Development of the IBM Integrated Solution Marketplace (ISM):
A Systems Engineering Case Study\textsuperscript{1}

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Abstract

Release 2.0 of ibm.com’s Integrated Solution Marketplace (ISM) was one of the first projects where IBM Global Services implemented their Systems Engineering and Architecture (SE&A) methodology. The ISM management team was now looking for the SE&A methodology, where requirements analysis is a core project driver, to help align stakeholder expectations and to deliver a feasible solution within the defined project schedule and budgetary constraints.

The SE&A methodology emphasizes clear definition and understanding of stakeholder expectations by the project team (including the stakeholders) in the initial project phases. Subsequently, system requirements are derived from these stakeholder requirements, and further decomposed and allocated to well-defined components that become the building blocks of the solution and verification architecture.

This gives the project team a powerful instrument to track progress, assess, locate and mitigate risk, and assess the impact of change requests.

The results of utilizing SE&A for the ISM 2.0 were positive. Consensus on core stakeholder expectations was set during the SE&A reviews and the project delivered on these expectations. In addition, the planned SE&A reviews allowed the team to identify and resolve key project issues before proceeding into subsequent project phases. This discipline, along with the attention to detail in developing quality requirements resulted in greatly reduced re-work for the project. Qualify phase testing reported one tenth of the anticipated defects projected and the quality of the deployed application was further substantiated by post launch defect reports. Besides producing a quality application that met stakeholder expectations, ISM 2.0 was delivered on schedule and five percent under budget.

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1.0. ISM Project Background

Two trends in the IT industry in late 1990s led to the development of ISM. The first was the exponential growth of Internet usage and its increasing importance as a marketing and sales channel. Second, IT customers increasingly requested complete solutions to solve their business needs rather than discrete software, hardware and service elements that they had to integrate on their own.

IBM was an early adopter of the Internet as a communication channel, but their web presence was discrete and product oriented. As an example, potential customers had to navigate the ibm.com site specifically and separately for server technologies, application software, and IT-services. IBM and its business partners realized that they were losing valuable leads and potential customers because of this product centric approach.

ISM was initiated specifically to address these concerns and its primary mission was to provide ibm.com with a single point-of-entry for solutions oriented browsing and searching thus allowing potential customers to search for integrated services, technologies, and products to specifically address their business problems. The goal was not to replace the traditional face-to-face sales strategies, but rather to enhance them by providing initial information to potential customers. Further, ISM 2.0 captures valuable leads and provides the sales organization with relevant information to directly engage potential customers.

1.1. ISM Organizational Context: Divergent Requirements from Stakeholders

The ISM project resided within the ibm.com line of business, and it interfaced with almost every other IBM line of business. IBM Global Services performed the actual technical implementation of ISM, and served as an internal supplier to ibm.com. The ambitions for the ISM project were high, reflecting its key role in IBM’s strategy to become a solutions provider. Different lines of businesses, each with diverse business processes, had diverging requirements and expectations for ISM. ISM imposed requirements and constraints back onto the lines of businesses, as well. Information structures had to be aligned for presenting products and services as part of an integrated solution. The different business processes had to be aligned to enable an integrated, “single point of contact” sales approach. It was a challenge for the ISM team to obtain concurrence on the ISM scope and intent from the numerous stakeholders. As one member of the team put it, “Everyone wanted everything”.

1.2. ISM – First Release Deployment

The development team for the first release of ISM had difficulties to pin down the requirements in this environment. Requirements kept changing, and the deployment date for the end of 2001 seemed to be in jeopardy. At the end, the management team had no choice but cutting functionality down to the bone to have a chance to reach the scheduled deployment date. When ISM 1.0 was deployed a few weeks after schedule, it had only a fraction of the functionality originally envisioned.

1.3. ISM – Preparing for the Deployment of the Second Release

The second release of ISM (Version 2.0) had to implement much of the capability originally envisioned for ISM 1.0. Jim, a senior project manager within the ibm.com organization, was appointed Product Development Team Lead (PDTL) for ISM 2.0 in the winter of 2002. The urgent need to project IBM as an integrated solutions provider in its web-presence resulted in increased executive management attention to the ISM project. Jim knew he needed a dedicated team with complete focus on a realistic and stable target. As he put it, “We had to drive a stake deep in the ground with regard to project scope”. Jim decided to “…focus the team on clearly articulated and achievable objectives, exercise the right amount of process and discipline, push decision making down to the lowest level possible, and promote accountability…” The team was strengthened with the addition of two experienced, IBM certified project managers.

This was an opportunity to “make things right” from the start. Time remained a crucial factor, and deployment for ISM 2.0 was scheduled for mid-December 2002. An explicit decision was made to follow
a “time box” approach to reflect the importance of getting critical mission functionality deployed on time instead of waiting for the perfect solution. A key project objective at the start was to manage executive management expectations. The key capabilities required and the project scope had to be clearly defined. It was important to define what was achievable within the defined schedule and cost constraints, and then get this approved by management.

Following Jim’s philosophy of “clearly stated objectives,” one of the first project tasks was to baseline ISM requirements. Although formal specifications existed for the first release, many requirements were implicitly and informally stated in e-mails, memos and other sources. Jan, the requirements-manager on the ISM team, consolidated information from different sources, identified the requirements, and captured them in a Lotus Notes repository. The formal and explicit documentation of all project requirements allowed prioritization, trade offs, and enhanced communications. The documentation also permitted greater visibility into conflicting requirements. As part of managing expectations, Jim had to get the stakeholders to prioritize their requirements. In the absence of forcing this issue “…all their requirements will have a priority of one.”

2.0. Deployment of the Formal IBM SE&A Methodology

IBM Global Services Division (IGS) supported the implementation of the SEA methodology on the ISM project. Ted, the Solution Project Manager for ISM from IGS, recognized the convergence between Jim’s approach and the SEA methodology that was becoming mandatory within IGS for all projects with a budget larger than $500k. In late winter 2002, when ISM 2.0 was well into the concept phase, he contacted Paul and asked him to get involved with ISM.

Paul is a business area manager in the SE&A organization within IGS. He has been one of the prime movers behind the IGS approach to Systems Engineering. One of his team members, Vito, an experienced system architect, had already undertaken training in the SEA methodology and had been exposed to ISM as part of the ISM architecture review process. Paul and Vito prepared the SE&A implementation concept for ISM. They communicated their “how to” approach to Jim during a teleconference and demonstrated a requirements management tool. Paul recalled how Jim had asked some tough questions indicating an immediate understanding of the core concepts. From Jim’s perspective, SE&A offered the well-founded methodology and process-rigor that he needed to control project scope. As he put it, “These guys spoke my language.” He embraced the SE&A implementation approach proposed by Paul and Vito. Several similar discussions followed with the objective of educating members of the ISM team on SE&A basics.

For Paul, this was a very welcome reaction. With a partnership established at the project outset, everyone on the team could focus on the same objectives. In the absence of a collective focus on key project objectives and deliverables, scope creep and requirements flux can become significant, which in turn often led to missed cost and schedule targets. Without significant and proactive management commitment, SE&A can become yet another process on top of all the others. “A process without passion,” as Vito liked to call it, “can make any process ineffective”. Fortunately for ISM 2.0, the SE&A process mandated by the leadership team was well received by most core team members and stakeholders.

2.1. IBM’s SE&A Methodology – Key Drivers and Concepts

At its core, Systems Engineering seeks to facilitate a thorough understanding of a need or deficiency, and to then to provide a framework to develop a solution and verification architecture to resolve the need or deficiency. This requires up-front investment to:

a) Ensure a common and consistent understanding of the need to be satisfied and the capabilities to be developed and integrated between the stakeholders and the project team, and

b) Translate this understanding into a robust solution and verification architecture to serve as a foundation for detailed design, development and qualification of the solution.
Avinash, Jim’s project manager, responsible for managing IGS as a supplier to ibm.com, commented, “Investing up front makes intuitive sense but it is rarely done since the results show up much later.”

To achieve a common understanding of the business processes and their characteristics, IGS developed an SE&A approach that is characterized by:

a) Clear distinction between the problem domain (mission and stakeholder requirements) and the solution domain (system requirements)
b) Clearly defined stages in the development cycle with respect to the level of detail with expected maturity of the solution and documentation
c) Intense focus on getting requirements right by defining their final acceptance criteria for compliance
d) A solid architecture and high level design that is driven by, and compliant with the requirements
e) A common, structured, traceable and richly attributed repository for requirements and design information
f) Structured and scored reviews to ensure the quality of work products at each stage in the project
g) A high level of interdisciplinary collaboration to ensure that all aspects of a problem or decision are accounted for
h) An SE&A team charter that includes overall responsibility for the technical solution and serves as the program or project manager’s technical resource while interfacing with the stakeholders, the development team, and the verification (test) team.

Figure 1 illustrates the IGS SE&A methodology and how it augments IBM’s enterprise project framework, BTOP, with activities, work-products and reviews.

Figure 1  SE&A activities mapped into the standard IBM project framework, BTOP.
3.0. ISM – Development of the Second Release (ISM 2.0)

3.1. Getting a Firm Grip on ISM 2.0 Project Scope and Requirements

Vito joined the ISM 2.0 Systems Engineering (SE) team as Lead Systems Engineer in April 2002. He was responsible for all SE work-products and deliverables. From the date he joined, Vito had 10 days to prepare for the ISM 2.0 System Requirements Review (SRR). At this review, IGS had to demonstrate to ibm.com a common understanding of the required ISM capabilities represented by a complete set of system requirements. Further, the SE&A team had to demonstrate a feasible concept for implementing the technical solution within cost and time constraints.

This would have been impossible without the work already done by Jan. While requirements had been identified and fundamental architecture formulated, there were outstanding issues to be addressed before the team had stakeholder and system requirements ready for the systems requirements review. Among the actions taken prior to the SRR was to establish:

**Consistent and correct level of requirements detail and completeness**

The stakeholder requirements had to be reviewed to ensure they communicated what the stakeholders expected of the system from an operational and business perspective.

System requirements, on the other hand, had to be written to describe the solution in terms of what it would provide, without constraining the solution by unnecessarily defining how it would accomplish that. The level of system requirements detail and completeness had to satisfy the stakeholders that their expectations had been addressed and the architects had a feasible architecture.

**Understandable and unambiguous requirements**

System requirements represent formal agreements between the stakeholders and the development team. It is essential that both groups have a consistent understanding of the desired system capabilities and characteristics. The terminology used had to be understandable by both; the requirements should not allow for broad and divergent interpretations.

**Discrete and independent requirements statements**

Making sure that requirements are stated in discrete and uniquely identified requirements statements ensures that the project’s technical content is quantifiable. Taking care that each requirement is as independent as possible from other requirements enhances the quantification fidelity and eases the assessment of future change requests.

**Requirements traceability**

Traceability is a core SE&A concept. Traceability is essential for assessing the impact of change requests, along with assessing compliance of the solution to system and stakeholder requirements. The identified stakeholder and system requirements on the ISM project had to be structured for traceability.

**Acceptance Criteria**

SE&A methodology requires that each system requirement be linked to verifiable final acceptance criteria. This supports the system test case definition, as well as enhancing the common understanding of the requirements. The risk of future disputes as to whether or not a requirement had been fulfilled is reduced.

**Stakeholder ownership**

Each stakeholder requirement was linked to the specific owner stakeholder(s). This stakeholder had to be involved in any decisions impacting this requirement.

Vito organized several pre-SRR sessions between architects and stakeholders from ibm.com to address the above concerns prior to the SRR. During the pre-SRR sessions, the number of stakeholder requirements was reduced from the original 100 (identified by Jan) to 48. During the three-day, on-line
SRR, the number was further reduced to 46. Rather than signifying a reduction in scope, this reflected an effort to achieve the correct level of detail and consistency in the requirements. **Figure 2** shows how two original ISM 1.0 requirements were replaced by one stakeholder requirement stating an expectation and a set of system requirements with corresponding acceptance criteria stating how compliance will be verified.

<table>
<thead>
<tr>
<th>Original ISM 1.0 Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR004 Save Search Results</td>
</tr>
<tr>
<td>The customer can save any set of search results.</td>
</tr>
<tr>
<td>SR005 View Saved Search Results</td>
</tr>
</tbody>
</table>

**ISM 2.0 Stakeholder Requirement and derived System Requirements**

**SHR-17**
The Expectation is that users can save find criteria and retrieve these criteria in later sessions to re-query the system.

**SR-17.1**
The system shall provide registered users with the functionality to save and retrieve browse criteria.

*Acceptance Criteria:* Registered end users can log in and save browse criteria. Subsequently retrieve and reuse stored browse criteria.

**SR-17.2**
The system shall provide registered users with the functionality to save and retrieve keyword search criteria.

*Acceptance Criteria:* Registered end users can log in and save keyword search criteria. Subsequently a logged in user can retrieve and reuse the saved keyword search criteria.

**SR-17.3**
The system shall provide registered users with the functionality to save and retrieve query criteria.

*Acceptance Criteria:* Registered end users can log in and save search query criteria. Subsequently a logged in user can retrieve and reuse saved query criteria.

**SR-17.4**
The system shall provide registered users with the functionality to view results based on browse, query and keyword search saved criteria.

*Acceptance Criteria:* Registered end users can log in and save browse, query, and keyword search criteria. Registered end users can return to ISM later, log in, and view results based on retrieved criteria.

**Figure 2** A sample of how original ISM 1.0 requirements evolved through SRR

The level of formality with regard to stakeholder and system requirements was new to everyone on the team. Jan recalled her experience from earlier projects. “We used to give our requirements to the development team and they would disappear behind ‘a curtain,’ and we did not see them again before they returned with the code that might or might not have done what we needed”. Keith estimated that they spent about 5 to 10 times as much time on requirements as what he was used to. “It was a tedious and painstaking process, but it definitely paid off in the end”. Jeannette, the Lead Architect, looked back at the SRR as one of the most valuable project activities. The collaborative review sessions and participation from both business and technical stakeholders from every area brought the business side and the technical side together, with a single, agreed-to set of system requirements. This proved to be a key foundation for the phases that followed by ensuring what was being designed, developed and tested met the business expectations. From a project management standpoint, Avinash was thrilled. “The fact that we could count the requirements provided us with a very strong project management metric”.

Despite the successful SRR, Vito was not completely satisfied with the requirements structure. Although the number of stakeholder requirements was reduced, he felt he lacked an instrument to keep the primary project objectives in focus. He felt they often found themselves in discussions around items that were not really in the scope of ISM 2.0. Thinking about his SE&A training, Vito recalled the concept of Critical Mission Requirements. Critical Mission Requirements state the overall project objectives in a small number of clearly articulated requirement statements. The ISM team agreed to four ISM Critical Mission Requirements. These are shown in **Figure 3**. Mission Requirement five was added later, reflecting that this was a “time boxed” project where the schedule was as important as the technical
content. The five Critical Mission Requirements proved to be invaluable in managing the project scope during subsequent project phases.

<table>
<thead>
<tr>
<th>MR1: Solution Information Source (Front End)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The &quot;solutions marketplace&quot; will allow customers to conduct solution research on the web and gain access to a single trusted source of IBM and IBM Business Partner solution information</td>
<td></td>
</tr>
<tr>
<td>MR2: Teleweb</td>
<td></td>
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<tr>
<td>The &quot;solutions marketplace&quot; will allow customers to quickly connect with a knowledgable IBM Business Representative to assist them through the solution purchase process, which may include linking them to an IBM solution provider</td>
<td></td>
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<tr>
<td>MR3: UE and IBM Standards (Front End)</td>
<td></td>
</tr>
<tr>
<td>ISM 2.0 will comply with ibm.com user interface and web site standards</td>
<td></td>
</tr>
<tr>
<td>MR4: Content Management</td>
<td></td>
</tr>
<tr>
<td>ISM 2.0 will be provide the mechanisms to manage Solution Content in compliance with the needs and guidelines set by the ISM business team for ISM 2.0</td>
<td></td>
</tr>
<tr>
<td>MR 5: Deploy ISM 2.0 by year end 2002 (Added 8/8/02)</td>
<td></td>
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</tbody>
</table>

**Figure 3** ISM 2.0 Critical Mission Requirements

3.2. The ISM 2.0 Project Infrastructure

The ISM 2.0 team was highly distributed geographically. This is not unique to the ISM project and is common within IBM Global Services internal projects. IBM is utilizing virtual “Team Rooms” within a Lotus Notes based environment to allow on-line collaboration between team members working on a project, along with providing them access to a common project data/documentation repository, regardless of physical location. Jim, working from a “home office” like many of the ISM 2.0 team members, was a strong believer in the concept of “virtual teams.” He utilized the Team Room, supplemented with teleconferences, very effectively. Apart from one interdisciplinary, co-located session that is discussed below, every ISM 2.0 meeting and review took place on-line to avoid travel time and expenses.

Jan had already captured the original stakeholder and system requirements in the Team Room repository, but they lacked the basic features of a requirements management (RM) tool. Features such as sorting, filtering, and tracking of requirements based on different attributes as well as capture of traceability links between requirements at different levels of design with corresponding test cases were missing. Vito had previous experience as a Lotus Notes developer and customized the Team Room environment to accommodate some basic RM functionality. Traceability could not be easily implemented in the Team Room environment and was captured in a specialized RM-tool; Requisite Pro.

3.3. Defining the High Level ISM 2.0 Design

Mapped onto the traditional IBM project framework, a completed SRR marked the end of the concept phase. The project now entered the Plan Phase, which ends with final commitments to scope, cost and schedule. Accordingly, the focus was now shifted to finalizing the architecture, high-level design, component requirements, and preparing for the Preliminary Design Review (PDR). Once the component requirements and design baselines were established through the PDR Ted, the ISM Solution Project Manager, used these baselines to determine the final effort (sizing, etc.) and time estimates for the ISM 2.0 development phase to finalize the project plan.

Traditionally within IGS, the system architecture and the high-level design are driven and defined by the software development team, while the project manager supervises customer communications and expectations. Ted recalled from his earlier projects, and from ISM 1.0 in particular, that he had to engage the customer with detailed discussions focused on project scope. Sound discussions required that he gain a
deep understanding of the system architecture. He found this frustrating, as it drew his attention away from managing the project and engaging the customer at a business level. Ted found that having the SE&A team responsible for the technical solution on ISM 2.0 allowed him to engage with the customer at the business level and eliminated one of his big frustrations with ISM 1.0

Splitting a development project into stages has traditionally been part of good software development practice. The elevated attention and visibility devoted to the system architecture and high-level design on the ISM 2.0 project, as a result of the SE&A methodology, was new to the team. These activities were formally and explicitly discussed with the customer and emphasized much earlier during the project, and a distinct team with an SE&A charter was accountable for the associated work products. In addition, the concept of a PDR to ensure compliance with the stakeholder and system requirements before the project could proceed into detailed design and coding was new to the team. Accordingly for ISM 2.0, the high-level design and architecture formulation activities were strictly requirements driven. Component level requirements were derived from system requirements to define the contribution of components to the overall system functionality. Traceability back to stakeholder and originating system requirement(s) was established and rigorously managed in accordance with the traceability map in Figure 4. A traceability flow down from a Mission Requirement has been included in Appendix A to illustrate the concept of traceability.

![Figure 4 ISM 2.0 Traceability Map](image)

The traceability map shows how a requirement typically flowed from a stakeholder requirement to a set of component requirements on the ISM 2.0 project. The traceability map also shows how the User Experience (UE) components were identified separately. Keith, who was in charge of the UE aspect of ISM, was challenged with making sense out of stakeholder requirements like, “It shall be easy for the user to update…” Although IBM has detailed internal standards for the look and feel of ibm.com-web-pages, these do not provide the level of detail needed for the actual implementation of an application. Keith conducted several user surveys based on ISM 1.0 and developed layout and interaction models. He designed “wireframes” which are static, graphical representations of every web page ISM would have to generate (see Figure 5 for an example wireframe). For critical user interactions he also developed
functional prototypes to serve as specifications for the development team. Pierre, the leader of the software development team, called this “the best UE specifications he had ever seen”.

Figure 5  Sample User Interface “Wireframe”

As the ISM 2.0 high level design evolved and the detailed development effort scheduling and budgeting was developed, it became clear to the project leaders that all the stakeholder requirements that were identified and agreed to during the SRR could not be implemented in the designated timeframe. The team now re-engaged with stakeholders, prioritized each stakeholder requirement, and developed a measure for the implementation effort needed for each of them. Each stakeholder requirement was reviewed for its contribution to the Critical Mission Requirements. The Mission Requirements helped everyone involved (both stakeholders and development team members) to focus on the critical and core capabilities of ISM 2.0 release. Jan recalls, “It killed discussions about this whistle or that bell and focused us on the core functionality to be implemented.” At the end of the discussion, the number of stakeholder
requirements to be implemented as part of this second release was reduced to 35, without compromising the fundamental project scope as stated in the Critical Mission Requirements.

Ted knew that in any other project this would have been a continuous fire-fighting exercise, and he would have been in the middle of it. Now the SE&A team played a facilitation role in the engagement with stakeholders with regard to the technical scope of the project. The SE&A team provided a rational and structured approach for executing this role. This combined with robust documentation and analysis at every step reduced potentially heated and contentious debates into rational and objective discussions. Ted could now concentrate on customer relations on a business level, and report progress with a high level of confidence.

Change management was given particular attention. Traceability of requirements from stakeholders to the architecture allowed for increased confidence during impact assessment. The team could immediately assess components impacted by a proposed change and return to the stakeholders with a consequent impact to the project schedule and budget. All change requests were justified and reviewed vis-à-vis the Critical Mission Requirements.

If issues surfaced at the implementation level, the traceability enabled the team to assess system level impacts. If an issue had the potential of impacting a stakeholder or system requirement, the stakeholder who owned it was involved in issue resolution. Every impacted stakeholder and project member understood the issue, its associated consequences, and the resolution.

The resulting architectural documentation allowed Ted to manage his resources with greater confidence. “I could now understand architecturally what resources needed to be engaged when.” Despite this, a firm deployment date made planning and resource allocation a challenge. One such planning challenge was to engage the necessary development resources; while the appropriate resources were identified and assigned to the project a good portion of these resourced did not become available as planned due to non-ISM development work priorities.

The requirements definition and architectural efforts leading to the SRR successfully addressed managements’ concerns in aligning stakeholder and project participant expectations and setting project scope and definition. The next challenge for the ISM team was to identify component level requirements and to produce a high level design in support of these requirements. These were to be reviewed at the next project review; the Preliminary Design Review (PDR) which was scheduled for mid July 2002.

Although the SE&A and user experience teams worked diligently to produce work products that directly traced to the defined requirements, the limited involvement of the development team due to their delayed full participation on the project produced a significant number of development related questions/issues during the PDR sessions. Although a good portion of these may be attributed to the late engagement of development resources, the high number of documented issues identified did not result in a passing score for this review.

The Systems Engineering process requires that a passing score must be achieved at each key check point and consequently that major impacting issues/defects are resolved before proceeding to the next phase of a project. For ISM 2.0 the issues identified during the PDR sessions in which the development team was a core participant, allowed the management team to gain a full appreciation of the gaps identified and to put in place an action plan to address these.

The issues identified during PDR emphasized the value of the scored reviews. Every member of the project management team would highlight the value in being able to quantify the quality of the work products and to be able to assess their maturity and progress towards the defined and agreed upon, project goals. “Earlier, I could only report if a deliverable was produced or not, and its cost when a milestone came up,” Ted commented. “The actual quality of the work performed and its compliance with customer expectations was traditionally not revealed until system testing and deployment.” Now the management team had a measure of work product quality and, through direct stakeholder involvement, the “quality of agreement” between the solution and the stakeholder expectations. This made it possible to identify risks, pinpoint dependencies, and establish action plans to address these.
4.0. ISM – Detailed Design and Development (ISM 2.0)

One of the actions taken to resolve the issues identified during the PDR sessions was to bring the geographically dispersed SE&A, development and business teams together for a week long, co-located series of Joint Application Development (JAD) sessions. The strong requirements definition set for ISM 2.0 in which requirements were categorized and prioritized, allowed the team to structure the JAD effort into separate focused break-out sessions in which specific project participants could focus on specific technical areas. Key to the success of these sessions was the participation of the third party vendor who developed most of the code base for the ISM 1.0 project as well as the availability of a mock up user interface prototype on behalf of the user experience team. The JAD sessions produced an action plan which allowed the team to resolve all key issues identified during the PDR session and to proceed on schedule towards the next key check point for the project the, Critical Design Review (CDR).

In preparation for the CDR the detailed ISM 2.0 design was documented in a series of Internal Design Documents (IDDs). Each IDD documented the implementation of one or more stakeholder requirements. It included UE details, interaction/interface details, and a detailed description of the solution approach, including the identification of the source code files and database data elements involved.

The SE&A CDR was conducted in late August 2002. While developers were used to peer-reviews of their designs, the CDR also involved selected stakeholders. Some development team members questioned if this was a useful and sensible approach, along with whether it was an effective use of precious development time. However, from an SE&A perspective, CDR is an important review, as it represents the last opportunity stakeholders have to identify and clarify any issues before full-scale coding begins. In effect for ISM 2.0 the CDR sessions were an instrument to reassure stakeholders that a viable solution existed that would satisfy expectations set during the prior reviews.

Another concern expressed by the development team was that they had only five weeks to finalize the code and conduct unit testing before ISM 2.0 was handed over to the Global Test Organization for functional and system testing at the next key project review; the Test Readiness Review (TRR). While typically such a short development cycle for a project of this magnitude would result in delays and project scheduling impacts, the level of detailed design specifications produced allowed the management team to allocate additional development resources to the project to handle coding of specific design elements. Staffing was added not only to the IBM internal development team but also from the third party vendor that had worked on the ISM 1.0 release.

According to Ted, the interaction with the third-party vendor went smoothly compared to the 1.0 release. Ted attributes this mainly to the well-documented requirements and a component structure that allowed for clearly defined work packages. He recalls, “During 1.0, rework was the rule of the road and caused quite a bit of contention. Now, they (the third party vendor) were very happy, they had clearly defined tasks, and rework hardly occurred. Over the whole project the third party vendor actually ended up spending four man-weeks less than what we had planned for.”

5.0. ISM - System Integration Testing and Delivery (ISM 2.0)

As Kelvin and his test team from IBM Global Test Organization reported ISM 2.0 Functional Verification and System Integration Test results, quite a few people started to get worried. The test team was hardly reporting any defects. “At the start, this would be normal,” Vito commented, “but as the tests got going, defects would normally start piling up.” Vito would have been worried himself, if it he had not worked closely with the test team to define the test cases. Kelvin reported approximately a two percent defect rate for level 1 and 2 defects. Level 1 and 2 defects are severe defects that have to be fixed before

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4 The original ISM 2.0 project plan had allocated hours for third party involvement in an advisory role. The indication of earlier then anticipated involvement indicated by Ted is in reference to the original plan.
ISM 2.0 could be released. Kelvin had expected and had planned resources for a defect rate of about 20%, based on experience with previous projects of similar size and complexity. Figure 6 shows how the actual versus the anticipated defects during the execution of the 1357 ISM functional verification test cases. Kelvin commented that he could not recall the last time he had seen code of this quality.

![FVT Defects Planned vs. Actual](image)

**Figure 6  Anticipated vs. actual defects found during the functional verification test**

The groundwork for smooth testing was done long before TRR. Well-documented and traced stakeholder requirements and corresponding acceptance criteria formed a solid basis for developing the approximately 1350 functional verification test cases. Kelvin pointed out that close collaboration with the architecture team during test planning was a key factor in the low number of defects detected. The high level test acceptance criteria and test architecture had been reviewed at PDR. Subsequent to PDR, with the architecture and high-level design mostly stable, the architects engaged directly with the test team to define and review test cases. Through this close interaction potential misunderstandings were addressed, and the test team gained a deeper understanding of the architecture and the functions of the application. According to Kelvin, the result was “flawless test cases.” “Very often,” Kelvin commented, “misunderstood requirements and poorly defined test cases cause up to 10-20% of reported defects.” Kelvin had estimated 6-7 weeks for testing; they were done after five. User acceptance testing, according to Keith, was a matter of hours, rather than weeks as is normally expected on other projects.

The only problems worthy of mention occurred during performance testing. Due to slight differences between the test and the production environment configurations, some performance issues surfaced. This caused some intensive troubleshooting and the revision of documentation, but this did not cause any delays since it was not on the critical path.

ISM 2.0 went live on the ibm.com website in December 2002, *on the day* projected at the exit of the Plan Phase. At project completion, spending was approximately five percent\(^6\) under budget. When Ted was asked to characterize the rollout of ISM 2.0 he summarized it in one word, “uneventful”.

The deployment of a new application or significant new release is often associated with significant problems during the initial operation. Figure 7 shows the total defect count over the whole project and the first three full months of operation. It shows that the low defect-count continued into the operation of ISM 2.0. If we relate the number of defects to the total of over 1350 functional verification test cases as a measure of functionality, the number of defects discovered during the first 3 months of operation was low.

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\(^5\) ISM Test Status Presentation 10/10/2002

\(^6\) ISM 2.0 ended up spending approx. 2.85 Mio $ out of the original budget of 3 Mio$
6.0. Observations; ISM vs. Non SE Projects

Comparing the ISM projects to 19 projects that did not use the SE discipline leads to the following observations. From the total defect counts by phase Non-SE projects exhibited 53.4% of total project defects during the test phase of the project while for ISM most defects were found during the plan phase (56%). Since SE was introduced towards the tail end of the ISM concept phase one may anticipate that some defects will be uncovered even earlier when SE is involved from project kick off.

Figure 8 shows how ISM compares with other IBM projects that did not utilize SE. Comparing the two curves, we see that the majority of the ISM 2.0 requirements defects were captured during the plan phase; when they can be fixed at a low cost with no significant consequences to the project schedule. In

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7 Compiled from the ISM 2.0 change and defect logs
8 Data compiled from a recent IBM internal study comparing projects utilizing SE and projects not utilizing SE. In this study data from 30 projects was utilized.
the non-SE&A projects however, the bulk of the defects are identified during test where the rework has a significantly higher price. Figure 9 below depicts costs to fix defects detected based on the defects identified by phase. Recent studies estimate that the cost to fix a defect found in concept phase of a project is approx. $20 per defect while the cost to remedy a defect found in the deploy phase of a project will cost $1,080. Utilizing this criteria, ISM demonstrated 2.4 times less cost to fix defects than that of projects not utilizing SE.

Figure 9  Estimated costs to fix defects by phase for ISM vs. projects not utilizing SE

7.0. Summary and Conclusions of this Case Study

The SE&A methodology for ISM 2.0 effectively addressed the concerns of the ISM management team regarding project scope and focus. The requirements driven SE process accomplished Jim’s objective of establishing team consensus on project scope and “...focused the team on clearly articulated and achievable objectives”. ISM 2.0 was delivered on schedule and under budget in full compliance with the set of requirements established for the project. In summary, SE&A enabled the ISM 2.0 team to:

- **Gain and Maintain Consensus on Scope and Objectives:** The definition and consensus on Critical Mission Requirements allowed the team to focus efforts on achieving project objectives. This approach allowed for removal of lower priority functionality without compromising on the overall mission for ISM 2.0. The regular reviews ensured that the whole team, both on the customer and the implementation side, had mutual understanding of the scope at critical stage of the project.

- **Maintain a Solid Requirements Baseline:** The stakeholders were involved in the development process. This ensured a solid requirements base under unyielding change control that was understood and agreed upon by everyone involved. The traceability between all levels of requirements and work products allowed for detailed assessment of any change request which prevented uncontrolled scope creep as well as facilitated sound trade studies and conflict resolution.

- **Keep the Project on Course:** The methodical way SE&A interacted with the stakeholders on a technical level gave the program and project managers the confidence to “let go” of detailed involvement in scope and architecture discussions. This freed their time and attention to focus on their management and leadership tasks. The SE&A checkpoint reviews kept all project participant expectations aligned and addressed any identified issues prior to moving on to the next phase of the project. This assured readiness for the next phase thus keeping the project on course.

- **Assert Better Project Control:** The scored SE&A reviews not only measured the quality of the work products themselves, but their compliance with the objectives of the project. This,
combined with the comprehensive requirements and design repository, allowed the project management team to identify, locate and act on risks at a much earlier stage and with much higher fidelity than from previous projects. As Jim put it when he summed up the benefits of SE&A: “The project management game is all about risk. Now I felt like I had control over what was being delivered, as opposed to earlier when I had the feeling that what was delivered controlled the project and me. SE&A not only lowered the risk, but it gave a better understanding of where the risks were.” All members of the project management team expressed a similar sense of control over the project, and now insist on using the SE&A methodology on their new assignments. Actually, almost everyone interviewed claimed to use and promote the SE&A approach wherever they have been involved since ISM.

- **Minimize Rework:** The SE&A process put more emphasis on up front requirements definition and design. More upfront work was performed to assure that the architecture and design met stakeholder expectations. This provided a solid framework for detailed design and coding. The development cycle was shortened and the development staff augmented for ISM 2.0. Instead of quality problems that conventional wisdom might suggest, the project encountered a low rate of defects and rework after the development phase, as seen in Figure 7.

- **Deliver a Quality Product:** The unexpectedly low defect rate during system level testing indicated an exceptional high quality of the code. This high quality was confirmed by the continued low defect rate reported during the initial months of operation.

- **Deliver on Schedule and Under Budget:** ISM 2.0 went live on the day committed and 5% under budget. SE&A ensured that the release was fully compliant with the overall objectives and the corresponding stakeholder and system requirements stated for ISM 2.0.

An IT project that delivers on every committed requirement on time and under budget is still an exception, rather than the norm in the IT domain. Considering that ISM 2.0 was a one of the early applications of the end-to-end deployment of the SE&A methodology, even the most optimistic were surprised by this degree of success. A project team rarely welcomes being a “guinea pig” for new processes, and a certain level of dissipation could be expected. In this case, leadership understood the SE&A potential and embraced it 100%. The team, which Jim referred to as “an incredible stable of talents”, was receptive to the new approach. According to Vito, “The requirements might have been the project glue, but it was the team that made it stick.”

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Appendix A  Excerpt from a traceability report from Mission Requirement 1

MR: Mission Requirements Trace-To Tree Report
ISM 2.0

Legend
MR  Mission Requirement
SHR  Stakeholder Requirement
BS  Business Scenario
UC  Use Case
SR  System Requirement
CR  Component Requirement
UE  User Experience

MR1: Solution Information Source
The "solutions marketplace" will allow customers to conduct solution research on the web and gain access to a single trusted source of IBM and IBM Business Partner solution information.

SHR1: RSD-02- Provide a standard solution record definition
The Expectation is to Provide a standard solution record definition (i.e. DTD) that meets the needs of ISM Content team, Internal IBM data source groups, and Brand/Customer Sets.

BS6: BS-6-Promotion of ISV solution to ISM
Market manager has a list of key ISV solutions from GSD that they want to have promoted in ISM marketplace so they can initiate the content acquisition process.

UC7: IMPORT ISV AND GLOBAL INDUSTRIES SOLUTIONS TO ISM
Promotion of ISV solution to ISM

SR1: SR-2.1
2.1-The system shall support a standard solution record definition (i.e. DTD) that meets the needs of ISM Content team, Internal IBM data source groups, and Brand/Customer Sets.

CR10: COM-C11- Standard DTD
This ISM2.0 content management component shall ensure support of a standard DTD.

UC2: TECHNICAL ENVIRONMENT SEARCH, REFINEMENT, SAVE SEARCH, REGISTER
Navigate the website with advanced search, make request to save the search, and register with website.

UC10: PUBLISHING SOLUTIONS WITHIN ISM - COUNTRY/REGION TAGGING
Publishing the solutions within ISM

SHR2: RSD-06 -Save and Retrieve Solution Reports
Stake Holder Requirement: The Expectation is to provide registered users with the ability to save solution reports and view saved solution details reports.

BS2: BS-2- Research a solution, save results, and present output
Business consultant has task to research getting a small/medium business customer online (e-Commerce solution), navigates through web site - outcome is presenting output from tool(s) to their client.

UC3: LOG IN, BOOKMARK, SOLUTION SAVE
Log in to the website, view saved search, bookmarks, solution, and saves the solution.

SR8: SR-6.1
6.1-The system shall provide the ability to save solution detail reports by registered users.

SR10: SR-6.2
6.2-The system shall provide the ability to retrieve and view solution reports by registered users.

UC3: LOG IN, BOOKMARK, SOLUTION SAVE
Log in to the website, view saved search, bookmarks, solution, and saves the solution.

UE1: 7.1 Saving Results
Saving Results

UE2: 7.2- Saving Reports
Saving Reports

UE3: 7.3 Saving List Items
Saving List Items

UE4: 7.4 Saved Results
Saved Results