resolved.

- Obtain significant project leverage by having early involvement of key suppliers and partners.
- Programmatic supply contracts (known as supplier relationship agreements or SRAs) should be used for strategic suppliers.
- Specify shipping and packaging early to reduce the overall waste stream (logistic chain load) and mixed material packaging.
- Specify packaging for the location-specific conditions to be encountered.
- Integrate major vendor schedules into the master schedule.
- AI-enabled supply chain management aids in sequencing tight logistics flows.

- Increase the focus on construction materials inventory management[11] (cost factor) and spare part and supply adequacy (time factor).
  - SKU (Stock Keeping Unit) management has proven to be effective.
- Augment shop inspection and testing to minimize field defects that then require remediation.

Logistics

- Extend the logistics role into major items of supply to maximize efficiency of the logistics chain.
- Evaluate and reinforce principal logistics paths.
- Use Antonov® [12] (or other large cargo aircraft) for schedule-sensitive, large/heavy equipment items.
- Use a prefabricated wharf for construction materials.

4. Construction

Location-challenged projects impact all aspects of project execution. These type projects may require significant modifications to traditional means and methods or the development of completely new ones. In select instances, such new means and methods have resulted in the development and building of new construction equipment.

A key question that must be addressed at the outset of the project is: What *must* be constructed on-site versus what *can* be prefabricated off-site in a more productive location? The answer is best found by beginning with the development of a *construction* basis of design that, together with the more traditional basis of design, will then guide all design development activities. While the use of a construction basis of design is good practice on all large complex project, it takes on added importance in location-challenged projects due to the numerous challenges to be faced.

Preassembly opportunities

- Precast underground duct banks
- Precast electrical and telecom pull boxes
- Maximize steel fabrication to complete assemblies (stair towers, access platforms)
- Pipe support, electrical/instrumentation stanchions all prefabricated and assembled
- Tanks that are shop built
- Prefab electrical vaults, telecoms buildings, switchgear substations, and control rooms
- Standardized electrical vault cable tray runs and preassemble (or include in modules as appropriate)
- Underground pipes spooled to 80-foot lengths, coated and tested
- Precast concrete sumps and pipe trenches

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[11] Executive Insight, Inventories – A Key EPC Consideration for Achieving Capital Efficiency
[12] Ukrainian heavy lift aircraft manufacturer; largest heavy lift plane in the world.

- Maximize size of vendor skids to include all piping, electrical, and controls
- Preassemble any overhead cranes not incorporated in modules
- All remote pumps mounted on common skids and pre-piped with all controls
- Precast road crossings for pipe or cable
- Warehouse and workshop as fold-away type buildings with internal frame for overhead crane
- Camp buildings fully modular including mess hall
- Precast and preassemble any haul road bridges required
- Precast road pavers
- Water treatment skids
- Tilt-up construction for any electrical fire separation walls
- Precast any temporary building foundations
- Conveyors completely preassembled including cable trays, walks, ladders railings
- Conveyor belts fabricated in largest transportable sections
- Temporary power, skid mounted
- Concrete cooling or blankets for large pours
- Special (insulating) foundations for cold weather construction facilities

Modules

- Maximize work-hours (vs tons) performed in a less location-challenged module yard
- Pre-install cables in modules and incorporate cable for home runs

Construction Facilities and Equipment

- Dynamic air shelters to provide rapid protection against extreme thermal, precipitation, and wind conditions
    - Controlled construction environments for welding and preassembly completion with controls components and instrumentation
    - Warehousing
    - Maintenance
    - Dining and break facilities
    - Early site mobilization in advance of normal construction season
- Micro grid to support dynamic dispatch and optimization of power on a multi-diesel generator site to reduce site-wide diesel consumption
- 3D printing of critical parts that are likely to fail due to location factors
- Use of SPMTs (self-propelled modular transporters) for modules, with appropriate traction
- Early assessment and reinforcement/ improvement of major logistics paths
- Emphasize preventative maintenance
    - Special attention to fuels, fills, and filters
    - Air vs. water cleaning to reduce water consumption
- Water collection and reuse
- Water storage bladders

- Fuel storage bladders
- Selective use of saline or brackish water in concrete for temporary construction

Construction Information and Technology

- Digital twins created in BIM to facilitate construction simulation
- Laser scans to record existing and as-built conditions and reconcile with digital twins
- Videos that are enabled with visual AI to assess safety risks, especially as they relate to location-specific attributes
- LIDAR (light detection and ranging) to identify buried structures and utilities (brownfield construction)
- Drones to track and record construction in real time and identify heat signatures of tracked workers (recognized as belonging to current work activities) (GPS or RFID) or workers not otherwise identified (unknown as to whether scheduled to be currently on-site and active or lacking any required tracking signals)

Construction Management

- Increased emphasis on workface planning

Summary

Large complex projects require a degree of management and granularity not often found in more traditionally sized projects. Often these projects, because of their scale, are in location-challenged settings. These may range from the North Slope of Alaska to the Outback of Australia to the urban core of major cities around the world.

These location challenges are often first reflected in estimate and budget development that is based on factoring or adjusting estimates or actual costs from similar projects in order to establish a budget for a new project. While these estimating and budgeting approaches can be a useful for many projects, this technique breaks down as scale and complexity grow in nonlinear ways. Large complex projects located in more extreme environments are further challenged to find relevant exemplars because of the numerous location factors touched upon in the descriptions that have been presented here.

This Executive Insight has provided a comparison of a half dozen location-challenged projects. Relevant strategies and tactics across this group have been identified for the reader. These strategies move well beyond developing reliable estimates and schedules. The depth that has been described here examines how management, engineering, procurement, and construction change, all resulting from the location factors that take on a more prominent role in project planning and execution in large, complex, location-challenged projects.

About the Author

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