Software Engineering Institute

Independent Assessment of the Commonwealth of Pennsylvania Unemployment Compensation Modernization System Program (UCMS)

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Executive Summary

The Unemployment Compensation Modernization System (UCMS) program was envisioned as the means to re-engineer business processes for delivery of unemployment insurance (UI) benefits to citizens, replace critical legacy information systems with new technology, and provide increased functionality to state employees, employers, and citizens. UCMS was planned to first implement a new information system technology infrastructure and then deliver new business functionality in three software applications releases: R-1 (case management and wage records), R-2 (employer tax), and R-3 (claims processing, payments, and appeals).

By industry standards, the UCMS is considered a large-scale project due to its complexity, size in software lines of custom developed code, and its cost. As of July 2013, the UCMS program will be 42 months behind the schedule set at contract award and based on the original contract price of $106.9 M, the Commonwealth has now dedicated funds approaching $170 M to the project. The Commonwealth issued no-cost contract extensions that expire on September 30, 2013 to allow time to further assess the program's status. The current DLI senior executive team has taken a hands-on and aggressive approach, beginning in 2011, in order to control and manage the UCMS project. In light of the situation, the current Secretary of DLI directed an independent assessment of the UCMS program to inform judgments about its future. This report presents the key findings and recommendations from this assessment and responds to DLI's key questions:

- Should DLI continue with UCMS?
- Can DLI operate, sustain, and evolve UCMS?
- What changes are necessary to solve the critical path issues?
- Are contractor and DLI resources sufficient to address these issues?

Context

The most critical element of the UCMS is Release 3 (R-3). R-3 must deliver the operational capability to process unemployment claims, calculate payments, and enable timely payments to eligible citizens of the Commonwealth who are out of work. R-3 must operationally perform these critical functions the "first time and every time" when deployed to be the sole information system supporting administration of the Commonwealth's Unemployment Insurance (UI) program. UCMS is therefore a mission critical system and R-3 must perform to a high degree of reliability, consistency, and accuracy for beneficiaries to receive timely payments and to enable DLI to have high confidence it can terminate operations of the legacy unemployment compensation information system.

The crux of the issue is that the UCMS R-3 software application has yet to demonstrate the mission critical capability to reliably, consistently, and accurately process unemployment claims, calculate payments, and enable payment to eligible citizens who are out of work. More importantly, there is no high confidence estimate for when the UCMS, as an integrated operational system, will demonstrate the level of performance necessary for DLI to justify a decision to approve its deployment as the sole Commonwealth UI enterprise information system.

Key Themes from the Assessment Findings

The assessment's key findings center around three themes that are summarized below: (1) quality of the system, (2) UCMS acquisition strategy and Contractor plans and assumptions, and (3) governance and program management. The specific assessment findings addressed in the assessment report appear in Figure 1 at the end of the Executive Summary. Two critical threads run through these three themes—risk and rebaselining (or restructuring).

In the context of system acquisition, risk refers to the probability of an event occurring and the consequences of this event impacting program (UCMS) performance goals and objectives within defined cost, schedule and performance constraints. Risk management is a continuous process accomplished throughout the system life cycle for identifying and making an assessment of the unknowns; developing mitigation options; selecting, planning, and implementing appropriate risk mitigations; and tracking the implementation to ensure successful risk reduction. Effective risk management is driven by leadership and management making risk an explicit consideration in organizational and program governance.[1]

The term rebaseline refers to restructuring the scope, content, and schedule of a program. Rebaselining is driven by decisions on the part of the customer (DLI) to first revise the goals, objectives, and outcome measures of the acquisition program. Subsequently the scope, content, and schedule of the program are realigned based on those decisions to achieve a higher confidence, lower risk approach.[2]

- **Quality of the system.** The term quality refers to the degree to which a system or software exhibits some combination of attributes or characteristics that have been explicitly defined and have value to the customer or user (DLI).[3] The UCMS solicitation did not specify a required set of attributes or particular quantitative system performance requirements. Rather, the solicitation requested bidders propose such criteria. The Contractor's proposed technical infrastructure (production and test environments) is in operation and the Contractor and DLI successfully implemented a planned upgrade of the UCMS infrastructure in February 2013. However, as DLI's OIT staff has assumed more responsibility for the UCMS test environments there are some issues that remain unresolved in DLI's view regarding why some processes work in the production environment, but not in the test environment. While the UCMS infrastructure is functioning, its performance limits are not known since the Contractor has not performed a UCMS stress test which is essential to provide critical planning information to DLI on the performance limits of the system. The UCMS infrastructure does have the inherent capabilities to be evolved and its operational performance can be tuned by DLI staff to address changing demands, data needs, interface impacts, and other factors.

  The Contractor's software development plan was based on using industry and company standards and practices. However, the discipline to execute these standards and practices eroded beginning early on in the program. In this environment, DLI accepted R-2 prematurely into production in March 2011 with known defects impacting performance. Material deficiencies continue to be discovered in R-2. These deficiencies include software defects, unresolved data conversion issues, and problems with batch processing operations.

DLI and the Contractor are at a stalemate over R-3 which is based on a significantly larger number and more complex set of business rules than R-2. This stalemate occurred because the DLI staff approved the Contractor's representation of business system requirements (in the form of use cases) without fully understanding what they were approving coupled with a lack of rigor and discipline in the Contractor's UCMS development and testing program. The result has been (1) a higher number of software defects than industry norms, (2) high code complexity which degrades testability, and (3) late discovery of missing business requirements.

The UCMS R-3 software has a significantly higher defect density than industry benchmarks. The vast majority of these (86 percent) are Severity Level 2 (serious failure) defects, indicating the persistence of systemic problems over a sustained period of time. Fully 50 percent of these defects were discovered during User Acceptance Test; this late discovery of defects is symptomatic of an ineffective System Test. Of even greater significance, systemic deficiencies in the testing program mean that there is no way to know how many of the total defects that reside in the code have actually been discovered. Simply by testing less effectively, fewer defects will be discovered.

Cyclomatic complexity (CC), another widely used industry indicator of software quality, represents the number of independent paths through the program source code. The CC number for individual modules or units can be calculated using one of several commercial tools. Best industry practice seeks to limit the complexity of individual code units to 10 or less because software modules having a CC greater than 10 have a higher risk of defects and a higher risk of "bad fixes" in which attempts to correct a defect result in new defects being inadvertently created. Typically, CC values exceeding 20 should be considered as alarming. While the percent of UCMS software modules with a CC greater than 10 is small, about 1,600 modules have a CC value greater than 20 which indicates a moderate to high risk. Of those with a CC greater than 20, almost 100 have a value of 50 or greater which means that they are not testable in a practical sense. The discovery of defects in User Acceptance Test may be, at least in part, the result of the high CC factor in these modules.

- **UCMS acquisition strategy; Contractor plan and assumptions.** The UCMS solicitation was sufficient to enable bidder response, but it exhibited four major weaknesses: (1) unprioritized and often ambiguous requirements, (2) lack of detailed and objective source selection criteria, (3) the lack of specification of detailed DLI UCMS operational system attributes, performance measures, associated metrics, and a risk management framework, and (4) the absence of an explicit risk assessment of bidder plans, schedules, and assumptions. The Contractor's proposal was consistent in scope and content with the expectations for a proposal from a major technology firm. The Contractor's proposed System Development Life Cycle (SDLC) approach was based on the Rational Unified Process (RUP) and other requirements as specified in the Commonwealth's solicitation. Using this approach, the Contractor planned a highly concurrent schedule for R-1, R-2, and R-3 SDLC activities starting at the same time with all three releases delivering within a 20-month period. The Contractor's approach entailed the planning, control, and timely integration of a large number of complex, concurrent, and often interdependent activities that are labor and management intensive. The initial criti-

cal path task in this approach was the effectiveness of the process for capturing user business requirements to the satisfaction of DLI. DLI's lack of confidence in the effectiveness of this process has been a major contributor to the current DLI – Contractor impasse regarding R-3.

Based on interviews with DLI and Contractor staff, the SEI Assessment Team identified three key assumptions in the Contractor's project plan that served to create further risks with major schedule and cost impacts: (1) there would be no UC legislative or rule changes even though this was contrary to previous legacy system history, (2) UC claim demands would remain constant, and (3) there was no need to analyze and understand the UC legacy system code, business logic, and data base to facilitate develop of UCMS. DLI did not conduct a formal risk assessment as part of its source selection process to explicitly address issues, concerns, and to identify such assumptions to inform negotiations. As a result, DLI and the Contractor had different expectations and understandings about the planning and execution of the program at contract award.

- **Ineffective governance and program management**. DLI's and the Contractor's plans were not well implemented. The Contractor track record of ineffective project management led to weaknesses in process and practice discipline. Concerns about the feasibility of Contractor project plans and the accuracy of its dashboard status reports to DLI were noted as early as 2008 by DLI's Independent Verification and Validation (IV&V) contractor. Another concern has been instability in the contractor's workforce creating discontinuity in the transfer of knowledge within the Contractor team to inform planning. For example, after completion of the Detailed Design Documents in August 2008, the Contractor rolled a large number of business analysts, who had become the contractor's "project memory" of UC business requirements, off the project. This decision created a significant knowledge gap as the program entered the critical application design and development phases. The consequences of this gap were amplified because the Contractor did not include application code developers and testers in the Joint Application Development (JAD) process which is an industry best practice. As a result, serious knowledge discontinuities existed in the Contractor's workforce about UC business processes to inform development and testing.

  Further discontinuities were created when the contractor's project manager and executive both left the project in early 2009 during a critical time. The size and churn within the Contractor's workforce has also contributed to program discontinuity. Since the start of the project, 638 different contractor staff members have worked on the project with the majority of the workforce having less than one year on the project and 75 percent having less than two years. [4] The churn of the workforce has likely impacted efficient project planning and execution.

  From the start, DLI was not able to provide adequate resources to staff its planned management and governance approach. Further, DLI made no formal delegation of roles, responsibilities, and authority for management of the program. DLI's approach to managing the UCMS program from contract award to early 2011, led to a situation in which no one in DLI was accountable and responsible for the administration of the program. As a result, there was no ef-

fective oversight or timely action to make definitive decisions to mitigate the systemic risks that were continually highlighted by the IV&V contractor.

The cumulative impact of the discontinuities in the Contractor's approach along with the dynamics of the workforce churn likely contributed to the Contractor's schedule and project management system not presenting an accurate picture of the state of the program. The Contractor's initiatives in 2012 to instill more rigor and discipline were on the right track, but came too late to change program outcomes. The discontinuities in the program together with weaknesses in DLI governance and program management further served to create differing views about the status of the program on the part of DLI and the contractor which continue to this date.

DLI's Questions

- **Should DLI continue with UCMS?** DLI should continue with R-1/R-2 and concentrate, as a priority, on maturing the Tax System functionality to resolve defects, data conversion, and system performance issues. DLI should not continue with the R-3 program. The characteristics of R-3 do not provide a high level of confidence that its intended goal will be achieved considering current fiscal, schedule, and risk considerations. More importantly, (1) there is no reasonable basis for a high confidence estimate for when R-3 will successfully complete DLI user acceptance testing and then (2) demonstrate the operational maturity to be the high confidence core mission critical information system for enterprise-wide UC claims processing and payment. Further, premature operational deployment of R-3 may create an inherently high level of potential for some types of failures with the consequence of degrading delivery of UC beneficiary services, specifically payments to citizens who are unemployed. R-3 can be rebaselined to a lower risk, higher confidence strategy based on successful accomplishment of key events. Alternatively, DLI could pursue other approaches to acquire UC functionality equivalent to that provided by the legacy system that would operate on the UCMS infrastructure and enable DLI to confidently terminate UC legacy system operations.
- **Can DLI operate, sustain, and evolve UCMS?** DLI does not have the capability for development and sustainment of UCMS' software applications. DLI does have the capability to assume greater responsibility for management of the UCMS production and test environments, with certain caveats as described in the paragraph below. The UCMS infrastructure has inherent characteristics that allow it to be evolved over time reflecting the characteristics of off-the-shelf technology (hardware and commercial off-the-shelf software) selected by the Contractor at the time of contract award as well the constraints specified in the solicitation. The characteristics of this infrastructure will create challenges for DLI. These challenges are related to a lack of expertise and the staffing capacity needed to sustain the custom application code base, tune the database and infrastructure, and transition some of the UCMS infrastructure from niche COTS products to less expensive, open source alternatives as determined to be appropriate by DLI. A major consideration is the need for DLI to begin planning now to

replace the UCMS portal technology due to decisions by the State Office of Administration regarding changes to the Commonwealth's portal capability, which is the gateway to UCMS.

- **Are contractor and DLI resources sufficient to address these issues?** DLI's IT resources are not sufficient in three critical areas: (1) skills and staffing capacity for sustainment of the UCMS software applications, (2) skills and capacity for acquisition/project management, systems engineering, and integration of complex programs, and (3) the range and depth of the specialized skills and capacity related to the management and operations of more modern technology environments like UCMS. The current DLI CIO has had success in assuming greater responsibility for management of the UCMS processing environment due in large part to extraordinary efforts of the OIT staff in the face of major challenges. However, the level of intensity that enabled this success will be difficult to sustain without greater range and depth of specialized skills and capacity. The Contractor has an expansive resource base of relevant knowledge, tools, practices, and experience to draw upon. However, these inherent capabilities do not necessarily transfer directly to the effective execution of a specific development program (UCMS). There are concerns about the Contractor's ability to effectively staff and manage a qualified on-site workforce at DLI based on three factors: (1) discontinuities in the contractor's workforce as detailed in this report, (2) DLI's on-going experience with the Contractor's challenges in providing on-site staffing of the R-2 sustainment contract with requisite specialized technical staff including business analysts, and (3) the Contractor's ineffective project management that led to weaknesses in process and practice discipline. The degree to which these concerns can be successfully mitigated near term is uncertain.

Recommendations

These recommendations identify strategic courses of action for consideration by DLI senior executives and they are grouped into two categories. The first set of recommendations identify seven critical courses of action that are essential to first enhancing DLI's capacities for managing complex technology programs and sustaining the current core mission. The second group of recommendations deals with the next steps regarding options related to the UCMS program.

- **Initial Imperatives**
  - Take ownership of UCMS and become aggressive in oversight and management of the contract and program. Beginning in 2011, actions by DLI executive leadership have changed the dynamics for day-to-day management of UCMS and for creating a strategic approach to address the systemic issues that are critical for UCMS life cycle success. This focus must continue. Create a rigorous and integrated governance structure to include re-establishing the IV&V function with regular engagement of DLI senior executives to ensure that IV&V findings are addressed.
  - Establish explicit criteria for the meaning of success and "go no-go" operational deployment decisions that are enabled by a performance measurement system. The absence of such explicit criteria, based on system attributes of value to the user, created different expectations between the Contractor and DLI about the level of operational system capability to be delivered and what is acceptable. The criteria should be set based on con-

siderations of UCMS not just as R-1, R-2, and R-3; but rather as an integrated operational enterprise system.

- Adopt and use a formal DLI risk management process to drive DLI senior executives and project managers toward timely risk mitigation decision actions.
- Appoint a skilled and experienced program manager (and deputy) who is empowered with authority to direct and control the program and contract; create and staff a dedicated program management organization with all necessary functions and performance measurement capabilities.
- Realign the position of DLI CIO to report directly to the Secretary as a Line-of-Business creating a peer-to-peer, partnership relationship across the senior executive staff.
- Execute and resource a strategy to operationally sustain the UC legacy system as a UC "insurance" policy until a high confidence operational information system capability for unemployment insurance claims processing and payment has been operational demonstrated to meet expectations.

- **Next Steps for UCMS**
  - Stop the current R-3 effort. While complex, large-scale projects generally have degrees of risk and pressure to meet schedule, the current R-3 effort is proceeding with no high confidence of immediate game changing outcomes.
  - Make maturation and achieving operational stability of R-1/R-2 the highest priority.
  - Begin technical and program planning to identify and evaluate affordable UCMS portal alternatives and interim strategies with the Commonwealth's Office of Administration
  - Rebaseline (restructure) the R-3 effort or seek an alternate pathway to acquire UC functionality equivalent to the legacy system as a first step. The scope of the R-3 rebaselining approach is described in Section 3 of this report. If DLI seeks an alternative pathway to R-3, this approach should be targeted to creating an essential operational UC functional capability that minimally provides the functionality of the legacy system to enable transitioning the UC business from the legacy system. This alternative minimum capability should be designed to enable incremental enhancements to achieve the DLI UC business vision and goals based on affordability and risk considerations.
  - In winding down the R-3 effort, DLI should: (1) require the Contractor conduct and document a stress test for R-1/R-2; (2) conduct a complete review of contract requirements for deliverables, their status, and quality with emphasis on tools and technical data including source code, and (3) insure the Contractor fully documents all code and tests to insure a complete record for use in any future efforts.

Conclusion

The problems evidenced in the UCMS program are not unique, but are too systemic in the acquisition of complex information technology systems. These problems are examples of the challenges organizations often experience in attempting to plan and execute complex software-intensive

technology acquisitions that exceed the organization's skills and capacities for program management and governance of complex, large scale technology projects.

The findings from this assessment should not detract from recognition of the positive factors which can contribute to achieving the goals of the UCMS program. These factors include:

- The strong leadership of current DLI senior executives starting in 2011 to make decisive and timely decisions about the future of the program.
- The high level of commitment and passion of the DLI staff to the organization's mission and to achieving UCMS success.
- The UC legacy information system is an enterprise asset with proven performance and reliability that has mitigated UCMS program risk.
- UCMS represents a significant investment in delivering knowledge, tools, data, and information to enhance DLI's infrastructure processes and practices. The UCMS infrastructure was successfully installed, upgraded, and is in operation and the DLI OIT staff has demonstrated the ability to assume greater responsibility for its operation.

The UCMS success that has been achieved is due to the heroic efforts of individuals within DLI. These individuals are passionate about the DLI mission and persevered in the face of monumental challenges that they did not know and understand at the time the project started. However, such an intense level of effort cannot be sustained and suffice for creating the institutional capacities needed for the task at hand.

The current state of the program is the result of the accumulation of risks and issues that were continually identified over a critical four year period (January 2007-June 2011) of the program. However, these indicators were not acted upon decisively by DLI senior executives at the time to mitigate the systemic risks in the program. These risks continued to roll forward with increasing impact on the program schedule. The Contractor has taken several initiatives to address program performance issues, but these actions have not resulted in game changing outcomes.

The current Secretary of DLI and the current Deputy Secretary of UC have recognized these issues and have taken the initiative to assume control over the UCMS program and consider how best to proceed. The task is formidable since in these situations there are no quick "silver bullet" solutions to the challenges. However, options such as rebaselining R-3 or seeking alternative acquisition pathways are feasible in working toward a lower risk, higher confidence approach to deal with the UCMS challenges. This lower risk, high confidence approach should be based on first delivering a demonstrated minimum essential UC functionality equal to the UC functionality provided by the legacy system. This approach will allow DLI to retire the UC legacy system and then relocate resources to begin incremental enhancement to the UCMS UC functionality as determined to be of value and affordable.

Key Themes and Findings

- **Quality of the System**
  - There is no high confidence estimate for when R-3 (UC Claims and Payments System) will demonstrate the performance necessary to justify a decision to deploy R-3 as the sole UC enterprise system.
  - The lack of integrity in UCMS requirements and testing are systemic risk factors continuing to contribute to schedule delays and lack of user confidence.
  - Code quality particularly for R-3 is a major risk factor; there is no way to know how many of the total defects that reside in the code have actually been discovered given the lack of test discipline.
  - UCMS' architecture performs as designed and can be evolved, but its design is not driven to meet specific user attribute requirements and its performance limits are not known.
  - The high concurrency of the Contractor's approach coupled with schedule pressure and DLI capability and capacity limitations create risk for effective transition, sustainment, and the ability to manage the evolution of UCMS.
  - The UCMS program can be rebaselined to achieve a higher confidence, lower risk approach to address critical issues and achieve success based on affordability and commitment considerations.
- **UCMS Acquisition Strategy; Contractor Planning and Assumptions**
  - The UCMS acquisition approach created a nexus of factors generating major and continuing risk to the program and mission success.
  - DLI's UCMS solicitation was extensive and detailed; however, it exhibited key weaknesses that disadvantaged DLI in the source selection for a large scale development project and the subsequent management of the contract and program.
  - The Contractor's proposal was extensive and reflected what would be expected from a major system integration company in terms of scope and content. The Contractor's System Development Life cycle approach was based on the Rational Unified Process, but its implementation coupled with unrealistic planning assumptions created inherent risks at program initiation.
- **Governance and Program Management**
  - Overall, project governance and project management were insufficient for the complexity of the UCMS program to achieve project and mission goals.
  - The Contractor's "plan on paper" for program management in the proposal was comprehensive reflecting what would be expected from a major systems integration firm. However, status information presented on the performance of the program did not logically flow from program measurement data to provide a clear view of the actual state of the program over time.
  - DLI did not implement an effective governance and program management approach. As a result, DLI was at a significant disadvantage in having the program management and governance capacities to effectively administer the contract, provide oversight, and engagement with Contractor senior managers and executives.

Figure 1: Key Assessment Themes and Findings

1 Background

In 2012 the Secretary of the Department of Labor and Industry (DLI) for the Commonwealth of Pennsylvania directed an independent assessment of the Unemployment (Insurance) Compensation Modernization System (UCMS) program to inform decisions about the future of the program. DLI initiated the acquisition of the UCMS in 2005 to enhance its business and information system capabilities for administering the UI program. The Secretary of DLI requested the Software Engineering Institute (SEI) to conduct this independent assessment which was accomplished during the period of late January—April 2013 and was supplemented by data updates in May and June. This report provides the findings and recommendations from this independent assessment.

This report is organized to describe the background and SEI's approach to conducting this assessment followed by a discussion of the context for the findings which are grouped into three thematic categories. The report then addresses the four key questions posed by DLI leadership concerning the UCMS program and DLI capabilities. The recommendations section presents a high level set of strategic actions for consideration that focus on building critical DLI capacities necessary for success in managing the acquisition of complex software-intensive systems such as UCMS. The recommendations section then identifies a set of actions for DLI leadership to consider regarding options for UCMS. The report concludes with a summary.

1.1 Overview

The UCMS is a critical mission system for administering the Commonwealth's Unemployment Insurance (UI) program. UI is the nations' largest income maintenance program and in fiscal year 2011, $116.8 billion was expended to provide compensation for the lost earnings of individuals who became unemployed. The UI program is guided by evolving federal law having been established by the Social Security Act of 1935, but benefits for individuals are determined in part by each state. The federal and state legislative frameworks for the UI Program that impact the administration of the program have been dynamic and continue to evolve.[5]

> **"Our mission is to improve the quality of life and economic security for Pennsylvania workers and businesses, encourage labor- management cooperation, and prepare the commonwealth workforce for the jobs of the future."**

The UI Program is administered in each state by the designated State Workforce Agency (SWA).[6] Within the Commonwealth, the DLI is the SWA for administering the UI Program. UI monetary benefits paid to beneficiaries are financed through employer payroll taxes at the state level and federal payroll taxes support the cost of program administration at the state level as well as the federal share of extended benefits and other expenses.

As the Commonwealth's SWA, DLI administers a range of programs that provide monetary and non-monetary benefits to eligible citizens of the Commonwealth. These programs include delivery of unemployment (insurance) compensation (UC) benefits to unemployed individuals, work-

ers compensation to individuals with job related injuries, vocational rehabilitation services to individuals with disabilities, and workforce development services for employment and job training. The DLI also enforces workforce safety and health standards as well as other laws.

The DLI administers these programs through a decentralized service delivery network of more than 150 offices across the state. Within the DLI, the Bureau of UC Benefits and Allowances provides for the intake and processing of UC claims through eight UC Regional Service Centers and the Office of UC Tax Services administers the employer tax elements of the UC Program through service centers and field offices to serve the employer community. The scope and details of the UC business architecture (rules, data, work activities, staff competencies) must be continually enhanced to reflect the dynamic nature of the UI federal and state policy and legislative environment. UI legislative and policy changes must be assessed for their impact on the functionality and architecture of the enabling information technology for administering these beneficiary claims processes and then the system changes required to execute these mandates must be made.

The administration of the UI tax and benefits program at the state level relies heavily on the use of legacy information technology systems. The administration of UI programs face significant technology challenges such as aging systems that are difficult and costly to sustain with limited functionality for case management and limited ability to integrate newer tools and technologies to enhance productivity.[7] These challenges also led the Commonwealth to initiate the UCMS program.

States and consortiums of states have taken actions to try to address these technology challenges through the acquisition of newer technology based systems. However, these UI technology acquisition programs have generally not been successful in delivering user operational capabilities on time and within program budgets.[8] This outcome for UI technology modernization is not unexpected given the now decades long pattern of failure in information system acquisition. Large scale software-intensive projects fail more than they succeed in terms of being on schedule and on budget, eventually delivering over 50 percent less functionality than originally planned. [9]

The ultimate measure of success for UI information systems is their demonstrated ability to enable processing or adjudication of UI claims and pay benefits to citizen accurately, timely, reliably, and consistently. Because UI systems deliver critically needed monetary benefits to eligible citizens, these systems are considered to be mission critical. While legacy systems have certain disadvantages that drive the need for their modernization, one of the advantages of legacy systems is that typically, they consistently and reliably perform the original mission functions for which they were designed. Operationally, this means that when a SWA transitions from a UI legacy environment to a more modern business and technology environment, the transition strategy must be based on an operationally proven system that can be deployed with high confidence to seamlessly meet or exceed the UI capabilities of the legacy system.

1.1.1 DLI's Technology Modernization Strategy

Modernization of DLI's business processes and enabling legacy information system technology has been a strategic thrust of the organization since the early 2000s. As a result of that strategy, DLI initiated the acquisition of two major information technology modernization programs in 2005-2006, the Commonwealth Workforce Development System and the UCMS, to enhance the efficiency of the administration of programs and the delivery of services to individuals and em-

ployers. Both of these acquisition programs were intended to replace legacy systems that were seen as presenting sustainability challenges. Additionally, both acquisitions included business process re-engineering activities and enhanced functionality to enable new processes, improve knowledge worker efficiency, and service delivery.

In 2004 the DLI initiated a competitive solicitation for the UCMS, but due to a pre-award protest the solicitation was canceled and reissued in May 2005. Subsequently, DLI awarded a fixed price contract in June 2006 for the acquisition of UCMS with a milestone of January 2010 for operations.

The goal of the UCMS acquisition was to provide DLI Unemployment Compensation knowledge workers, citizens making claims, and employers paying unemployment taxes with greater automated functionality. This enhanced functionality was intended to be delivered through implementation of a new technology infrastructure and new functionality:

- Increment 1 - capabilities for case management and other foundational capabilities for administration of wage records/tax and remittance posting
- Increment 2 – capabilities for employers and their third-party agents administering payroll and taxes to maintain tax account information and make unemployment tax payments
- Increment 3 - new and enhanced functionality for individuals to file unemployment compensation claims, adjudication of those claims in order to execute a monetary payment to claimants, and appeals

The schedule for the UCMS "Go-Live" for operations milestones for each of these three increments appear below in Table 1.

Table 1: UCMS Go-Live Contract Milestones

UCMS Increment	**Go-Live Milestone June 2006 Contract Award**
1 - Case management and wage record/tax and remittance posting	April 2008
2 – Payroll and tax administration	May 2009
3 – UC claims processing and payments	January 2010

1.1.2 Commonwealth Office of Technology and DLI Leadership Concerns About UCMS

The historical context for the Commonwealth's concerns about the UCMS program is important in understanding the reasons for the current Secretary of the Department of Labor and Industry seeking this independent assessment. This context describes a complex decision environment that existed in 2011 resulting from the accumulation of risks over a period of years since project initiation.

The acquisition life cycle of the UCMS program now spans 10 calendar years from the development of the original UCMS solicitation, nine calendar years from submission of vendor proposals, and eight calendar years from contract award. As discussed later in the report, governance and management have been key factors influencing UCMS program performance during the life cycle of the program. The Commonwealth governance and management environment, within which the program has been administered, materially changed in 2011 to become proactive and decisive in addressing the critical state of the program. DLI did consider courses of action in 2008—2010, to address program performance issues. However, these actions were limited and did not decisively address and mitigate the systemic risk issues in the program that continued to accumulate creating continual delays in achieving program milestones and increasing the schedule in a fixed-price environment. The 2011 time period was a tipping point in the life of the program as the scope and consequences of these risks came into focus demanding time and resource sensitive decisions about the future of the program.

This change in approach to managing the UCMS program started with the transition of the new governor's administration that began in January 2011. The Commonwealth's Office of Administration (Deputy Secretary for Information Technology) recognized that the UCMS program was a high risk project due to significant cost overruns and delays in meeting milestone requirements. Subsequently, on June 29, 2011 the Commonwealth issued the UCMS Contractor a letter which had the practical intent of being a contract "cure notice." This letter detailed the Contractor's project planning and execution deficiencies and identified specific actions to be performed by the Contractor to mitigate further Commonwealth actions. At the time the Commonwealth issued its "cure notice," the Commonwealth had paid the Contractor approximately $130M and committed an additional $29M against the UCMS contract.[10]

In April 2011, the governor appointed a new Secretary of the Department of Labor and Industry, and later in October 2011 the governor appointed a new Deputy Secretary for the Unemployment Compensation (UC) program. The new secretary took an aggressive approach to understand the performance problems with the UCMS program. This included directly engaging with the Contractor's senior executive leadership to address critical program performance and contract issues since the contract was set to terminate in December 2012.

Three major UCMS decisions were made before and during the time the new Secretary of DLI was transitioning into that position in April 2011 that created further risk to the program.

- In March 2011, the month prior to the new Secretary of DLI assuming office, the then CIO of DLI contractually accepted the R-2 Tax System functionality for internal DLI uses. Inter-

views with DLI staff consistently highlighted that this decision was made even though the R-2 UC business manager and other business staff strenuously objected to the decision as being premature. This objection was based on the fact that R-2 had not completed testing and known software defects had not been corrected.

- On May 4, 2011 DLI and the Contractor entered into an agreement to combine UCMS System Test—ST (the responsibility of the Contractor) and User Acceptance Test—UAT (the responsibility of DLI) that called for DLI to assume primary responsibility for performing merged ST and UAT.
- A decision was evidently made in early 2011 not to extend the IV&V contract and it terminated in June 2011.

Upon assuming his position in October 2011, the new Deputy Secretary took an aggressive approach to understand the actual status of the UCMS program. He also took steps to empower the UC UCMS manager in her role and to address the fact-of-life challenges associated with the premature introduction of R-2 into business operations. Additionally, DLI was faced with making decisions about significant contract changes (Program Change Requests—PCRs) and their funding to address design and requirements issues. During the early period of his tenure, three other events occurred.

- The Contractor's October 2011 UCMS Status Report called for a "go live" operational date of December 2011 for R-3, the most critical functionality of UCMS. However, the same report stated that only 15 percent of the test cases had exited DLI User Acceptance Test which is at odds with the status of a program that was asserted to be on schedule to "go live" in December.
- In November 2012, DLI began transitioning R-2 into production for employer use to include electronic filing of unemployment compensation, or UC, quarterly reports (Form UC-2/2A) and payment of UC contributions. To date, more than 82,000 employers of the 300,000 employers in the state of Pennsylvania have successfully registered; more than 39,000 employers have used the system to file, and more than 38,000 employers have paid taxes using UCMS.
- In December 2012, the Commonwealth issued a non-cost extension of the UCMS contract through March 31, 2013 and subsequently extended the period of performance through September 30, 2013 to further assess the program.

1.2 Independent Assessment (IA) Charter

The overall approach to the UCMS assessment was guided by SEI's experience in conducting such assessments and the specific issues raised by the DLI leadership that were viewed as critical to making informed decisions about the future of the program.

1.2.1 Independent Assessment Guidelines

An independent assessment is an objective, third-party appraisal (evaluation or review) of a specific program or policy; in this case UCMS. The purpose of this type of assessment is generally twofold. First, the results of the assessment in terms of data and information from the findings of the assessment are intended to facilitate executive level understanding of the technical and man-

agement issues of concern. Secondly, these findings together with specific recommendations enable more informed executive decisions on courses of action to achieve the desired program or policy outcome.

Independent assessments are performed by individuals and organizations who are not members of the organization or program being assessed and who have no conflicts of interest related to the outcome of the assessment. SEI's independent assessments are also guided by certain ground rules.

- Assessments are approached as being collaborative and non-adversarial in planning and execution with the sponsor, stakeholders, and system integration or prime contractor.
- Interviews with individuals are conducted on a non-attribution basis.
- The design of the assessment is tailored in range and depth sufficient to address the questions at hand and informed by data and information discovered during the assessment.
- Those individuals performing the assessment comply with appropriate non-disclosure agreements for handing of data.
- Assessment findings are evidence-based and recommendations for courses of action are focused on practical considerations.
- Ongoing engagement with the senior leadership sponsor during the assessment is essential to highlight any critical and emerging, time sensitive risk concerns.
- The final report is the property of the client for decisions on disposition and release.

1.2.2 UCMS Scope and Charter

In planning the UCMS assessment, the SEI engaged with DLI senior executive leadership to identify the key issues of concern. The Secretary of DLI identified four major categories of issues that were viewed as critical to making judgments about the future of the UCMS program. These four issues include:

- Are we on the on right track and making progress with the UCMS Project? In other words: Is the quality of the system design, development, and performance including the software applications and data migration sufficient for us to have confidence in the UCMS solution and approach to continue?
- Is the quality and characteristics of the design and UCMS implementation such that we can operate, sustain, and evolve the system to meet future needs?
- What are the scope and magnitude of the changes necessary to solve the critical path technical and program management issues?
- Do we have the resources to address these issues and achieve success?

To further scope the charter of the assessment, SEI solicited from DLI's executive leadership their principal measures for assessing the success of the UCMS program. DLI leadership identified the following measures of success:

- Achieving an operational UCMS that works to meet the needs of government, employers, and claimants for administration of unemployment benefits and taxes.
- Implementing a system that provides the foundational capability to evolve to meet future business and technology needs.
- Training government and other users to effectively use and understand the system.
- Attaining the knowledge and the capability to operate and sustain the system within the DLI enterprise architecture and infrastructure after the end of the UCMS contract.
- Enabling seamless transition from the legacy environment to the UCMS for business and the IT system environment.

1.3 Assessment Approach and Data Collection

SEI's assessment approach was tailored to address the critical issues facing the Department. The approach as described below also included a significant review of available data and information that emerged from interviews with DLI staff and members of the staff from the UCMS Contractor.

1.3.1 Approach

The framework depicted in Figure 2 describes the scope of the assessment in terms of the principal domains of interest. This framework includes the policies, processes, practices, data, tools and technology that compose the UCMS program and technical infrastructure. The range and depth of the assessment in each of the domain areas was driven by what was sufficient to address DLI's concerns.

Figure 2: Assessment Framework[1]

1.3.2 Data Collection and Synthesis

The SEI conducted a review of available UCMS data and information. This data and information included the following: (1) the UCMS solicitation, proposal, contracts, change requests, and contract deliverables; (2) DLI and Contractor program review and status reports; (3) the deliverables from the UCMS Independent Verification and Validation contract (2007–2011); and (4) other documents provided by DLI and the Contractor. In the course of this document review, SEI sampled sets of the Contractor's deliverables and Program Change Requests (PCRs). The data collection effort also included information provided in response to detailed data requests and questions submitted to DLI and the Contractor.

SEI also conducted interviews with current and former DLI and Contractor staff. In some cases, these interviews were conducted in group sessions. Interviews with individual DLI and contractor staffs were conducted consistent with SEI's non-attribution ground-rules which were described to

[1] Clockwise, from top: Acquisition Strategy and Plan, Program and Technical Management, Business Architecture and Requirements, Legacy System, Target Architecture and System Design, Software Architecture and Engineering, Test and Evaluation, Transition to Operations, Sustain and Evolve

both DLI and contractor staff. These interview sessions were conducted on-site at DLI, by phone, and were complemented by extensive use of group conference calls.

The data from the document reviews and interviews was synthesized by the SEI Team during an iterative process with follow-up written questions submitted to DLI and the contractor for clarification. Additionally, conference calls were conducted with Contractor staff as necessary for clarification.

2 Findings

2.1 Context for the Findings

The vision statement for the Commonwealth is a powerful message. It communicates the "big picture" of UCMS success to the DLI Unemployment Compensation staff, employers who pay taxes and citizens who received UI benefits. In practical terms, the overriding concern and focus of this assessment was whether or not the UCMS program was planned, designed, and executed to deliver mission critical operational performance the "first time and every time" to meet DLI, employer, and beneficiary needs.

The current UC legacy information system has certain disadvantages common to UI information systems supporting other SWAs. However, the Commonwealth's UC legacy system performed to consistently high standards during the recent period of unprecedented increases in UI claims demands by out of work citizens.

This vision describes the key elements of success for UCMS:

- *the demonstrated operational ability to consistently, with high reliability and timeliness, process and adjudicate UI claims, accurately calculate payments, and then create and execute payment files*
- *achieve this level of performance with such confidence that DLI can "turn off the legacy UC system" and rely seamlessly and totally on UCMS to support the Commonwealth UC mission.*

In presenting the key findings from the assessment, the report provides the historical context for the relevant issues. This context is important in understanding the key issues to address in strengthening DLI's institutional abilities for the acquisition and management of complex information systems.

2.2 Recurring Themes from the Assessment

During the assessment a number of recurring threads or factors emerged as being central to contributing positive value to the UCMS program. These factors merit recognition and consideration by DLI leadership in making judgments about future action regarding the UCMS program. The assessment also identified recurring threads of issues that appear to have been systemic during the life of the program which are highlighted in the assessment findings. Complex technology acquisition programs are often plagued with technical and programmatic challenges which become the focus of assessments such as the case with the UCMS assessment. However, these challenges should not overshadow the factors contributing positive value. There are four key factors that DLI

can leverage to enhance its organizational capabilities for sustaining UC service delivery and improving the UCMS program.

- **Strong DLI leadership**. The leadership of the current Secretary of DLI and the Deputy Secretary of UC beginning in 2011 changed DLI's approach to management of the program and resulted in aggressive actions to take control of the program. Changing the historic patterns of behavior in managing the UCMS contract and program is a critical factor for future success.
- **DLI staff commitment.** Members of the DLI staff, who have been engaged in the UCMS program, have demonstrated a high level of commitment and passion toward achieving the goals of the UCMS program and perseverance in dealing with significant challenges. The DLI staff was handicapped by the lack of knowledge and seasoned experience in planning and managing a complex acquisition program. They were also hampered by lack of support from and integration with DLI senior executive management. However, the DLI UCMS staff has performed admirably and demonstrated great resiliency given the situation and the issues that have plagued the program. It is likely that absent their commitment the status of the UCMS program may have been more severe.
- **Legacy UC system performance**. The UC legacy information system is a key DLI asset. Based on the planned UCMS capability milestone dates at contract award, DLI made decisions about transition of the legacy UC information system to the UCMS. The nexus of increased UI claims demands due to rising levels of unemployment coupled with the delayed activation of the UCMS then created a high risk for DLI to satisfy UI claim processing requirements. While the UC legacy system has certain disadvantages, the UC legacy system has demonstrated that it is robust, reliable, and consistently dependable in supporting DLI's UC line of business. The performance of the UC legacy system and the commitment of the UC IT, and business staffs enabled DLI to deliver uninterrupted UI services to beneficiaries.
- **Significant investment in UCMS.** UCMS represents a significant investment in terms of DLI financial and labor resources that can be leveraged by DLI to enhance its infrastructure capabilities. This investment enabled re-engineering of some UC business processes along with organizational learning from knowledge transfer and experience in the disciplines associated with the system acquisition life cycle. This includes data and tools for complex project management, business process analysis, testing, and configuration control of processes and technical functionality. This investment also created a new UCMS architecture infrastructure now supporting the initial UCMS tax functionality which provides the means to evolve the UC technology infrastructure.

2.3 Assessment Findings

For the purposes of this assessment, the term finding is used to characterize a set of conclusions about the UCMS program based on a logical synthesis of data and the analysis of that data to generate information to address the specific question or issue at hand. These conclusions are based on the summation of the information about the UCMS program (plans, activities, functions, decisions, and other factors) which were analyzed or evaluated and considered to be of interest, concern, or of value to DLI leadership. A finding is also important because it enables understanding

of the situation at hand, the key factors that led to the situation or project status, and the potential impact of these factors.

The findings from the assessment are organized into the following three categories and the details of the findings appear below.

- quality of the system
- UCMS acquisition strategy and Contractor planning and assumptions
- project management and governance

2.3.1 Quality of the UCMS System

- **The lack of integrity in UCMS requirements and testing remain systemic risk factors that have contributed to schedule delays and low user confidence.**
- **Code quality, as measured by defect density and complexity, is a major risk factor and impacts achieving timely system maturation and sustainability.**
- **UCMS' architecture performs as designed; can be evolved, but its design is not driven to meet specific attribute requirements and its performance limits are not known.**
- **The high concurrency of the Contractor's approach coupled with schedule pressures and DLI's capability and capacity limitations created risks for effective transition and sustainment.**

2.3.1.1 UCMS Requirements Process

The Contractor's UCMS business requirements development process, including business process re-design, was based on using the industry standard Joint Application Development (JAD) process (sometimes referred to as Joint Application Design and Development). JAD involves a contractor leading multiple teams of business users through a structured series of facilitated sessions to baseline the "as is" business process and then elicit the requirements of the "to be" redesigned business processes. This new "to be" baseline becomes the basis for design of the software functionality of the system and other associated system features such as data and system interfaces.

Five factors degraded the effectiveness of the JAD process and its implementation:

- The complexity of the JAD process overwhelmed DLI's capacities in terms of the number of subject matter experts available to participate in multiple, highly concurrent JAD sessions.
- The premature removal of the JAD sub-contractor by the UCMS Contractor from the project created a gap in knowledge transfer for design even though the Contractor's SDLC methodology was based on an iterative approach to development. This iterative approach necessitates the continual refinement and updating of requirements, design, development and tests which demands a high degree of continuity in knowledge throughout the SDLC.
- The failure to include system design and test staff in the JAD process to understand the nature of the UC business and requirements and to then ensure that requirements were defined in sufficient detail to be testable.

- The development and review of requirements in an isolated manner, with each JAD team focused on an individual functional domain and with DLI reviewing individual domains six weeks apart from each other.
- The short turn-around time allocated for DLI review of complex requirements and design documentation.

These factors are discussed in more detail below.

DLI endeavored to manage a pool of UC subject matter experts to participate in a series of highly concurrent JAD sessions with a short turn around cycle allocated for review and approval of key business requirements documents. DLI staff emphasized they often approved these JAD requirements documents (and Detailed System Design documents also) under pressure to meet the short turn cycle for approval.

In DLI's view, the premature release of 36 JAD sub-contractor staff created gaps in knowledge transfer to the design effort leaving the Contractor with limited experience in understanding the details of UC business requirements. Interviews with DLI staff indicated that the Contractor's decision was made over the objections of DLI. This decision had significant implications because, as indicated through interviews with Contractor staff, the Contractor did not have a comprehensive understanding of the nature and details of UI claims processing when the program started. Knowledge from the JAD process was vested in the JAD sub-contractor. This gap in knowledge was further exacerbated by the Contractor not including design and test members as part of the JAD process, which is a best practice.

The systemic issues regarding the quality of the requirements process (and the design process) were noted in IV&V reports beginning in 2007. For example, in early 2009, the Contractor started a design remediation process for R-2 (Tax System) after recognition that the design did not reflect all requirements, functionality, and other information that were necessary to support the start of design. The Contractor's decision to remediate R-2 requirements and design in 2009 was appropriate. However, the effectiveness of this effort is in question given the subsequent R-2 schedule delays and the premature release of R-2 into operations with known defects and continuing discovery of problems.

R-3 is based on a larger number and more complex set of business rules than R-2; the cumulative impact of these systemic issues manifested themselves in R-3. These issues resulted in a set of complex use cases, inadequate knowledge transfer to the developers and testers, late discovery of requirements, and continuous churn in system and user acceptance testing, and ultimately Design/Program Change Requests. Under schedule pressure, DLI approved requirements documents prematurely, thus allowing design to proceed to the point where there has been decreasing traceability of delivered functionality to the intended "to be" requirements. This situation contributed to a degraded trust environment. The nature of the requirements and development process resulted in no one having a complete end-to-end view of how the system as a whole would function; the functional gaps discovered during UAT are a symptom of this lack of a full operational system view.

2.3.1.2 UCMS Testing

The Contractor's testing approach as presented in its proposal conformed to what would be expected in terms of industry practices for levels of testing (unit test—UT, component integration testing—CIT, system test—ST, user acceptance test—UAT). Another key element of system testing is the conduct of stress testing which is discussed later.

UCMS UT, CIT, ST, and UAT

> ***UCMS test discipline (UT thru UAT) has eroded to the point that the testing approach has been disjointed and incomplete. This situation has evolved to a "test and fix" philosophy to drive toward what the Contractor perceives as "being done," but there is no DLI-Contractor agreed upon criteria for completion of testing.***

The erosion of test discipline appears to have been caused by a breakdown in the Contractor's internal project management and oversight. It is not clear why this occurred given the significant emphasis the Contractor placed on project management in its proposal. Further evidence of the ***fundamental breakdown in UCMS testing discipline was the Contractor's decision to use test scripts from DLI users who are business domain experts, but not test experts coupled with adoption of a combined system test and user acceptance test approach.*** In practical terms, UCMS UAT scripts now represent the de facto UCMS business requirements with uncertain traceability to original JAD derived requirements.

Since early 2011, when the Commonwealth began more rigorous oversight of the UCMS program, the Contractor has made at least seven attempts to improve the test program.[11] Table 2 below summarizes these various initiatives.

Table 2: Contractor Test Improvement Initiatives

DATE	CONTRACTOR APPROACH
Spring 2011	Contractor requested DLI assistance with ST
March 2011	Formal agreement to combine Contractor ST-DLI UAT
December 2011	Contractor adds 15 testers for UAT (testers were previously removed from the program)
February 2012	UAT Process Improvement
March 2012	Root Cause Analysis Red Team
May 2012	Goal Based Build Process
August 2012	Focus Team Process

Beginning in late 2012 the Contractor, as part of its Focus Team Process, created a process for the identification, analysis, and remediation of defects and created a test readiness review process for entry into UAT. This process evidenced the type of substantive and rigorous analytical based approach that would be expected for such complex software–intensive programs. While this is a step in the right direction, it comes late in the program and has not resulted in substantively changing program outcomes.

The key UCMS test implementation issues are summarized below.

- Flaws in the UCMS test program were introduced early on when the Contractor did not include testers as members of the JAD effort even though including testers in the business determination process is a best practice. This is even more significant since the Contractor's SDLC process (Rational Unified Process—RUP) is based on an iterative strategy where knowledge and practice continuity from iteration to iteration is critical.
- This flaw in the test program contributed to there being no explicit criteria for test coverage being specified for any phase of testing as well as the previously identified gaps in knowledge transfer. Test coverage is the proportion of a software component or software application that is tested—usually expressed as a percentage. The specific measure of coverage depends on the purpose of the test suite and on the nature of the software unit under test (module, subsystem, system). A common test coverage measure is the number of independent paths tested in a code module (i.e., measure cyclomatic complexity and develop tests to coverage that number of independent paths). If system integration is done in a disciplined manner, the system is progressively built up into larger subsets of the system. The Contractor did not present any measure of test coverage for any test phase to the SEI Assessment Team. The Contractor did state that each use case was tested, but there was no indication of any measure of coverage within a use case. The SEI Assessment Team interviewed the Contractor's staff in an effort to discern the details of the test coverage approach to clarify the situation, but we were unable to elicit a coherent description of how the Contractor conducted its tests.
- Another weakness in the test approach was the over-reliance on manual testing which is very labor intensive and time consuming. The industry best practice is to leverage automated testing as a core strategy. The limited use of comprehensive regression testing creates an increasing feedback cycle time and a continuous churn in defect remediation.
- The constant churn in the testing approach led to decisions made under schedule pressure. For example, DLI agreed to begin User Acceptance Testing prior to the Contractor completing System Test for R-2 and R-3. Further, the consequence of these events was that under schedule pressure the Commonwealth gave approval to move R-2 into production prematurely with known severity 1 and 2 defects.
- Another critical issue is that the allocation and execution of responsibilities between Contractor ST and DLI UAT remains a nexus of uncertainty. In 2011, the Contractor-DLI entered into a contract agreement for a joint ST and UAT that made DLI responsible for ST and UAT. We were unable to find evidence that this agreement was operationalized with policies, detailed processes, and specification of practice guidelines. The effect of the joint ST and UAT agreement was to "muddy the waters" on roles and responsibilities and create more churn in schedule and traceability of requirements. Further, the scope of DLI's UAT is not industry standard practice and is more appropriately classified as ST.

The lack of rigor in system test is especially disturbing, given that the Contractor is now relying on a "test and fix" strategy. Even rigorous testing alone will never achieve quality and an operationally suitable system. This point is emphasized in a paper not yet published, but made available to the SEI Assessment team by a leading authority in software measurement. [12] As stated in this paper:

"Testing by itself... is not sufficient to achieve high quality levels... However modern risk-based testing by certified test personnel with automated test tools who also use mathematically-derived test case designs and also tools for measuring test coverage and cyclomatic complexity can do a very good job and top 65% in defect removal efficiency for the test stages of new function test, component test, and system test."

The paper goes on to state that *"Untrained amateur personnel such as developers themselves seldom top 35% for any form of testing. Also bad fixes are inversely proportional to cyclomatic complexity...Bad fixes by a novice trying to fix a bug in an error-prone module with high cyclomatic complexity can top 25%."*

There is a critical need to execute a rigorous and disciplined testing strategy that is consistent with the complexity of a large scale software-intensive system. This was not done with UCMS. The repeated efforts by the Contractor to address UCMS program performance by improving testing suggests these efforts may not have been successful in part because these initiatives were attempts to deal with symptoms, not the root cause performance issues. These root-cause issues, which go back to the quality of the requirements process, cannot be solved through a test and fix approach.

Performance, Load, and Stress Testing

A key element of a test program is to conduct a range of tests that assess the overall characteristics of the system to include performance, load, and stress testing. The UCMS infrastructure is in operation today supporting the R-1 and R-2 business applications. However, there are questions that do need to be addressed about how well the system performs so that the DLI CIO organization has the data and information necessary to effectively plan and manage the UCMS environment over the life cycle. A key factor in conducting these tests is the UCMS test environment. Based on interviews with Contractor and DLI staff, DLI made a decision that the UCMS test environment (with the additional role of disaster recovery) would have 50 percent of the UCMS production capability in terms of processing capability.

The three test categories identified below are included in system test.

- Performance testing evaluates the performance of certain features of a system such as user response time, operational reliability, process execution flow time, data updates, end-to-end response time to include interfaces with other systems, etc.
- Load testing essentially places a demand on the system to observe how it responds. It typically evaluates the behavior of the system under operational conditions given certain factors such as the number of users, number of transactions, and others. This test is conducted against a baseline system configuration so there is an analytical basis for evaluating the impact of system changes on performance over time.
- Stress testing is about testing a system to failure by placing a demand on a system that far exceeds normal operational conditions to understand the limits of the system in terms of its patterns and degrees of failure, for example, does the system degrade gracefully or does it totally freeze? Stress testing is important because it provides information to the user community

(DLI) to understand the limits of the system to inform life cycle planning for enhancements to meet evolving user needs.

Our assessment identified three key concerns.

- DLI did not specify a minimum set of measures and metrics for UCMS system performance in the solicitation. Rather, the solicitation requested prospective bidders to propose "performance measures and values" for "Response time concurrency, system performance, impact on network performance, and scheduled maintenance." As a result, the UCMS infrastructure was not designed to meet specific DLI performance requirements. We were not able to elicit from the Contractor the performance criteria and assumptions that were used to arrive at the architecture design they proposed for UCMS.
- Although the solicitation required "load/stress" testing assuming 3,000 concurrent business users, the Contractor did not conduct a stress test per se, but rather conducted a load test even though the Contractor's reports use the term "stress/load" tests.
- The condition of the R-2 and R-3 software applications at the time of the Contractor's "stress/load" test do not appear to have met the qualifications specified for entry into those tests. The entry criteria state "*The Applications to be tested will have successfully completed unit, component integration, system, and if necessary UAT testing prior to entering this phase of testing or the code has been declared stable enough to begin Stress/Load testing*. We were not able to determine what criteria and evidence was considered to make a determination that both application releases were stable.

During our interviews, the Contractor indicated that the load test for R-1 and R-2 was based on a 3,000 concurrent business user scenario. However, the load test for the version of R-3 that existed at the time of the test was constrained to "1,528 users" because the UCMS test environment had been down sized to 50 percent of the production environment as a cost saving measure.

In addressing questions about why a stress test was not accomplished, the Contractor stated that "there are license restrictions impacting stress test to failure versus load and performance test—up to the limitations of the test tool license...this license has a restriction of 3000 virtual users which limits the ability to test to failure via a stress test. The number of licenses purchased by DLI was determined by the RFP which contained the requirement to support 3,000 concurrent users."

We note that in the Contractor's November 2010 "Stress/Load Testing Results" report for R-2, the report states that *"As a result of testing, we conclude that there is* ***low*** *risk in deploying Release 2 of the UCMS application to the production environment and going live with the system. The results also showed that the current environment is not sized for Release 3 and would not be able to handle a Release 3 load."* This statement suggests that the original UCMS design may have been insufficient to enable operations of R-3, the most critical functionality of UCMS. The Contractor subsequently upgraded the performance capabilities of the system for the production and test environment during the required refresh of the infrastructure as specified in the solicitation. During our discussions, Contractor staff stated that they were investigating how to accomplish a UCMS stress test.

2.3.1.3 Software Code Defects

The UCMS solicitation specified that the J2EE (Java 2; Platform, Enterprise Edition) development framework would be used for the program. Java is one of the most popular languages for programming client-server web-based applications.

Defect density is a common measure of code quality and is defined as the number of defects discovered divided by software size (usually defects per thousand lines of code—expressed as defects/KSLOC). For the purposes of our analysis we used the data provided by the Contractor to DLI regarding defect rates, the Contractor's analysis of those UCMS defect rates, and our own model estimates to independently assess the reported defect rates.

Context for Assessing Software Code Defects

A software defect is any flaw or imperfection in a software work product or a software process that has the consequences of impairing the functionality or value of the application or aspect of the application. A software work product is any artifact created as part of the software process including computer programs, plans, procedures, and associated documentation and data. And, a software process refers to a set of activities, methods, practices, and transformations that people use to develop and maintain software work products.[13]

Defects are categorized in terms of their severity as described in Table 3 below. While severity 1 and 2 defects have significant impact on mission performance, severity 3 and 4 defects on an individual basis have less impact and are usually perceived as being of less priority to resolve. However, the cumulative impact of severity 3 and 4 defects in terms of the size of the defect backlog and/or the synergy of the functionality impacted by even a small number of severity 3 and 4 defects can have significant mission impacts. Making informed decisions about strategies to prioritize defect remediation—burn down of technical debt—demand disciplined business and engineering processes along with affordability and value analyses to inform decisions.

Table 3: Definitions of Defect Severity Levels

Level	Description (Source: UCMS R2 & R3 Test Strategy Deliverables)
1	Function or Application Unusable or Inoperable - The application has demonstrated a complete failure causing total loss of function or mnemonic creating a critical impact on the business. No bypass exists. Testing cannot continue until the correction is in place Examples: Application code abnormally ends.
2	Function or Application Severely Restricted - The application has demonstrated a severe failure preventing use of certain function(s) or mnemonic(s) within the application. A workaround is available for a limited duration and must be negotiated and agreed to by those areas performing or affected by the interim process. Testing can continue but will be limited until the correction is in place. . Examples: Data Source Failure.
3	Function or Application Minimally Restricted - The application has demonstrated a minor failure with minimal impact to business functions or mnemonics. A workaround is available for an indefinite period of time or is unnecessary. Testing can continue and is not significantly limited by the correction not being in place. Examples: Sorted Data not correct.
4	Testing is not affected. The problem is insignificant and can usually be easily bypassed. Example: Format/alignment errors

One of the major lessons from decades of software-intensive systems development is that the earlier a defect is discovered, the more quickly it can be corrected with the least impact on a project's schedule and ultimately development and sustainment cost. The hallmark of an effective test program is that the majority of defects are discovered in the early phases of test. As depicted below in Figure 3, most defects are generated during requirements analysis and design.

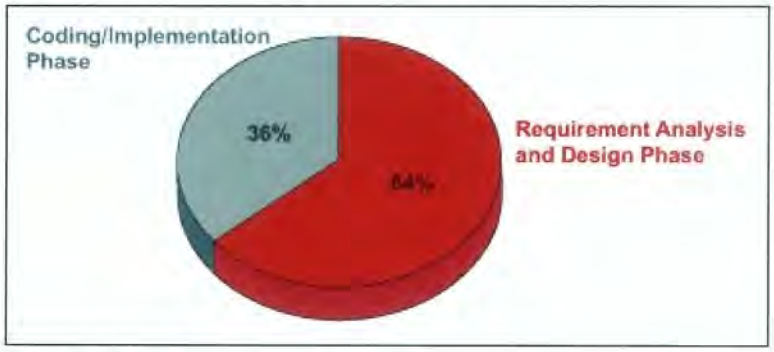
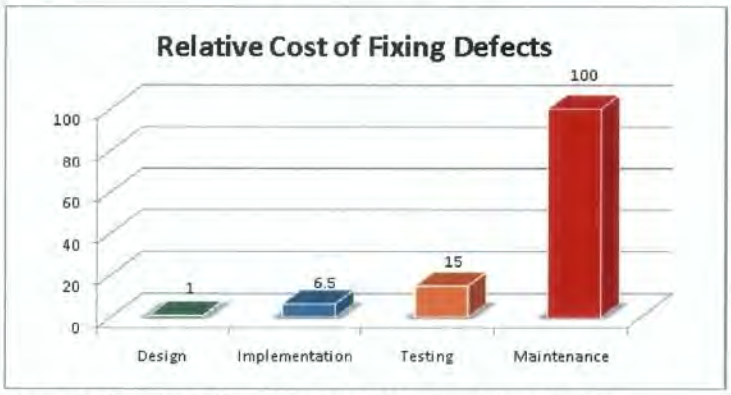


Figure 3: Origin of Software Defects

(Source: Crosstalk, the Journal of Defense Software Engineering[14])

The later defects are identified in the development life cycle the greater the cost of correcting those defects. In general, the poor quality of the code coupled with the deficiencies in a testing program creates a bow wave of technical debt—future consequences in sustainment of addressing code defects and system deficiencies—that will need to be addressed in the future. Figure 4 below highlights this fact.



Source: Implementing Software Inspections, IBM Systems Sciences Institute

Figure 4: Cost to Fix Defects

UCMS Defect Density

As a baseline for the discussion on UCMS defects, Figure 5 below provides a snapshot of the reported cumulative defect data by severity level for R-2 and R-3 taken from Contractor status reports provided to DLI.

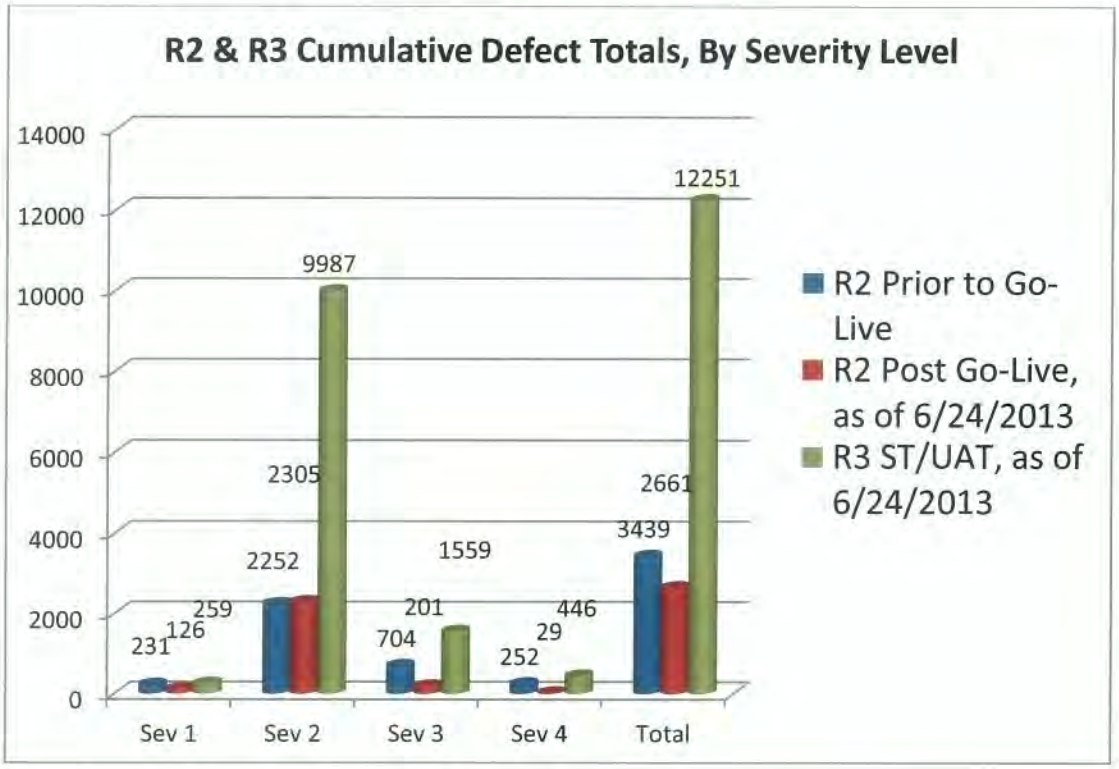


Figure 5: UCMS Cumulative Defects by Severity Level

The large number of Severity Level 2 (serious failure) defects the program has encountered—compared to the overall number of defects—is significant. Equally significant is that these defects were overwhelmingly discovered late in the program. The Severity Level 2 defects for R-2 "Post Go Live" and R3 "ST/UAT" represent the vast majority—over 86% and 81%, respectively—of all R2 and R3 defects found as of June 2013. There are several reasons why issues are flagged as UCMS defects. These reasons include uncovered programming errors; observed software failures; and situations where the system actually did "work as designed/specified," but it did not meet DLI's current expectations (e.g., business process changes may have occurred after the requirements were defined). Regardless of the reasons for the defects, the large number of Severity 2 defects is a strong indicator of persistent and systemic problems over a sustained period of time. These problems relate to requirements verification (conformance of the system to specifications) and validation (assurance that the system meets the needs of the customer such as DLI) and/or traceability of requirements to design (ensuring formally documented requirements were completely mapped to developed and tested functionality).

The UCMS solicitation (page 104) required that bidders propose an acceptable defect level based on industry standards, industry averages and best practices for DLI's approval. During our discussions with the Contractor's testing and quality assurance staff regarding defect data and trends, Contractor staff stated they used internal Contractor and industry benchmark data to assess UCMS quality trends. In response to our inquiries, the Contractor did not identify methodologies and associated benchmark data demonstrating how it evaluated UCMS defect data relative to internal Contractor or industry benchmarks. Also, we were unable to determine if such data had been pro-

vided to DLI for approval as specified in the solicitation or if the Contractor and DLI had mutually agreed to a defect performance measurement and mitigation criteria.

Defect Analysis

In response to DLI concerns about UCMS defects, the Contractor prepared a defect analysis report in June 2012 that was provided to the SEI Assessment Team by DLI. In performing its analysis, the Contractor cited published defect rate data from Mr. Capers Jones who is a recognized authority by industry and academia in software engineering practices and measurement. Our analysis of UCMS defects considered the underlying defect data used in the Contractor's June 2012 study as a starting point. We also conducted extensive discussions with the Contractor to gain an understanding of their defect identification, classification, and remediation process as well as how this process has evolved over time. The Assessment Team was also able to have several interchanges with Mr. Jones regarding the Contractor's analysis without identification of the contractor.

The Contractor's analysis compared defect data for R-1/ R-2 and R-3 to benchmark data published by Mr. Jones in 2000. The Contractor cited this comparison to argue that the projected defect density of 10.7 software defects/KSLOC at test completion for R-3 is well within Mr. Jones' benchmark defect density factor of 14.7 for a project of this size and duration.[15] The Contractor concluded from this comparison that the projected R-3 defect density is well under industry averages and is therefore indicative of solid code quality.

There are three observations related to this Contractor comparison that merit consideration.

- Mr. Jones' benchmark data has changed dramatically in recent years. The benchmark data cited by the Contractor was derived from more than 10,000 projects that spanned a period of almost 40 years. As described by Mr. Jones, this data was derived primarily from older projects using older languages such as assembly and C which had many more defects than more modern languages such as Java, which is the software language used for UCMS.
- Recent benchmark comparisons provided by Mr. Jones to the SEI Assessment Team shows a much lower defect density (38 percent of his earlier defect density data) for applications developed with more modern languages such as Java.
- The Contractor's test program, as previously described, has demonstrated a systemic lack of rigor and discipline. In particular, the Contractor presented no measures of test coverage for any test phase to the SEI Assessment Team. *Consequently, there is no way to know how many of the total defects that reside in the code have actually been discovered. Simply by testing less, fewer defects will be discovered, giving a false impression of low defect density.*
- The pattern of defect discovery provides further evidence for the ineffectiveness of System Integration and Test (SIT), with as many defects found in User Acceptance Test (UAT) as in System Integration and Test. Benchmark comparisons provided by Mr. Jones to the SEI Assessment Team show that 91 percent of the defects should have been found in SIT (rather than only 50 percent).

In performing our analysis we consulted with Mr. Jones in estimating the expected defect density for an "average" project (i.e., not a better than average project let alone world class) using defect density data from more current Java based projects in his benchmark database. This analysis was based on assuming 756,738 lines of Java code (the R-3 SLOC stated in the Contractor's June 2012 report). The expected defect density for the combined SIT-UAT was 4.48/KSLOC; fewer than half the 10.7 defects/KSLOC projected by the Contractor. This analysis using data from Mr. Jones' benchmark data indicates the Contractor's projected R-3 defect rate to be twice as high as industry data would suggest.

Pattern of Defect Discovery

Table 4 presents the number of R-1 + R-2 software defects discovered during Integration, System Test, and User Acceptance Test (UAT); the corresponding percentage of defects for each test category is also presented. It is noteworthy that, of the total number of defects discovered, 50 percent were discovered during UAT. According to Mr. Jones' data, 91 percent of those defects should have been discovered prior to UAT and only 9 percent should have been found in UAT. This suggests a lack of effectiveness in conducting Integration and System Tests indicating many more defects are likely to be latent in the code.

The Contractor did not present a comparable breakdown for R3. This is likely due to the fact that System Test and UAT were combined so there is no meaningful breakdown of defect data between these two test phases. This again points to a lack of effectiveness in the overall test program and the likelihood of more defects being latent in the code.

Table 4: Distribution of Defects Discovered by Test Phase for R1+R2.

Release 1+Release 2	Integration Test	System Test	User Acceptance Test	Total
Number of Software Defects	1,233	629	1,840	3,702
Percentage of Software Defects	33%	17%	50%	100%
Capers Jones Benchmark Data (2011)	82%	9%	9%	100%

Note: The benchmark data were provided by Mr. Jones to the SEI Assessment Team and were estimated from the Software Risk Master™ tool by one of the SEI Assessment Team members.

Cyclomatic Complexity (CC) Considerations

Inadequate management of code complexity is another software characteristic driver that can be an indicator of quality. CCyclomatic complexity (CC) is a widely used industry measure of complexity.[16] It represents the number of independent paths through the program source code. Best design practice seeks to limit the complexity of individual code units to enhance understanding which, in turn, improves the testability and maintainability of the code or application. The actual determination of the CC for individual software modules in a software application can be calculated using any one of several commercially available tools. Industry best practice is to strive to limit CC for individual code units to 10 or less since studies have determined that modules having

a cyclomatic complexity greater than 10 have a higher risk of defects.[17] A CC of 50 or greater is a meaningless threshold because such a value means the software is deemed to be untestable and perhaps not maintainable. The relationship between cyclomatic complexity and the "risk" in a procedure are highlighted in Table 5 below.[18]

Table 5: Cyclomatic Complexity and Risk

CC	Type of procedure	Risk
1-4	A simple procedure	Low
5-10	A well-structured and stable procedure	Low
11-20	A more complex procedure	Moderate
21-50	A complex procedure, alarming	High
>50	An error-prone, extremely troublesome, untestable procedure	Very high

Typically, cyclomatic complexity values for code modules or functions that exceed 20 should be considered as alarming. Procedures with a high cyclomatic complexity should be simplified or split into several smaller procedures since CC equals the minimum number of test cases that must be executed to cover every possible execution path through the procedure or module of functionality. Another manifestation of CC is the "bad fix probability" relationship as highlighted in Table 6 below.[19] This table shows the probability of an error accidentally inserted into a program while trying to fix a previous error. As the complexity reaches high values, changes in the code are likely to produce new errors.

Table 6: CC Bad Fix Probability

CC	Bad fix probability
1-10	5%
20-30	20%
>50	40%
approaching 100	60%

The IV&V contractor expressed concerns in 2008 about the Contractor's approach to CC for UCMS application design. These concerns were generated because the Contractor indicated that it had set the CC metric at 50. The SEI Assessment Team had discussions with the Contractor regarding CC standards in an attempt to determine if the Contractor had formally set such a standard and how CC had been managed as a design driver. We were not able to determine from these conversations if a UCMS CC design standard had been set and if so how such a standard had been executed systematically.

In response to requests from the SEI Assessment Team, the Contractor provided data on the CC value for each UCMS software module. As previously stated, the CC number for individual modules within a software allocation can be calculated using one of several commercial tools. The CC value for a software application is a metric and the algorithm for counting CC values is not proprietary. The SEI Assessment Team subsequently analyzed this CC data. Based on this analysis,

only 3 percent of UCMS software modules have high-complexity units with a value of 10 or greater. However, this statistic is misleading.

While the percent of modules with a high CC value of 10 or higher is low, there are about 6,000 modules with a CC of 10 or greater. Of those 6,000 modules with a CC of 10 or greater, almost 1,600 modules have a CC value greater than 20 which indicates moderate to high risk. Of those with a CC greater than 20, almost 100 have a value of 50 or greater which means they are not testable. The greatest proportion of defects is likely to be contained in these 6,000 complex units. The discovery of defects in UAT may be, at least in part, be the result of the high CC factor in these modules.

Observations on UCMS Defects

It is reasonable to conclude that only some percentage of the latent defects in the code have been discovered because of the lack of integrity in the UCMS test program. The test program has been characterized by discontinuities—in approach, roles and responsibilities, methods, management, analysis, staffing, and skill levels—over a sustained period. As a result, the testing that has occurred has not been planned and executed in a consistent manner so that all code has been tested in the same stable and disciplined environment over the life of the program with an emphasis on automated testing. Given the lack of integrity in the UCMS test program and the absence of measures for test coverage, it is also reasonable to conclude that there is great uncertainty about the overall UCMS testing results. The cyclomatic complexity of many of the software modules further exacerbates the testability of the UCMS applications and increases the likelihood of inducing additional errors during defect mitigation.

2.3.2 UCMS Acquisition Strategy and Contractor Planning and Assumptions

> ***The UCMS acquisition approach created a nexus of factors generating major and continuing risk to the program and mission success.***

In 2004 the DLI developed a competitive solicitation for the UCMS, but due to a pre-award protest the solicitation was canceled and reissued in May 2005. Subsequently, DLI awarded a 6.5 year contract in June 2006 for the acquisition of the Unemployment Compensation Modernization System with a milestone of 2010 for "go live" operations.

2.3.2.1 DLI Acquisition Strategy

> ***DLI's UCMS solicitation was extensive and detailed; however, it exhibited key weaknesses that disadvantaged DLI in the source selection for a large scale development project and the subsequent management of the contract and program.***

The SEI Assessment Team reviewed the solicitation to understand the scope of work and the source selection criteria, but the Team did not perform a detailed critique of each section of the solicitation or delve into the source selection process itself. The assessment identified several

concerns that likely contributed to placing DLI at a disadvantage in administering and controlling the UCMS contract. These concerns are highlighted below.

- The UCMS solicitation exhibited four major weaknesses: (1) un-prioritized and often ambiguous requirements (also noted by the IV&V contractor): (2) lack of objective source selection criteria; (3) the lack of specification of detailed DLI UCMS operational system attributes, performance measures, associated metrics, and a risk management framework, and (4) absence of an explicit risk assessment of bidder plans, schedules, and assumptions.

  The solicitation was complex in structure and content. While not the cause of the lack of discipline in the requirements determination process as noted earlier in the report, the ambiguity in how the solicitation communicated the extremely large number of requirements may have been a contributing cause to differing expectations on the part of DLI and the Contractor. The inability to trace the current functionality of UCMS to what was placed on contract and the results of the UCMS requirements determination process remains a major concern and risk factor.

  The source selection criteria were adequate to assess potential bidder core competencies and past performance, but it did not provide detailed and objective criteria for evaluation of the technical proposals consistent with the complexity of the program requirements. The criteria were general in nature and lacked a comprehensive focus on risk as part of the evaluation. The absence of an explicit DLI source selection risk assessment carried forward into the execution of the program with risk management becoming a systemic weakness in DLI's governance and management approach. Further, the solicitation did not include specify a detailed risk management framework for systematic identification, analysis, mitigation, and tracking of risk for the program life cycle.

  Additionally, the solicitation did not define and describe explicit quantitative and qualitative operational system performance measures and metrics for the UCMS. The operational purpose of the UCMS was obvious. However, the solicitation did not emphasize the overarching goal of delivering an operational system which is the ultimate measure of program success. This was never explicitly stated. Although this measure of success should have been intuitive to bidders, the Contractor's proposal focused on "go live" milestones for each of three distinct functional releases rather than on delivery of an operational enterprise-wide system that must satisfy specific operational performance measures.

  The solicitation specified the staffing DLI planned for the UCMS program in great detail to leverage DLI's UC business expertise, CIO staff knowledge of the legacy system, and to facilitate knowledge and skill transfer to DLI. However, this plan did not reflect an understanding of the complexities, functions, and skills necessary to manage such a large scale technology acquisition program. As a result, DLI did not have the capacities in place at contract award for effective oversight and management of the contract and program as discussed later in the report.

- While the solicitation did not evidence the characteristics expected for the acquisition of such a large scale software-intensive capability, it was minimally sufficient to enable potential bidders to assess the scope of the modernization effort and the risks involved. However, the Questions and Answer exchanges between the Contractor and DLI did not indicate that substantive discussions occurred or that DLI asked detailed questions about proposed technical and programmatic approaches and associated risks that would be expected before making an award for such a complex, multi-year project. This situation likely led to differing expectations and understanding about the planning and execution of the project by DLI and the Contractor.

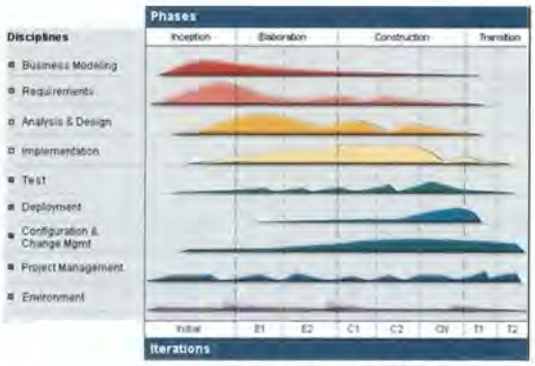
2.3.2.2 Contractor Proposal Approach

The Contractor's proposal was extensive and reflected what would be expected from a major system integration company in terms of scope and content. The proposal was based on using the Rational Unified Process approach to develop UCMS applications as specified in the solicitation. The actual implementation approach coupled with unrealistic planning assumptions created inherent risks at program initiation.

The Contractor's proposal was consistent with the expectations for a major technology firm and relied on industry and company standards and practices. The Contractor's proposed System Development Life Cycle (SDLC) approach was based on the Rational Unified Process (RUP) and other requirements as specified in the Commonwealth's solicitation.

RUP and Waterfall Approaches

RUP is an accepted industry standard methodology that is based on a phased approach to development with each phase being organized into a number of separate and successive iterations. In this model, software applications are designed, developed, and tested in repeated cycles as new functionality is added until the application's functionality is determined to be ready for operational deployment. The Contractor planned a highly concurrent schedule with R-1, R-2, and R-3 SDLC activities starting at the same time with all three releases delivering within a 20-month period. This schedule would have appeared as a major red flag had DLI implemented risk assessment practice during the source selection. The RUP approach requires the integration of a large number of complex, concurrent, and often interdependent activities as well as continual risk mitigation. The critical path task in this approach is effectively capturing user business requirements to the satisfaction of DLI, which has been a major contributor to the current impasse regarding R-3 as highlighted earlier.



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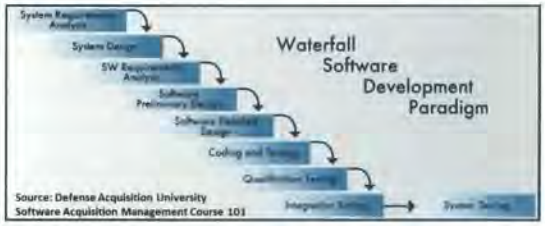
RUP has different characteristics from the traditional waterfall approach. In the traditional waterfall approach each stage or phase of a project or program is a prerequisite for beginning subsequent activities. For example, in the waterfall approach, the requirements and design phases are being accomplished for the entire program. Successful completion of a stage is required before starting the next one. The RUP and waterfall approaches are not incompatible. Within each of the RUP iterations there are elements of the basic tasks that have to be accomplished in a sequence—requirements, design, code and test—except they are done in an iterative fashion. In a RUP iteration, you accomplish an "iteration's worth" of requirements, then coding & testing those requirements.[20]

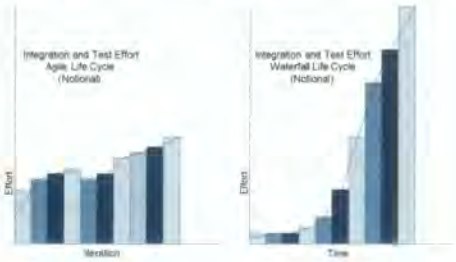


In executing the RUP SDLC process, the Contractor's implementation appeared to take on characteristics of the waterfall approach. For example, the JAD requirements process culminated in the Contractor providing deliverables (requirements and design) for DLI to accept contractually. This created the expectation that the requirements process was complete and all requirements had been successfully captured to inform the design phase, the next step in the development life cycle. The premature release of sub-contractor staff leading the JAD effort before the design phase suggests that there was no explicit consideration that requirements would be refined through the successive RUP iteration cycles.

Interviews with Contractor staff and IV&V reports identified concerns that the Contractor's proposal underestimated the scope and complexity of the UCMS project which led to optimistic assumptions about the schedule at the start of the project. At contract award, the schedule called for delivering all UCMS increments to achieve "go-live" milestones within a 20 month period which was based on a the three releases (R-1, R-2, and R-3) being highly concurrent, but the activities were waterfall with the development of each release. Problems emerged early on in executing this concurrent contract schedule which further exacerbated the risks that were previously highlighted.

These problems created upfront schedule and technical risks in the program that were not satisfactorily mitigated, if at all, early-on. These risks rippled forward through the program creating schedule pressure that continued to push key development activities further to the right in schedule which occurred in a fixed price contract environment. The end result was that (1) the Contractor scheduled and missed six dates for operational deployment of R-2 and it was prematurely accepted into production by DLI and (2) there is no high confidence estimate as to when R-3 will be operational.[21]

These type problems took on the behavior of a waterfall project in terms of effort. As highlighted here, the most significant labor effort associated with testing in a waterfall approach tends to occur late in the schedule in contrast to other approaches like the agile development approach (which is also



an iterative model) places emphasis on providing the user with visibility into the details of the functionality early in the process.[22]

Key Contractor Proposal Assumptions

Based on interviews with Contractor staff, the assessment identified three key assumptions made by the Contractor in planning the UCMS project that do not appear to have been challenged by DLI during the source selection process. These assumptions had major impacts on the schedule and cost of the program.

- The Contractor assumed there would be no legislative or rules type changes impacting UC claims processing. This assumption had major cost and schedule impact due to program change requests associated with UI legislative and policy changes that became known. This was clearly an unrealistic assumption given the history of similar changes to the legacy system as described in interviews with the current DLI CIO and UC business staff.
- The Contractor also made certain assumptions about UC claims demands in sizing the capacity of the UCMS infrastructure architecture. Over a 12-month period, the Contractor conducted a review of the infrastructure processing environment and redesigned certain aspects of the environment to support a significant increase in UC transaction loads. This change was made as part of the 2011 program change request to refresh the UCMS production and test environments. While this refresh was called for in the contract, the need to resize the processing environment indicates that the Contractor's initial design assumptions may not have considered the potential for a dynamic demand environment.
- Finally, the Contractor assumed that in developing UCMS that it was not necessary to analyze and understand the logic of the legacy UC software applications and the associated data. The knowledge that is reflected in legacy system functionality and data represents a corporate asset and specifies rules and logic of the business.[23] Interviews with DLI UC staff and IV&V reports highlighted a persistent concern about UCMS data conversion including mapping of legacy data to the UCMS data model. It is likely that the Contractor's assumptions about the legacy applications and associated data contributed to UCMS data conversion delays. Backloading data conversion is another indicator of a waterfall type approach.

2.3.3 Governance and Program Management

Overall project governance and management were insufficient for the complexity of the effort necessary to achieve project and mission goals.

Governance and project management have been consistently demonstrated as being decisive factors for IT acquisition program success.[24] Governance refers to the set of corporate policies, structures, processes, and practices for making decisions about the way the organization, activity, or function is controlled and managed. IT governance is one element of corporate or enterprise governance. Program management refers to the exercise of delegated authority and responsibility for the strategic and tactical leadership and direction of the life cycle of IT project planning, oversight, management, and execution of all business, contract, technical, and financial aspects of an IT acquisition program.[25]

Governance and project management are interdependent in that the position of program (or project) manager exercises authority for the program and bears ultimate responsibility and accountability for success. The program manager receives direction from the governance authorities who specify the specific parameters for the program or project including the corporate and business goals to be achieved as the result of the program.

The lack of discipline in the Contractor's execution of the program as previously highlighted coupled with the dynamics of its workforce contributed to the Contractor's schedule and project management system not presenting an accurate picture of the state of the program. This factor together with weaknesses in DLI governance and program management further served to create differing views on the parts of DLI and the Contractor about the status of the program.

2.3.3.1 Contractor Program Management and Governance

The Contractor's governance and program management "plan on paper" as presented in the proposal was comprehensive and reflected the scope and content of what would be expected from a major systems integration firm. The Contractor's execution of its project management plan and the associated reporting of project performance did not logically flow from the program data to provide a clear picture about the program based on the SEI Team Assessment

The Contractor's proposal specified a robust project management approach relying on an integrated master plan, integrated master schedule, associated processes, and infrastructure for project control. This approach also identified the key management and executive leadership team members and its principal sub-contractors. We reviewed samples of the Contractor's schedules and dashboard status reports. Our conclusions regarding the weaknesses in the Contractor's project management are consistent with the findings of the IV&V contractor's recurring reports to DLI, the IV&V contractor's June 2011 Project Closeout Report, and the Grant Thornton UCMS Assessment in June 2011.

Issues regarding the quality of the Contractor's project reporting were noted beginning as early as 2007 in various IV&V contractor reports to DLI. The sample of project status reports we reviewed often contained data that was presented in excruciating detail without a "big picture" view of its meaning for DLI to understand the nature of the issues and to make an informed judgment about the risk and consequences. More importantly, there did not appear to be consistency in these UCMS status reports and there was limited continuity from what had been previously presented to have some sense of trends impacting the program.

An example of this disconnect between the Contractor's plans and the actual status of the program was evident in the Contractor's October 26, 2011 UCMS Status Briefing to DLI. It is inexplicable as to why, at that time, the Contractor was predicting a "go live" date of R-3 for December 2011; its performance dashboard was reporting that only 15 percent of User Acceptance Tests had exited test.

The instability in the contractor's workforce served to create gaps in the transfer of knowledge within the Contractor's staff about the details of UC business operations necessary to continually

inform the development process. For example, the Contractor employed a sub-contractor to lead and administer the JAD requirements process and the detailed knowledge of the DLI UC process resided with this JAD sub-contractor team. In August 2008, DLI approved the Detailed Systems Design (DSD) documents for Releases 2 and 3. Within a few months after the DSD was completed, the Contractor rolled off a significant number of business analysts from the project that were the "project memory" on UCMS business requirements. This decision created a critical knowledge gap entering application design and development which was planned to be an iterative process.

The impact of this action, which created gaps in knowledge transfer, was intensified because the contractor did not include application code developers and testers in the business requirements process which is an industry best practice. As a result, serious discontinuities emerged in essential and detailed knowledge about UC business processes during development and testing. In early 2009, the Contractor's project manager and executive both left the project adding further discontinuity at the top of the organization during a critical juncture in the project. Since the start of the project, 638 different contractor staff members (61 percent sub-contractor staff/39 percent prime contractor staff) have worked on the project with the majority having less than one year on the project and 75 percent having less than two years. [26] The size and churn of the workforce created an environment for inefficiencies in project planning and execution as well as challenges to creating an effectively integrated team.

2.3.3.2 DLI Governance and Program Management

DLI was not able to effectively implement an effective governance and program management approach. As a result DLI was at a significant disadvantage in not having the program management and governance capacities to effectively administer the contract, provide oversight, and engagement with Contractors senior managers and executives.

The UCMS procurement solicitation (in Appendix L) described, at a high level, the program management and governance approach and structure DLI planned to "utilize…staff, the respective teams and roles, to make the best use of the available DLI skills and ensure that UC staff can support the application as each release is implemented."

DLI's approach to implementing these approaches was limited resulting in accountability and responsibility for the UCMS program being diffused and oversight essentially delegated to the IV&V contractor. As a result, (1) no one was accountable and responsible for performing core governance and program management functions; (2) DLI did not define a set of criteria to use in assessing the program; and (3) an on-going performance measurement system was not created to systematically assess the UCMS program at the DLI corporate level to make informed and timely decisions to mitigate technical and programmatic risks.

The solicitation stated DLI would hire a vendor to provide independent verification and validation (IV&V) to assist the DLI project team. Subsequently DLI awarded an IV&V contract with a start-up date of January 2007 that was closed out in June 2011. The use of IV&V is a best practice in the technology industry and government.[27] It adds value in identifying high-risk areas early in the project effort which allows the program organization to mitigate risk by providing objective analyses to executives to inform their decisions.

The IV&V analyses reviewed as part of this assessment were thorough and of high quality. In a practical sense DLI outsourced UCMS program oversight to the IV&V vendor given DLI's limited program management and governance capacities. The IV&V vendor consistently highlighted red-flags and warning signs of critical issues needing Contractor and DLI executive and management attention. It is common when using the IV&V practice for the engagement to be structured to enable the IV&V vendor to report regularly to senior executive leadership. However, the IV&V reports do not provide evidence that DLI's senior leadership routinely interacted with the IV&V vendor to discuss and address critical IV&V findings and trends. DLI lower level staff and Contractor staff did interact with the IV&V vendor to deal with findings on a routine basis. The IV&V vendor was no longer under contract when DLI's new executive staff began at the department.

In this environment, DLI's informal governance structures (steering, configuration, and architecture groups) did not mature to be effective.[28] Another factor perhaps contributing to the historically weak governance for UCMS is that the position of the DLI CIO is not aligned as a peer-to-peer line of business member of DLI's executive leadership team reporting directly to the secretary. This alignment inhibits the ability of the CIO to surface key technical and program trade-off issues for corporate deliberation and facilitate decisions impacting enterprise IT resource and mission capabilities.

This DLI governance approach was not effective before 2011 with major UCMS issues impacting program risk often being addressed by lower level staff. The practical consequence of the DLI approach led to there being two project managers for the UCMS program; one part-time manager in the DLI CIO organization and a full time manager representing the UC line of business. The authority and roles and responsibilities for these two managers were never officially defined or documented. Another consideration is that the authority for sign-off acceptance of contract deliverables was often vested with the DLI OIT project manager with limited oversight and vetting of decisions at a higher level before sign-off. As discussed later, this situation led to premature sign-off on key UCMS contract deliverables, particularly those related to business requirements and premature acceptance of the R-2 functionality for the Tax System.

2.3.3.3 Transition and Sustainment

The UCMS solicitation placed significant emphasis on the winning vendor providing training to the DLI UC and OIT staffs with the goal of enabling knowledge transfer related to business process redesign methods and the support of new technology. Acquisition of UCMS represented a major shift in DLI's UC technology infrastructure creating a gap in knowledge, skills, and experience. However, the cumulative impact of the high concurrency of the Contractor's approach coupled with schedule pressure and DLI's limited capabilities severely impeded accomplishing this goal.

The Contractor's proposal was responsive to the solicitation requirements and there is evidence some training was provided to DLI staff. Further, the Contractor also conducted an organizational impact assessment and provided recommendations to DLI in 2007 concerning organizational and staffing changes resulting from the UCMS integrated design and business process re-engineering effort. The Contractor's analyses identified that the principal impacts of the redesign effort would result primarily from changes related to R-2 and R-3.

A significant factor impacting transition of expertise and experience for new technology to DLI was DLI's inability to provide the level of DLI staffing assumed in the Contractor's proposal. In response to the solicitation, the Contractor proposed that DLI contribute about 30 labor years of effort to the UCMS development program to further knowledge and skill transition. However, DLI was not able to allocate resources to staff this commitment and subsequently agreed in a funded Program Change Request to reduce the staff commitment to about 50 percent of the proposed target with the Contractor providing additional, off-setting labor.[29] A recurring theme that emerged from interviews with DLI staff was that the high concurrency and churn of the project as it continued to slip in schedule, coupled with limited DLI staff resources, made it difficult to maintain momentum and focus on transition and sustainment planning. The DLI OIT staff expressed significant concern that while DLI staff was to be part of the "hands-on" team during each phase of the development effort, in reality this did not happen with any consistency even at the reduced level of DLI staffing.

We were not able to identify data demonstrating goals, objectives, measures, and metrics for managing and evaluating transition training, sustainment, and organizational workforce changes. The significant delays in the program as well as normal workforce attrition likely made it difficult to sustain continuity of DLI staff in the face of program pressures. It is also likely that with time the effectiveness of initial Contractor training of DLI staff may have eroded, particularly as it relates to the schedule delay for R-3.

3 Key DLI Questions

3.1 Should DLI Continue with UCMS?

Is the quality of the system design, development, and performance including the software applications and data migration sufficient for us to have confidence in the UCMS solution and approach to continue?

DLI should continue with R-2. R-2 is based on a simpler set of rules than R-3 and the performance of the UCMS infrastructure does enable Tax System operations although R-2 continues to evidence new defects, data, and batch operations problems arising from its premature release into operations. The effort to put in place an R-2 sustainment contract with the Contractor does provide continuity of knowledge and expertise to apply to facilitate maturation of the R-1/R-2 functionality. DLI has a realistic plan for completing the transition of employers onto the UCMS Tax System and understands the measures necessary to achieve that challenging goal. Success of the R-2 maturation effort will be driven by putting in place effective DLI governance, program and technical management, quality assurance, and other capabilities identified later.

DLI should not continue with R-3 unless it is rebased as described later. From an operational system perspective, the R-3 Claims and Payment System which is the core mission functionality of UCMS must operate seamlessly with high confidence to insure there is no interruption in delivery of beneficiary services and payments; meaning the UCMS must work the first time and every time.

The characteristics of the UCMS R-3 program do not provide the high level of confidence to achieve this intended goal considering current fiscal, schedule, and risk considerations. There is no reasonable basis for a high confidence estimate for when R-3 will demonstrate the maturity to be the core mission critical information system for enterprise-wide UC claims processing and payment to support beneficiaries.

Further, premature R-3 operational deployment may create an inherently high level of potential for some types of failures with the consequence of impacting key performance parameters degrading delivery of UC beneficiary services, specifically payments to out-of-work citizens.

UCMS can be rebaselined to a lower risk, higher confidence event based strategy providing a seamless and assured mission critical operational capability. The term rebaseline refers to restructuring the scope, content, and schedule for the program based on revising the goals, objectives, and outcomes measures of success.[30]

This conclusion is based on consideration of several factors to include:

- The R-3 sub-system is now 42 months behind schedule from contract award and the application has a large number of unresolved defects, change requests, and inherent complexities.
- DLI and the Contractor are at an impasse regarding requirements, testing, and suitability of the most complex and critical functionality of UCMS. R-3 may have some functionality that (supposedly) works "as designed," but the functionality that is "working" is "working" to a set of requirements that have been diluted due to the systemic problems arising from the erosion of technical and program management discipline over the course of the program. Early in the life of the UCMS program, the discipline to apply appropriate Contractor standards and practices began to erode; thus resulting in poor requirements traceability, loss of testing integrity, and inconsistent quality controls.
- UCMS is yet to operationally demonstrate that on an annual basis it can (1) accurately process and adjudicate over 1.2 million initial claims and their continuation then (2) accurately calculate and timely, consistently, and reliably generate and transmit more than 40 million payment files annually which are essential to enable timely payments to beneficiaries. The ability to demonstrate this level of performance with high confidence is imperative to assure that citizens are able to file for unemployment insurance and can receive their appropriate monetary benefits.
- The Contractor made strides beginning in the fall of 2012 to enhance the program's technical performance and project leadership. This was the latest in numerous attempts to make changes to address UCMS issues that should have been identified and successfully mitigated years previously. Any improvements that may arise from the Contractor's most recent improvement initiative are yet to be realized in terms of "game changing" outcomes. Even if successful, these changes along with completion of current user acceptance testing would not demonstrate the high confidence level essential for operational deployment and seamless delivery of services in the near term.
- Finally and perhaps most important, DLI users now have low trust and confidence in R-3 which is critical to achieve a shared commitment to a successful outcome.

3.2 Can DLI Operate, Sustain, and Evolve UCMS?

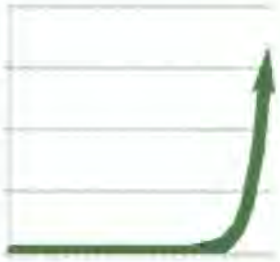
Is the quality and characteristics of the design and UCMS implementation such that DLI can operate, sustain, and evolve the system to meet future needs?

Based on the scope of this assessment, the Contractor's technical solution appears to be compliant with solicitation requirements and the UCMS infrastructure can be operated, sustained, and evolved over time. The UCMS technical solution is complex and its design reflects the characteristics of off-the-shelf technology (hardware and COTS software) proposed by the Contractor at the time of contract award as well the technical constraints specified by the Commonwealth in the

UCMS solicitation. The characteristics of the UCMS architecture will create challenges for DLI to sustain the custom application code base and transition some of the UCMS infrastructure from niche COTS products to less expensive, open source alternatives as determined to be appropriate by DLI. Technical approaches to address these challenges that will emerge over time must be evaluated relative to their affordability and risks to achieving increased levels of performance and system enhancements.

Five principal technical considerations create significant challenges for DLI in meeting future UCMS needs. While legacy systems have certain disadvantages and the adoption of new technology based systems may address those disadvantages, the adoption of new technology also comes with its own set of challenges.

- The pace of information technology change is continuing to increase at an accelerating rate. This rate of change demands DLI have the technical and management abilities that are continually refreshed to engage in a continuous technical and business value trade-off analysis process. Such analyses are critical for DLI executives to make informed judgments about the technology investments that will enable UCMS to be viable in the face of changing technology and business needs.



- The UCMS architecture demands DLI be proactive in leveraging the inherent capabilities of the architecture so its configuration can be tuned to enable the system to meet evolving performance, reliability, and availability requirements which may change depending on the scale of deployment and system load. This is a non-trivial task.
- There is a major technical learning curve for the DLI OIT organization to be able to sustain custom code based applications, COTS products, tools, and knowledge. DLI invested in tools, data, processes, and knowledge transition with the goal of enhancing its internal capabilities. If this infrastructure is not used and refreshed for the DLI OIT and UC business organizations, DLI's ability to sustain and evolve the UCMS will be significantly degraded.
- These UCMS investments provide the enterprise management infrastructure critical to being able to accomplish sustaining systems and software engineering of UCMS as well as the means for evaluating evolving business needs. This infrastructure provides the intelligence essential for management and integrated configuration control of the UCMS business and technical architecture.
- The quality of the code coupled with the deficiencies in the testing program creates a bow wave of technical debt—future consequences in sustainment of addressing code defects and system weaknesses—for the future. R-2 was prematurely accepted and included a large number of known defects; the same will likely be true for R-3 if it continues on its current course. Typically technical debt costs much more to address later.

- A significant and emerging challenge relates to the future

interoperability of the UCMS infrastructure with the Commonwealth's web portal gateway solution. The UCMS system is designed using portal technology. Portlets supporting the UCMS system for all users (DLI staff, citizens, and employers) are created using a standard interface with the gateway portal installation housed and managed by the Commonwealth's Office of Administration. The portal technology is a critical component in the UCMS application system design as all access is through the portal and application roles are assigned to users within the Commonwealth's portal. The Commonwealth has made a decision to replace the current portal technology supporting state agency websites and outsource management and maintenance of state websites to a third-party vendor. As a result, DLI UCMS site access will remain on the current portal technology. The current technology will need to be managed and maintained only for UCMS and the cost for the technical staffing and skills may be cost prohibitive. DLI will need to begin technical and program planning to identify and evaluate affordable UCMS portal alternatives and interim strategies with the Commonwealth's Office of Administration.

3.3 What Changes Are Necessary in the Program?

What are the scope and magnitude of the changes necessary to solve the critical path program and technical management issues?

The changes necessary to address the critical path issues are in three areas: leadership, program management, and technical strategy/management. Leadership and program management changes must be organizational imperatives. It is essential that these changes be in place before dealing with the current UCMS technical issues or pursuing other alternatives. These changes are also essential to create institutional capabilities within DLI for successful and affordable acquisition and sustainment of complex software-intensive technology.

3.3.1 Leadership

- Continue the shift started in 2011by the current Secretary of DLI to adopt a new paradigm toward contract and program management. Relying on the "contractor" to self-manage to get the UCMS capability (or other new contracts or capabilities) developed and operational has not been a successful strategy and is not a best practice.
- Establish a formal governance structure and process for adjudication of critical trade-off decisions and continual assessment of an integrated set of program performance measures (particularly risk) and decision criteria for judging milestone success. The existing informal governance structures have not been effective.
- Create a formal set of performance criteria, measurement system, and metrics for assessing the program and to use in providing timely information to senior leaders from continuous analysis (cost, risk, system trade-off, project and system performance,

etc.) for effective and systematic decision making. This will involve explicitly identifying goals and objectives as well as criteria for success and making "go-no go decisions" on IT investments, upgrades, and deployment. For example, DLI should establish specific quantifiable measures and metrics of performance for key decision points such as "go-live" criteria.

- Realign the position of the DLI CIO to report directly to the Secretary as a Line-of-Business within the organization. This will create a peer-to-peer, IT-business partnership relationship across the senior staff and make the CIO function as a team member with other lines-of-business. This realignment is essential to insure IT and business capability and resource needs are always aligned for success and the Secretary has line-of-sight visibility of mission critical IT capabilities.

3.3.2 Program Management

- Appoint a dedicated program manager (PM), reporting to the position of the DLI CIO, who is experienced in the acquisition of complex, software-intensive information systems with authority and responsibility to execute the UCMS program and the contract. Appoint a deputy program manager (DPM) from the UC business organization to enable a shared responsibility as a team. The roles, authorities, and responsibilities of the PM and DPM should be formally established.
- Establish and staff a formal UCMS program office consistent with the technical and non-technical disciplines, processes, and practices required for complex program or project management.
- Resource OIT staffing needs to enable the capabilities necessary for DLI to have the organic capability to effectively support the UCMS.

3.3.3 Technical Strategy and Management

The UCMS R-3 program can be rebaselined to achieve a higher probability of success or alternative acquisition pathways can be considered. As DLI considers its options, it should revisit the original UCMS baseline of goals, expectations, assumptions, cost, schedule, and functionality as well as other factors previously highlighted. The DLI may wish to consider the following actions as part of its rebaselining strategy.

- Assure the viability of the legacy system as an insurance policy for claims processing and payments to include updates to address legislation and policy mandates.
- Mature and stabilize R-2 as a priority before continuing with R-3; once R-2 is mature and stable look to transition niche COTS products to less expensive, open source alternatives as DLI determines to be appropriate and affordable.
- Explicitly set criteria for a "go-no go" decision to operationally deploy UCMS as the core UC enterprise system. This requires that DLI (1) determine and describe what level of performance UCMS R-3 (and an integrated R-1/R-2/R-3) must demonstrate in operational testing for DLI to have confidence that UCMS can be deployed initially and at scale across the enterprise; (2) define the measures, associated metrics, and data necessary to achieve that level of confidence; and (3) determine the DLI process for making the decision about UCMS deployment and the transition of the legacy system.

- Change the current "big bang" R-3 deployment approach to an incremental capability and deployment strategy to reduce risk and increase confidence. Changing from the current "big bang" approach has two elements. (1) Shift to a deployment strategy for R-3 based on deploying R-3 in increments of capability (i.e., R-3A, B, and C…) which inherently leads to higher confidence for success at a lower risk. Initially deploy a minimum essential initial claims processing and payment operational capability and then add other functionality such as appeals over a period of time based on demonstrating a specified level of maturity.

  For this incremental release based strategy approach to be effective, DLI must determine what functionality provides the most important business value. (2) Deploy this minimum essential capability in one service area for new claimants to gain DLI and public user experience confidence in the system and then expand the deployment to other service delivery regions based on achieving established performance goals. Pace deployment by the readiness of DLI knowledge workers and IT staff to use and support the system as well as achieve system performance.
- Pace the timing of a decision to advance R-3 based on establishing a disciplined technical process that has integrity and creates user confidence. This will demand several specific actions that are identified below.
  - Re-validate and prioritize all user requirements to first achieve the minimum essential operating capability necessary to transition off the legacy system with confidence. This effort spans all aspects of the requirements process and requires rigorous configuration control so there is visibility and traceability of requirements to test outcomes. This requirements re-validation activity should include participation of the same Contractor and DLI testers who will conduct ST and UAT.
  - Halt the "test and fix" approach and implement a disciplined and rigorous automation driven test program. This effort should require 100 percent independent path coverage in unit test. To date, this has been a missed opportunity to discover defects earlier, prior to System Test. Additionally, (1) set explicit goals and objectives, criteria for test coverage, test readiness, and test success for all use cases and test scripts so there is consistency across all aspects of R-3 testing; (2) prioritize test objectives to address user minimum essential capabilities first; (3) create a detailed test plan with buy-in by DLI and Contractor senior leadership with training for all DLI and Contractor testers so all are on the "same page." The engineering based approach implemented by the Contractor in late 2012 is more representative of the characteristics of this type approach, but it was not applied to 100 percent of the R-3 program. There must also be continual engagement of DLI and Contractor leadership in testing to provide total transparency.
- Determine the quality attributes of the Contractor's design of the UCMS infrastructure and the operational attributes DLI requires of the system to inform future decisions about how to modify or evolve the system and identify patterns of potential changes to achieve a defined set of performance goals.
- Conduct an actual stress test to determine the actual performance limits of the UCMS infrastructure for R-1/R-2 and the factors that drive performance degradation; resize and configure the test environment to 100 percent of the production environment as affordable.

- Make successful completion of UAT the entrance criteria for operational testing of the UCMS. The term operational testing is used to mean the field test of UCMS under real claims scenarios and events for the purpose of determining the effectiveness and suitability of the system by typical knowledge workers. The objective of operational testing is to determine the degree to which the system can be placed into operation and accomplish the critical mission for which it was intended. This operational test should be based on the use of large numbers of UC field level claims processing scenarios or cases until the confidence level criteria for deployment has been achieved. In other words, induct a significantly large number of beneficiary claims into the operational test environment and measure the timeliness, accuracy, and consistency of transactions and payment files until DLI is highly confident that once UCMS R-1/R-2/R-3 is turned on as an integrated enterprise system that it works seamlessly the first time and every time.

3.4 Are Contractor and DLI Resources Sufficient?

Is the combination of PA and contractor resources sufficient to address design, quality, performance, and functionality issues and achieve success?

- **DLI**

  DLI's current IT staff resource capabilities were not sufficient at project initiation for the scope and complexity of such a large scale project. That situation has not changed. DLI's resources are insufficient in three critical areas: (1) skills and staffing capacity for sustainment of the UCMS software applications, (2) skills and capacity for acquisition/project management, systems engineering, and integration of complex programs, and (3) the range and depth of the specialized skills and capacity related to the management and operations of more modern technology environments like the UCMS architecture.

  The DLI staff has demonstrated exceptional knowledge and expertise in all aspects of the UC business requirements and the DLI OIT IT staff has made strides in assuming greater responsibility for the UCMS infrastructure. The success that has been achieved to date is due in large part to the efforts of certain DLI staff members who succeeded in the face of incredible challenges. However, these efforts cannot be sustained as a substitute for creating the institutional capabilities that are up to the task of managing the UCMS life cycle. The level of intensity that enabled this success will be difficult to sustain without greater range and depth of specialized skills and capacity. The Contractor has significant bench strength, but the key issue is DLI's ability to plan and provide management oversight of the Contractor.

  As evidenced during the course of the program, there is limited expertise and capacity in terms of numbers of UC staff who can be made available and have the abilities to perform in this complex technology acquisition environment. The current DLI resource base has not been sufficient to achieve and sustain active engagement with the Contractor over the life of the UCMS program to staff critical program management capabilities. Further, DLI was never able to staff the project management functions proffered in the UCMS solicitation and DLI as

an organization is not aligned with the technical and program management skills required for such a complex acquisition program.

The DLI IT staff has successfully been able to facilitate the refresh of the UCMS test and production processing environments and assume greater responsibility for their management, but the IT organization is thinly resourced. Currently, the OIT application staff has only about 50 percent of its positions filled and it has no Java expertise which is the programming language for UCMS. There are two key aspects to this staffing issue. First, support of advancing technology environments creates a demand for even more specialized IT expertise than in the legacy type environment so there is generally less flexibility in being able to re-allocate staff to tasks outside their area of expertise without significant and continual training. Secondly, DLI has limited capacity to assume technical oversight and management of the Contractor software maintenance contract for R-1/R-2.

The DLI needs to move swiftly and deliberately to obtain the organic resources and expert competencies to assume greater responsibility for technical support to acquire and integrate in-house and contractor resources to successfully address five key challenges. These challenges include: (1) completing development and maturation of R-2 that was prematurely transitioned into production; (2) managing the associated R-2 maintenance contract; (3) transitioning the requisite technical knowledge and skills to sustain UCMS (R-2) from the Contractor to the organic staff; (4) sustaining the legacy system to insure uninterrupted service to beneficiaries; and (5) completing development and transition of R-3. DLI's decision to have the Contractor assume the R-2 sustainment role is a significant step in mitigating risk to maturing R-2, but is not sufficient without investing in greater in-house capabilities and capacity.

- **Contractor**

  The Contractor has an expansive resource base of relevant knowledge, tools, practices, and experience to draw upon. As demonstrated in the UCMS program, these inherent capabilities do not necessarily transfer to a specific development program, like UCMS, without a qualified workforce that is well led and managed staff to execute a disciplined process. There are concerns about the Contractor's ability to effectively staff and manage a qualified on-site workforce at DLI. These concerns are based on three considerations: (1) discontinuities in the UCMS contractor's workforce that have been detailed in this report, (2) DLI's on-going experience with the Contractor's challenges in providing on-site staffing of the R-2 sustainment contract with requisite specialized technical staff including business analysts, and (3) the Contractor's ineffective project management that led to weaknesses in process and practice discipline. In moving forward, DLI may wish to consider other options to complement its capabilities such as technical and program management expertise that can be accessed through contracts for systems engineering and technical assistance. DLI's ability to leverage this resource is driven by affordability considerations and its ability to effectively manage and perform oversight of complex systems, software engineering, and exercising appropriate project management oversight.

4 Recommendations

These recommendations identify strategic courses of action that senior DLI leadership may desire to consider in making decisions about how to move ahead regarding the UCMS program. These recommendations are grouped into two categories. The first set of recommendations identify courses of action regarding seven critical factors that are essential to first enhancing DLI's capacities for managing complex technology programs and sustaining the current core mission. The second group of recommendations deals with the next steps regarding options related to the UCMS program.

4.1 Critical Path Success Factors

- Continue to take ownership of UCMS and become aggressive in oversight and management of the contract and program.
- Create a rigorous and integrated governance structure to include re-establishing the IV&V function with regular engagement with DLI senior leadership.
- Establish explicit criteria for the meaning of success and "go no-go" decisions that are enabled by a performance measurement system to include measures and metrics.
- Appoint a skilled and experienced program manager (and deputy) who is empowered with authority to direct and control the program and contract; create and staff a dedicated program management organization with all necessary functions and performance measurement capabilities.
- Realign the position of the DLI CIO to report directly to the Secretary as a Line-of-Business creating a peer-to-peer, partnership relationship across the senior staff.
- Adopt and use a formal risk management process to drive leadership toward timely risk mitigation actions.
- Execute and resource a strategy to operationally sustain the UC legacy system as an "insurance" policy until a high confidence operational capability for unemployment insurance claims processing and payment has been demonstrated.

4.2 Next Steps Regarding UCMS

- Stop the current R-3 effort.
- Prioritize efforts to stabilize the UCMS infrastructure and mature R-2; then enable planning actions to begin transitioning the UCMS architecture from niche COTS products to open source alternatives where appropriate.
- Rebaseline (restructure) the R-3 approach or seek an alternate pathway. If DLI elects to rebaseline the approach to R-3 this will require DLI to create a contract that that explicitly defines the terms and conditions of the restructured effort previously identified in this assessment. Whether DLI rebaselines R-3 or seeks an alternative acquisition pathway to R-3, the approach should be based on first placing in operation a minimum essential operational UC

functional capability for claims processing and payments that provides the functionality of the legacy system and operates on the UCMS architecture. The alternative minimum capability should be designed to enable confidence in turning off the legacy system and enabling incremental enhancements to achieve the DLI UC business goal based on affordability, risk, and business value considerations.

- In winding down the R-3 effort, (1) conduct a complete review of contract requirements for deliverables, their status, and quality with emphasis on tools and technical data including source code, and (2) insure the Contractor fully documents all code and tests; and (3) conduct a thorough review of this documentation to insure it is complete and potentially able to inform future options.

5 Summary

The problems evidenced in the UCMS program and highlighted below are too systemic in the acquisition of complex information technology systems. They are characteristics of the challenges organizations often experience in attempting to plan and execute complex software-intensive technology acquisitions that exceed the organization's capacities for program and technical management.

The UCMS success that has been achieved is due in no small way to the hard work and dedication of individuals within DLI. These individuals are passionate about the DLI mission and persevered in the face of monumental challenges that they did not know and understand at the time the project started. However, such a level of effort cannot be sustained and cannot for long suffice for creating the institutional capacities needed for the task at hand.

The accumulation of UCMS technical and program risks and issues were continually identified over a critical four-year period (January 2007-June 2011) of the program by the IV&V contractor. However, these red flags and warnings were not acted upon decisively by senior DLI executive leadership at the time creating a bow wave of schedule pressure and program performance issues.

The current Secretary of DLI and the current Deputy Secretary of DLI have recognized these issues and have taken the initiative to assume control over the UCMS program and consider how best to proceed. The task is formidable since in these situations there are no quick "silver bullet" solutions to the challenges. However, options such as rebaselining R-3 or seeking other acquisition pathways are feasible in working toward a lower risk, higher confidence approach in dealing with the UCMS challenges given adequate resources and time.

The underlying UCMS infrastructure does perform; the R-2 Tax System functionality was prematurely pushed into production and will take calendar time and resources to mature. DLI has recognized these R-2 challenges and is taking aggressive action in this regard. The R-3 program is the crux of the problem. R-3 embodies the most critical UCMS functionality—UC claims and payments—which must operationally perform the first time and every time. UCMS has not yet demonstrated that capability to justify a decision to approve its deployment as the sole Commonwealth UI enterprise system.

The UCMS schedule was based on initiating a set of complex tasks that were to be implemented in parallel at the start of the program. The scope of the effort was underestimated to deliver the operational UCMS capability required. This situation created inherent risks that were not mitigated early on in the schedule and were amplified by an erosion of discipline in the Contractor's execution of processes and practices.

The Contractor successfully implemented the UCMS infrastructure and has made numerous efforts to remediate the technical and management problems in the development of the R-2 and R-3 software applications. In 2012, the Contractor put in place a more rigorous engineering-based approach to instill discipline in the program, particularly impacting R-3 development and testing. This effort is the most recent of many such improvement efforts taken by the Contractor. While

commendable, it came much too late and has not delivered the outcomes necessary to achieve UCMS program goals.

A key concern is that DLI's capacities are barely sufficient to sustain the legacy system and address the premature deployment of R-2. This fact suggests the need to establish DLI priorities based on business value and affordability and to quickly enhance the DLI OIT in-house and contracted capabilities.

Finally, the aggregate risk in the program today creates a set of challenges that cannot be solved quickly. The level of risk coupled with the current resource environment, the mission critical nature of UC systems, and the contract environment demands DLI make timely, decisive decisions. The UCMS program is clearly challenged, but the program can be rebaselined to a lower risk, high confidence approach to achieve its intended goal or alternatives can be pursued to leverage the investment in the UCMS infrastructure.

References and End Notes

[1] Risk and risk management concepts and practices are defined in the project management, acquisition, and engineering literature. Examples include the Risk Management Guide for Department of Defense (DoD) Acquisition, Project Management Institute Project Management Body of Knowledge, Software Engineering Institute Continuous Risk Management Guidebook.

[2] The term rebaseline is a common term in the language and practice of project management. Rebaselining is generally used to mean reassessing the original set of requirements, cost estimates, schedule, scope of work, project assumptions, measures of success, and other aspects of a project. These aspects of the original baseline for the project are then restructured based on the assessment with the goal of achieving a high confidence, lower risk approach to achieving success. See OMB Memorandum for Chief Information Officers, "Information Technology Investment Baseline Management Policy," June 28, 2010.

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[25] Kossiakoff, Alexander, William N. Sweet, Samuel J. Seymour, and Steven M. Biemer. Systems Engineering. Principles and Practice Wiley, 2011. Other definitions of program and project management can be found at the Project Management Institute, A *Guide to the Project Management Body of Knowledge (PMBOK® Guide)* and the Defense Acquisition University.

[26] DLI UCMS Workforce Master List of Contractors.

[27] "Why IV&V Matters," Georgia Technology Authority White Paper.

[28] The issue of ineffective governance is a key thread running through the UCMS IV&V reports and the Grant Thornton June 2011 assessment.

[29] UCMS Program Change Request No. 73; December 17, 2008.

[30] The term rebaseline is a common term in the language and practice of project management. Rebaselining is generally used to mean reassessing the original set of requirements, cost estimates, schedule, the scope of work, project assumptions, measures of success, and other aspects of a project. These aspects of the original baseline for the project are then restructured based on the assessment with the goal of achieving a high confidence, lower risk approach to achieving success. See OMB Memorandum for Chief Information Officers, "Information Technology Investment Baseline Management Policy," June 28, 2010.