IMPROVING THE ODDS OF PROGRAM SUCCESS: AN ADAPTIVE DEVELOPMENT MODEL

This article explores how the application of flexibility principles within a systems integration (SI) framework fosters resilience to the impacts of destabilizing events, preparing programs to respond to uncertainty more effectively.

The Achilles heel of many major infrastructure programs is dealing with uncertainty. Destabilizing events, very often politically or financially motivated, aggravate schedule and cost overruns that are so common in complex programs. It is widely recognized that attempting to address all foreseeable risks using conventional risk management analysis does not scale to major programs. Any attempt to fully capture all stakeholder requirements upfront are likely to produce disappointing results, as major rail programs are faced with high levels of uncertainty that undermine the value of such analysis.

A better approach is to invest in designing a development model that is optimized for managing programs through uncertainty. The following concepts can form an approach that positions programs to adapt to a changing and an emergent delivery environment: use of strategies such as employing a convergent design process that integrates the emerging design at all levels of the development, from operational functionality down to the supply chain; partitioning the system and project breakdown structure with respect to uncertainty and susceptibility to change; and factoring in technical margins.

Current Deficiency

The classical approach to major infrastructure programs is to first capture and analyze the business objectives and stakeholder needs then complete a system-level design and then progress the subsystem design sequentially. This top-down approach has resulted in a historically poor delivery record.

Two factors have routinely brought about program failure: a development strategy that makes the program vulnerable to early scope lock-in; and design fixity that creates a delivery environment inhospitable to change and uncertainty. Such an approach usually leads to substandard engineering practice—one that requires additional engineering work at some point in the lifecycle to resolve latent issues.

The preponderance of this approach stems from the unjustified belief that fixing requirements early (as opposed to building in adaptability) will help build a robust cost envelope and from the ill-conceived notion that concurrent design is a suboptimal methodology with out-of-stage work increasing the risk of downstream rework.

Hudson Bergen Light Rail Transit, United States

Currently in major programs, multiple suppliers are appointed at differing stages, all working to different design maturities. This practice poses the challenge of keeping all suppliers in technical synchronization where design information must be exchanged at differing maturities. A typical problem would be the civil engineering contractors needing to dimension an equipment room when the equipment it will house has not yet been designed.

The Four Flexibility Principles

The long planning horizons, short technology refresh rates and uncertainty triggered by political interference demand a system design that can swiftly adapt in the face of change. Experience has shown that four main flexibility principles can effectively shape the development model at the front end of the program lifecycle to better respond to uncertainty:

- Apply agile methodology
- Preserve options
- Control design margins to protect the capability and performance envelope
- Build resilient architecture—open, flexible and extensible properties

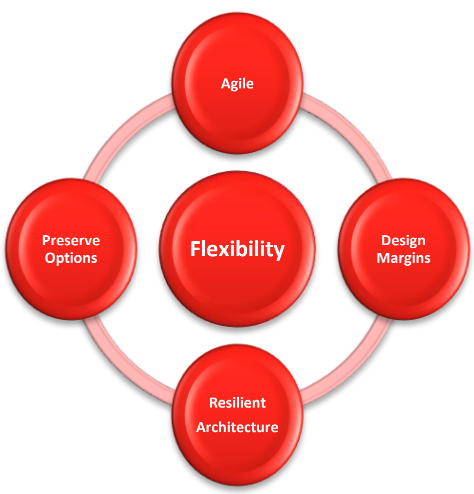

Figure 1 - Four Flexibility Principles

Agile Methodology

In the software development field, agile development methodologies have long been used successfully for fast incremental delivery of value. At first, it might appear that agile practices would have no place in major infrastructure programs where construction features heavily; but, in actuality, the front end of the program lifecycle during the early design stages is well suited to agile methods. If all levels of the design are advanced simultaneously with fast learning cycles, as shown in Figure 2, then the design will converge toward a solution that is better aligned to the business objectives, and the overall design development duration will be reduced when compared to the traditional sequential development model. The purpose of this approach is to advance all levels of development concurrently to arrive at an integrated design in a shorter period of time and thereby deliver value sooner.

The use of fast feedback coupled with advancing the design at all levels (sponsor, system and subsystem) will help expose issues with the technical requirements, such as deliverability, maintainability and affordability. This concurrent design approach allows the resolution of issues "on-the-fly" and reduces the likelihood of uncertainty flowing downstream. Moreover, the VUCA (volatility, uncertainty, complexity, ambiguity) characteristics for each capability can be assessed in a holistic way to support a system design that protects against future change and rework.

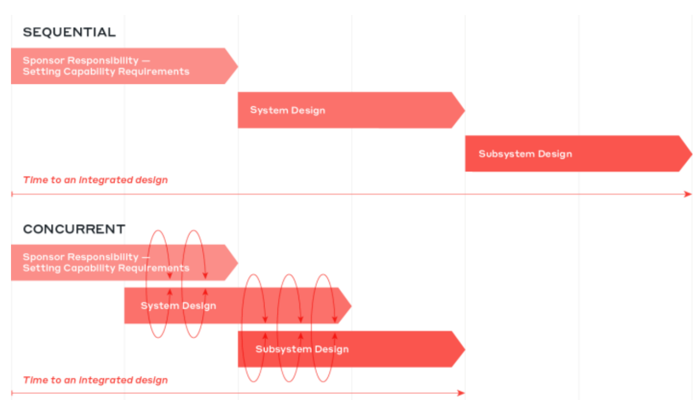

Figure 2 - Development Model Concept (Concurrent vs Sequential)

The concurrent design approach promotes tighter alignment between the business objectives and technical solution by starting the system design early in the program lifecycle, balancing the system effectiveness against lifecycle costs. A model that blends the incremental capability delivery of the agile methodology coupled with the hard-gate reviews of the traditional waterfall lifecycle will retain a level of rigor necessary for complex system development.

Preserve Options

The design principle of preserving a broad set of options and progressively eliminating options as understanding improves can promote a more effective design. This approach runs counter to the prevalent approach of selecting technology and fixing requirements early in the lifecycle. Again, though the conventional approach is driven by a motivation to build a reliable cost envelope, in practice it builds an "order or magnitude" estimate that creates an illusion of stability masking the true level of uncertainty present. Any attempt to pick an "early winner" is likely to lead to a suboptimal outcome, as the sheer range of options coupled with the fast-paced nature of technology can quickly render such an early decision invalid. This tension can be lessened by using the reference class forecasting method in the early stages before refining the cost estimate once the design has matured. Of course, understanding when design decisions should be made is equally important to making the best-informed decision.

Large-scale programs that are delivered over decades are susceptible to committing to a design concept which specifies a particular technology or product too early in the lifecycle, leading to scope lock-in and creating a system design that is brittle and costly to change. Within the rail sector, the relatively fast technology of train control data transmission technologies coupled with the long useful lifetimes of the system demand that adaptive infrastructure is designed today—to accommodate the emergence of successor technologies such as 5G or LTE, and thus avoiding expensive retrofits.

> The WSP **SI:D[3]** framework includes processes and guidance to help program leaders develop a route map for shaping strategic decisions and their dependencies. The route map shows clear timing as to when decisions should be made—to avoid premature commitments to identified solutions that in reality lead to costly reversal.

Understand Design Margins

The identification and tracking of design margins—that is, budget reserve for key technical properties, such as space, bandwidth, speed, availability and how the margin is being utilized over the lifecycle, is essential to build resilience into the development, thus protecting the development from uncertainty.

The adoption of a margin philosophy where margin is progressively released to the supply chain can guard against risk by understanding performance thresholds and how margin is allocated across subsystems. The active tracking of design margins over the lifecycle can alert the design team when the performance measures are approaching unacceptable limits or when margins are driving excessive cost into the outturn cost. Actively building in wiggle room can help the development cope with change. For instance, the sponsor may request higher performance or a supplier may request a relaxation of a performance requirement.

Understanding the design margins concept will help program leaders ensure consistency in the level of detail among all the design parties and is therefore extremely important in applying the integrated development model. When allocating design margin, it is crucial to visualize using the system architecture how the subsystem margins contribute to the system-level margin. This practice provides an analytical approach to trading off margins across the system and helps the design team allocate more margin to a subsystem with low maturity and therefore increased risk.

For example, in high-speed rail schemes, the route alignment will be designed with a performance margin that aligns with the civil infrastructure. Such an approach provides operational advantages by permitting the line speed to increase up to the design limits to recover the timetabled service under degraded conditions.

Through the use of stakeholder discussions, design reviews and working group meetings, it is possible to actively measure the design margin against program schedule throughout the program lifecycle. The measurement of performance thresholds and targets at the overall system level will support the program management team in effective program planning, risk management and change control management. The performance measures can be either applied vertically against the subsystem level to show which contracts are under-delivering or over-delivering, or they can be applied horizontally to show if the system design maturity is behind or ahead of the program schedule. In this way, application of these measures helps the program identify risk as early as possible and implement a recovery strategy.

Resilient System Architecture

In infrastructure programs with very long lifecycles, it is not possible to predict every capability that a system must be designed for or to anticipate changing user needs and emergent technologies. The transportation sector has relied on a concept known as “passive provision” that attempts to safeguard against future changes to the design by building in additional design margin (such as space, performance, availability, or mass). The sector is witnessing a shift from this crude approach to something more systematic that considers the overall architectural health of the design. The high levels of complexity present within modern transportation systems requires a resilient system architecture that allows owners and operators of rail networks a clear and low-risk upgrade path many years beyond the original system design life.

By designing a system that is modular with a well-established standard, loosely coupled interfaces and architecture partitioned to minimize contractual boundaries, a more composable design is created. This focus helps the development team better understand the whole picture and minimize the risk of changes in one area of the system propagating throughout the system in unexpected ways.

The design of architecture that is inherently modular can come at higher upfront capital costs; however, such costs are often offset by the gains through simpler and less operationally intrusive mid-life upgrades and technology insertions. The use of open architecture principles, such as modular and standardized interface protocols, can improve the “upgradeability” of the system, enabling the introduction of additional capability many years into the future.

***

Delivering major infrastructure programs is inherently uncertain and difficult. Flexibility principles, hard-won over many decades by other sectors, such as manufacturing and automotive, can be harnessed to provide an adaptive development model and help insulate the program from uncertainty. Since the adoption of these principles requires considerable stakeholder buy-in when the stakes of failure are unacceptably high, there is a natural tendency for unfamiliar practice to be considered with tentative interest. Program leaders can create positive momentum by trialling flexibility practices in their programs.

This adaptive engineering approach is predicated on strong technical leadership at all levels of the program organization. Technical leaders must actively seek out, promote and embody flexibility within the engineering culture and foster a collaborative, inclusive culture where face-to-face communication is encouraged to keep the development effort as efficient as possible.

The application of the four flexibility principles can unleash the power of systems integration by helping technical leaders maintain a relentless focus on achieving operational capability, build in resilience and upgradability from the beginning, and actively look for opportunities to simplify the design and expose the true user requirements in an expedited way.

Author

Darren Grey, Associate
Systems Engineering and Integration, United Kingdom
Darren.Grey@wsp.com

Contributor

Yan He
Chief Engineer, Rail Systems Engineering, Canada
Yan.He@wsp.com

About WSP

As one of the world's leading professional services firms, WSP provides engineering and design services to clients in the Transportation & Infrastructure, Property & Buildings, Environment, Power & Energy, Resources and Industry sectors, as well as offering strategic advisory services. Our experts include engineers, advisors, technicians, scientists, architects, planners, surveyors and environmental specialists, as well as other design, program and construction management professionals. With approximately 49,000 talented people globally, we are uniquely positioned to deliver successful and sustainable projects, wherever our clients need us. wsp.com