PROJECT SCHEDULING AND RISK MANAGEMENT

Schedule Risk Analysis and Recovery Planning for Large-Scale Entertainment Projects in Saudi Arabia

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Abstract

Large entertainment developments combine conventional building works with specialist equipment, controls integration, commissioning and operator mobilisation. A schedule can show physical progress while the activities required for a safe opening fall behind. This paper develops a schedule risk and recovery framework for Saudi entertainment projects through a structured narrative synthesis of Saudi construction delay research, project scheduling literature and professional guidance. It links the contractual baseline to a logic driven current forecast, then connects risk drivers and opening dependencies to specific recovery decisions. An illustrative network compares a delayed forecast with procurement acceleration, site resequencing and coordinated recovery. The example shows how a supplier intervention can move the critical path to utility readiness and how a larger recovery package can improve the likelihood of a target while leaving substantial residual exposure. The proposed approach preserves commissioning and acceptance requirements, assigns accountability for cross package handovers and retains auditable programme versions. Its contribution is a decision sequence that connects construction progress, milestone risk and operational readiness in the same planning process.

Keywords: Schedule risk analysis; recovery planning; entertainment construction; Saudi Vision 2030; critical path; commissioning

1 Introduction

1.1 Physical progress and opening readiness

The opening of an entertainment destination depends on several delivery teams meeting at a common operational milestone. The principal contractor can progress the structure and envelope while an attraction supplier waits for approved interfaces, factory testing or a confirmed installation window. An operator may need a controlled area for staff training, stable system configurations for rehearsal and verified emergency procedures before visitors can enter. Each team can report satisfactory progress against its own package while the overall opening date becomes increasingly difficult to achieve. The planning problem is therefore to identify which missing condition controls the next handover, how much flexibility remains and which intervention can change the outcome.

1.2 Saudi entertainment development

Saudi Vision 2030 places entertainment and recreational opportunities within the broader quality of life agenda. Publicly documented projects, including the SEVEN destination in Almadinah, illustrate the coexistence of building construction, multiple visitor experiences and operational preparation at a single site. Their relevance here is the variety of physical and organisational interfaces they bring together. The paper uses Saudi entertainment development as the industry setting and develops a

hypothetical network independent of any named facility. The duration assumptions, cost allowances and simulation results belong to that network.

Saudi construction studies have documented recurring issues across design, finance, procurement, labour and decision making. Those findings are useful prompts for a risk workshop. Their relative rankings can differ according to contract structure, work type and respondent group, so the recovery team should connect each issue to local evidence and to a current milestone before prioritising it. A general concern about late materials becomes actionable when the planning team identifies the release date, factory slot, delivery route and installation dependency for a specific package.

2 Research purpose and methodology

2.1 Questions and analytical scope

The paper addresses three questions. First, which checks make an entertainment project schedule suitable for identifying risk to opening? Second, how can the team compare recovery actions when the controlling path changes between scenarios? Third, what evidence and governance arrangements are needed to carry a recovery decision from the planning office to field execution? The analysis focuses on the delivery period from detailed design and specialist procurement to commissioning, owner acceptance and opening readiness. The unit of analysis is the integrated programme for a single destination, with package schedules and near term work plans supplying supporting detail.

2.2 Source selection and synthesis

The study uses a structured narrative review supported by a worked example. Source selection focused on Saudi construction delay studies, foundational work on network scheduling and uncertainty, evidence on progress and forecasting measures, and professional guidance on schedule assessment, commissioning and delay analysis. Searches used combinations of Saudi construction delays, critical path, schedule risk analysis, project schedule recovery, time cost tradeoff, earned value forecasting and commissioning. Public programme and project information established the sector context. Sources were selected for their contribution to a practical planning decision or to an assumption that warranted explicit treatment.

The synthesis classified evidence by four decisions: whether the schedule represents the remaining work, which risks threaten a specified milestone, which actions are feasible and how their execution will be verified. Field studies informed the catalogue of potential drivers. Scheduling and production control sources informed the logic and short term planning methods. Guidance on commissioning and records informed acceptance and change control. The illustrative analysis tests internal consistency across the decisions. It does not estimate the prevalence of delay or measure the effect of any intervention on a completed Saudi project.

3 Building a reliable schedule model

3.1 Baseline and status integrity

The accepted baseline should cover design release, procurement, construction, systems installation, testing, turnover and operator preparation at a level appropriate to each package. The current schedule should reuse traceable activity identifiers, align on a defined status date and show approved scope changes against the relevant programme version. A schedule basis document records calen-

dars, production assumptions, exclusions, delivery commitments and the meaning of each milestone. During recovery it should also state which assumptions were changed, who supplied them and how the new durations will be tested in the field.

At each reporting cut, the planner reconciles actual starts and finishes with completion records and asks package owners to confirm remaining durations. A progress percentage calculated from an invoice may reflect a billing milestone with little relation to the number of workdays remaining. Equipment described as delivered may be at a freight terminal, at the site gate or physically installed. A schedule should distinguish those events when they have different successors. The same discipline applies to approvals, which may be submitted, returned with comments, technically accepted or fully released for fabrication. Procurement and site teams need the same definitions to avoid premature commitments.

3.2 Logic, constraints and calendars

The planner checks that significant activities have defensible predecessors and successors, with intentional exceptions for the endpoints of the network. Hard constraints should be reviewed because they can conceal the effect of a late predecessor or produce float that is difficult to interpret. Waiting periods that represent real work or external decisions should be visible where practical. A calendar should reflect the actual operating pattern of the responsible organisation. A factory may work different days from the site, and a witness team may be available only during a planned window. Duration estimates and date arithmetic should account for those differences.

Out of sequence work deserves a specific review. A crew may start in an available area before its predecessor is complete across the whole building. Treating the entire successor as free to continue can overstate future progress. Retaining an artificial restraint across the whole project can also understate what the crew can deliver. Splitting activities by meaningful zones and specifying partial handovers gives the programme a factual basis for modelling both progress and remaining limits. Each split should correspond to a field boundary, a responsible person and a usable completion record.

3.3 Critical and near critical paths

The team traces driving relationships backwards from the selected opening milestone and repeats the exercise for earlier gates such as permanent energisation, ready for integrated testing and operator acceptance. An activity may be critical to a particular gate even when it has room against the final completion date. Total float estimates flexibility under the current model and can change when calendars, constraints or logic change. Reviewing the longest path alongside float values helps expose situations in which a date constraint masks the controlling sequence. The planner should check that the apparent path is operationally credible before it drives an acceleration decision.

Near critical paths warrant monitoring because a modest increase in duration can make one of them control the same successor. At a merge where the site, supplier and facilities team all contribute prerequisites, the downstream activity starts only when the latest branch is ready. Individual packages can have favorable expected finish dates while the combined gate has a lower probability of meeting its target. Near critical work should therefore be described in terms of the local milestone it can threaten and the remaining time available to respond.

4 Analysing schedule risk

4.1 Turning risks into testable assumptions

A useful risk statement specifies a cause, an event and a milestone consequence. For example, delayed approval of load specifications could postpone release to manufacture and prevent installation before the integrated test window. The approval lead may monitor unresolved comments, while the supplier verifies manufacturing slot availability and the planner shows the affected path. This distribution of responsibility helps the risk owner act at the earliest controllable point. It also gives management a clear choice when a risk crosses package boundaries and requires a decision beyond the owner's authority.

Routine variation and discrete events require different assumptions. Installation productivity may vary within a plausible range on every run of a simulation. A failed factory acceptance test is an event that occurs in some runs and, when it occurs, adds rework and potentially a missed release window. Independent sampling can understate joint exposure when one design decision affects multiple packages. Such effects can be represented through common risks or defensible correlations. The team should document the mechanism behind any dependence and examine sensitivity before it draws conclusions from model output.

4.2 Estimation and interpretation

A risk workshop should ask discipline leads for a credible favourable value, a central value and an adverse value for selected remaining durations. Supplier correspondence, actual production records, inspection history and experienced judgement can be used to establish the ranges. For each estimate, the team records the assumed number of crews, work fronts, access hours and technical prerequisites. Three point estimates can be represented using a triangular distribution when information is limited. More detailed distributions require a defensible basis, particularly where long delays depend on missed bookings, redesign or repeat testing.

A simulation samples the activity durations and discrete events and recalculates the schedule for each draw. The resulting distribution allows the team to report the modelled likelihood of achieving an agreed target along with percentiles such as P50 and P80. P80 is the duration at or below which approximately eighty percent of simulated outcomes fall, given the stated inputs. The decision to adopt that confidence level depends on the cost of late delivery, available contingency and the commitments attached to the milestone. A percentile is conditional on the accuracy of the network and assumptions, and should be interpreted together with data quality and sensitivity.

4.3 Measuring early warning signals

Weekly controls should track measures that allow timely action. Relevant signals include approval age, outstanding release conditions, supplier slot confirmation, the number of unready work fronts and the gap between a confirmed witness appointment and the forecast readiness date. For a milestone with several predecessors, a simple readiness checklist can show the last forecast prerequisite and the responsible lead. Changes in that lead or a repeated decline in available float should prompt a discussion about alternate work sequences and independent verification of dates.

Earned value, earned schedule and look ahead measures add context to the network forecast. Earned value summarises progress in budget terms and can show a developing gap relative to plan. Earned schedule translates that progress into time based measures using the baseline profile. Their outputs

are sensitive to the way work is weighted and to network structure. A package with inexpensive but essential integration can therefore require intervention despite healthy aggregate indicators. The dashboard should show the selected milestone forecast, the remaining driving work and the constraints on the next executable tasks beside any summary metric.

5 Designing a recovery programme

5.1 Evaluating feasible interventions

Common responses include reassignment of labour, targeted overtime, alternate delivery arrangements, parallel work by zone, earlier technical decisions and selective changes in sequencing. The planner first estimates the effect on the driving chain and checks whether the action creates another dependency. Expediting an attraction shipment has limited value if the installation team cannot access the area, the storage condition is unsuitable or required utilities have yet to be energised. The action can still have value if it reduces adverse delivery outcomes, but that benefit should be visible in the risk comparison.

Resource based acceleration requires a credible plan for labour, supervision, equipment and site access. Adding crews in a confined area can reduce productivity or interfere with other packages. Working a second shift changes supervision, logistics and inspection needs. An estimate should identify actual work fronts and distinguish incremental production capacity from additional expenditure. Where parallel execution relies on incomplete design or partial system readiness, the team should identify the point at which rework becomes likely and confirm which technical decisions must precede release.

5.2 Protecting acceptance and operational readiness

The recovery programme should preserve the approved sequence of tests and verification requirements unless the competent technical and operational leads approve a technically equivalent approach. Factory testing, site testing, integrated commissioning and operator rehearsal establish different conditions. Earlier completion of a factory test may free shipment without demonstrating performance once the equipment is installed. Integrated testing may depend on fire and life safety interfaces, stable power, communications and configuration baselines. Operator readiness can depend on documentation, training, spare parts and a reliable process for closing discrepancies.

Specific records make each gate usable. The planner should identify who can sign a release and what evidence must be present. A zone handover may need an access plan, closure of blocking defects, physical isolation and confirmation that subsequent work can proceed safely. If management proposes a phased opening, the team should assess whether the relevant areas and systems can operate independently and whether emergency routes, staffing and operational controls support the proposed scope. The result belongs in the scenario schedule as a distinct milestone and set of prerequisites.

5.3 Comparing options and preserving records

Each scenario should start from the same status date, completed work and agreed scope, with the changes to logic, duration, resources or cost documented. The commercial lead estimates incremental direct spending and identifies consequential effects such as rework exposure, longer supervision or storage. The planner calculates the expected change in the driving path and the probability of

achieving the relevant gate where reasonable evidence supports simulation. Management can then assess whether the extra confidence justifies the premium and whether a further action or contingency is needed.

The accepted baseline, the statused forecast and each approved recovery scenario serve different purposes and should remain identifiable. Records of instructions, notices, releases, priorities and daily production can support both future analysis and an accurate account of the work. A recovery forecast should specify the commitments assumed for the next reporting period without silently changing previously reported dates or quantities. Where a cause of delay or a contractual entitlement is disputed, the schedule should retain the relevant factual chronology and the assumptions used to model each position.

6 Worked entertainment project example

6.1 Network and assumptions

The example begins at a common status date measured as day zero. Two activities start in parallel. The specialist equipment path consists of design release, factory completion and delivery, followed by installation. The site path consists of utility readiness, followed by local site readiness. Both paths must finish before integrated commissioning begins. Operator rehearsal and acceptance follow commissioning. All durations are remaining working days on a common illustrative calendar. The target is eighty working days, and all scenarios retain the same testing and rehearsal scope.

Under the current most likely durations, the supplier path takes sixty days and the site path takes fifty six. Fifteen days of commissioning and ten days of rehearsal and acceptance put the deterministic forecast at eighty five days. Supplier acceleration reduces the factory and delivery phase by eight days, moving the controlling path to site readiness. Site resequencing reduces local site readiness by eight days and accelerates installation by five days through earlier access to an independent work front. The coordinated option applies both interventions. Its deterministic forecast is seventy three days because the shortened site branch takes forty eight days and controls the combined gate.

The central estimates form the comparison in Table 1. Direct premiums are illustrative and quoted in thousands of Saudi riyals. Procurement acceleration is priced at 240 thousand, site resequencing at 180 thousand and the combined package at 420 thousand. The example assumes no discount or interaction in direct cost. An actual estimate would consider the supplier quotation, productivity allowances, cash exposure and budget approval. It would also check whether site changes require an additional design or temporary works review.

Table 1. Comparison of recovery options in the illustrative network.

Scenario	Modal path	Modal finish (days)	P50 (days)	P80 (days)	Direct premium (SAR 000s)
Current forecast	Supplier	85	92.3	97.5	0
Supplier acceleration	Site	81	88.3	92.8	240
Site resequencing	Supplier	80	86.8	92.1	180
Coordinated recovery	Site	73	81.9	86.6	420

The modal finish uses the most likely duration for each activity. P50 and P80 are simulated completion percentiles.

6.2 Simulated exposure and option selection

For each activity the model uses a triangular distribution. The low and high estimates for design release are eight and eighteen days, with a mode of twelve. For factory completion and delivery they are twenty four, forty eight and thirty four days for the current strategy, expressed here as low, high and mode. Acceleration changes the corresponding figures to nineteen, forty and twenty six. Installation uses ten, twenty two and fourteen days under the current strategy, or six, sixteen and nine with resequencing. Utility readiness uses nineteen, thirty six and twenty six days. Local site readiness uses twenty four, forty and thirty days, or seventeen, thirty three and twenty two after resequencing. Commissioning uses twelve, twenty four and fifteen days. Rehearsal and acceptance use eight, fifteen and ten days.

The simulation uses twenty thousand replications and a common set of random draws for corresponding activities across the four scenarios. Within each scenario the activity durations are independent. This simplified assumption helps isolate the effects of the interventions. It omits joint exposure from events such as common utility disruption, changes affecting several packages and missed testing appointments. In each draw the model takes the later of the supplier and site path finish times, then adds commissioning and rehearsal. Figure 1 shows the resulting cumulative completion distributions.

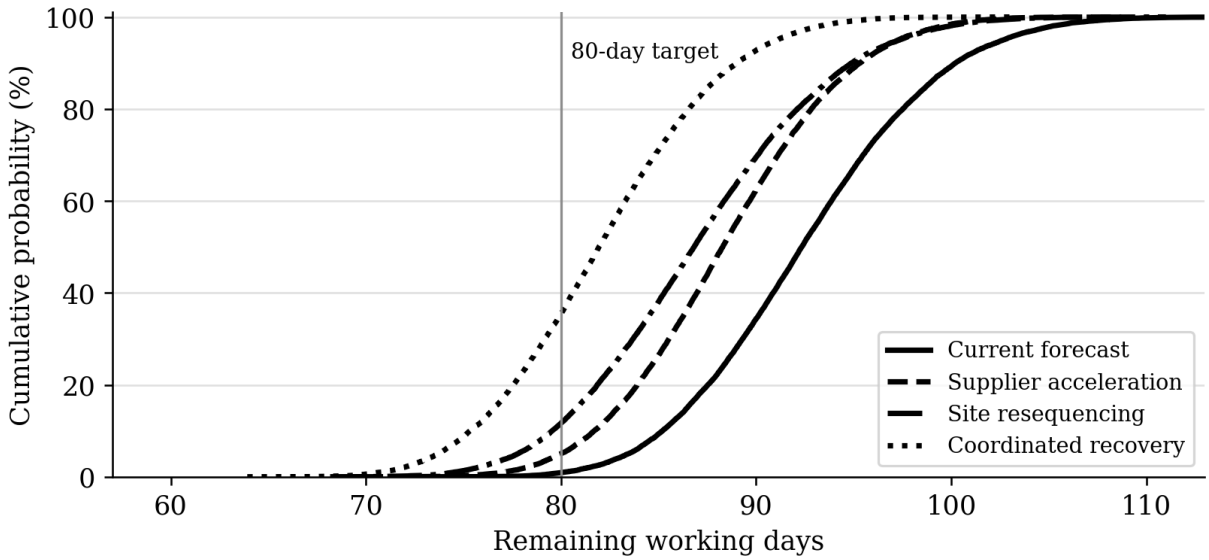

Figure 1. Simulated cumulative completion probability by recovery option. Illustrative simulation using the assumptions given under 'Simulated exposure and option selection'.

The simulation illustrates the difference between the schedule built from modal durations and the probability of meeting the target. Many sampled activities have greater exposure on the adverse side of their ranges. The later of two uncertain branches controls commissioning, further affecting the distribution. Figure 2 therefore compares the options using target achievement probability. Procurement acceleration and site resequencing each improve the forecast, while the coordinated option creates a meaningful gain by treating both sides of the commissioning gate. The model still leaves residual risk that should be disclosed to the decision maker.

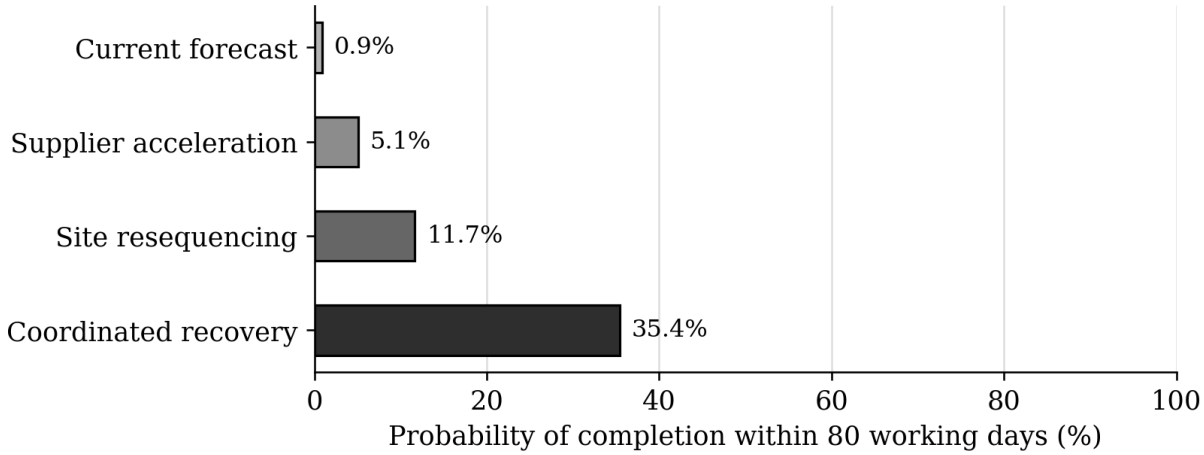

Figure 2. Simulated probability of meeting the 80-day target. Illustrative simulation using the assumptions given under 'Simulated exposure and option selection'.

6.3 Learning from scenario results

The current forecast draws attention to the factory and delivery phase, but testing the supplier intervention alone shows that local site readiness then controls the modal schedule. This is the practical reason to calculate a fresh path after each schedule change. The greatest movement in an individual activity does not necessarily translate into the greatest gain at opening. The cost of an intervention should therefore be assessed against the improvement at the milestone and the flexibility it creates on related paths.

7 Implementation and evaluation

7.1 Integrating programme and look ahead planning

An integrated schedule identifies which work matters to the milestone. A short term plan identifies which work is ready for execution. The weekly coordination meeting should translate upcoming activities into work packs with confirmed access, labour, material, information and inspection coverage. A constraint register assigns a due date and a named owner to each missing prerequisite. The planner feeds unresolved constraints back into the current programme whenever they threaten a relevant handover, using estimated resolution dates provided by the responsible leads.

7.2 Accountability and decision cadence

The lead planner owns the integrity of the integrated model and the traceability of its versions at each status date. Package managers own the realism of remaining durations and the availability of work fronts. Procurement owners verify release and delivery evidence. The commissioning lead confirms test prerequisites and resources, and the operator confirms staffing and readiness arrangements. The owner's representative or designated sponsor decides whether to accept a change in spending, scope or milestone confidence. Clear ownership is especially useful when an interface is visible in the schedule but neither package manager has authority to resolve it alone.

Recovery actions should have indicators tied to execution. A delivery intervention may be tracked through approval closure, written slot confirmation, witnessed factory tests and transport booking. A site intervention may depend on released drawings, workforce mobilised and signed access for an independent zone. Management should review these indicators before the action reaches its latest

viable decision date. If progress falls behind, the team can verify the remaining benefit, test an alternative and bring forward a decision while there is still time to act.

7.3 Evaluating effectiveness in practice

Validation would ideally use archived programme snapshots from several projects with comparable operational gates. The analyst would reconstruct the forecast known at each status date, record the dates at which decisions and constraints became visible, and compare forecast distributions against realised outcomes. A forecast log should distinguish changes in scope, logic and estimation. That enables assessment of whether a better forecast resulted from a more accurate model, fresher information or an actual change in the work.

8 Limitations and conclusion

8.1 Limitations and future work

The review combines evidence from Saudi construction and general project controls. Several delay studies use perceptions or samples from public construction, and their rankings should be interpreted in the context of those studies. Entertainment projects introduce specific risks around specialist attractions, operator turnover and integrated commissioning. How often these risks occur and how strongly they influence different types of facilities requires access to observations across a portfolio. Actual dependencies and calendars may be more complex than those in the worked example, especially where several zones open on different dates.

The simulation is a decision illustration based on synthetic durations, independent sampling and a simple network. Its results describe that network and can be reproduced from the stated assumptions. Future work could compare the predictive performance of models that include common causes, time restricted acceptance windows and resource limits. A useful extension would link labour and supplier commitments to schedule and cost risk in the same analysis and test whether better schedule readiness measures predict fewer last minute changes to the opening plan.

8.2 Conclusion

Effective recovery planning begins by defining the actual conditions for opening and tracing them through a credible programme. The approach developed here brings together baseline checks, confirmed status, path analysis, targeted uncertainty modelling and verification of recovery commitments. It gives management a way to judge the effect of a proposed intervention after allowing for new bottlenecks, unavoidable acceptance obligations and the residual risk of a missed date.

The worked example shows that a supplier intervention can improve delivery and still leave another branch controlling commissioning. Coordinated action gives a larger improvement because the analysis follows both readiness branches to their merge. For Saudi entertainment developments, the proposed method gives the planner, specialist suppliers and operator a common basis for reviewing dates and releasing work. Its application depends on reliable progress data, explicit ownership of interfaces and management decisions made while recovery options remain feasible.

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