Distributed Development Improvement with VPD™ and Iterative Development, An Experience Report

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Honeywell Aerospace

- Avionics for small to large commercial aircraft
  - Flight controls, flight management, displays, communications
  - Real-time; embedded; database applications
- Software produced in 9 major North America sites and 4 sites outside North America
  - Many distributed development teams
  - Distributed development becoming common
- Recent Aerospace reorganization reinforced the need to develop software in a collaborative, virtual work environment.

The VPD™ Method

- Six Sigma in Honeywell
  - AlliedSignal & Honeywell – Merged in 1999
- Six Sigma and Lean
  - Complementary methodologies
    - Product quality and value stream
    - Looking at the product and looking at the process from product viewpoint
- Lean and Software Development
  - Lean Manufacturing Principles
  - Agile Methods
- Remainder of presentation
  - Application of the Velocity Product Development (VPD™) Method
  - A VPD™ Project: ProjD and Iterative Development

Iterative Development – Project Background

- **Project Description:**
  - Development of a Ground-based Software application
  - Systems Engineering work in Phoenix – 3 engineers
    - System Requirements, System Architecture, SW Requirements, System Integration, System Verification, Delivery
  - Software application development in India – 7 engineers
    - Software design, coding, software integration, software testing
  - Acceptance testing performed jointly with customer
- **Project Challenges:**
  - System domain knowledge resides in Phoenix
  - Interface with customer is via Phoenix systems personnel
  - Minimal product domain knowledge in India
  - Customer's product requirements subject to frequent revisions/ clarifications
  - Customer's priorities subject to change with an expectation for Honeywell to be highly responsive

Iterative Development – Project Background

- **Project Schedule:**
  - Required Deliveries to Customer: Every 3-5 months
    - Delivery 1 – Feb
    - Delivery 2 – July
    - Delivery 3 – October
    - Delivery 4 – January
- **Development approach for Delivery 1: Large Batch**
  - Phoenix provides India with the System architecture definition and software requirements for the product capabilities required in Build 1.
  - India develops and delivers functionality to Phoenix for system integration and test.

Iterative Development – Project Background

- **Delivery 1 Results: Large Batch**
  - Very low yield, ~20% (number of requirements that passed validation testing)
  - Required significant rework to create a version of the product that was acceptable to the customer.
    - Performed nine one-week “iterations” to resolve all issues.
    - Made an extra delivery to customer.
- **Overall results: Large Batch**
  - Product delivered 8 weeks late
  - Significant additional labor to achieve required quality.

- The need for change was obvious. The Project Leader asked for help. A team was brought in to analyze the current situation and identify solutions.

Analyze the Current Situation Using the VPD™ Method

VPD^{TM} Application – Case for Change

- Large amount of unexpected work
  - Driven by Customer and Honeywell management
  - Large % time is being spent on unexpected work
  - Consuming planned contingency time
- Unplanned dependencies with other groups
- Need to change now to mitigate future risks
  - Project Leader asked for help
- Desire to improve performance as a team

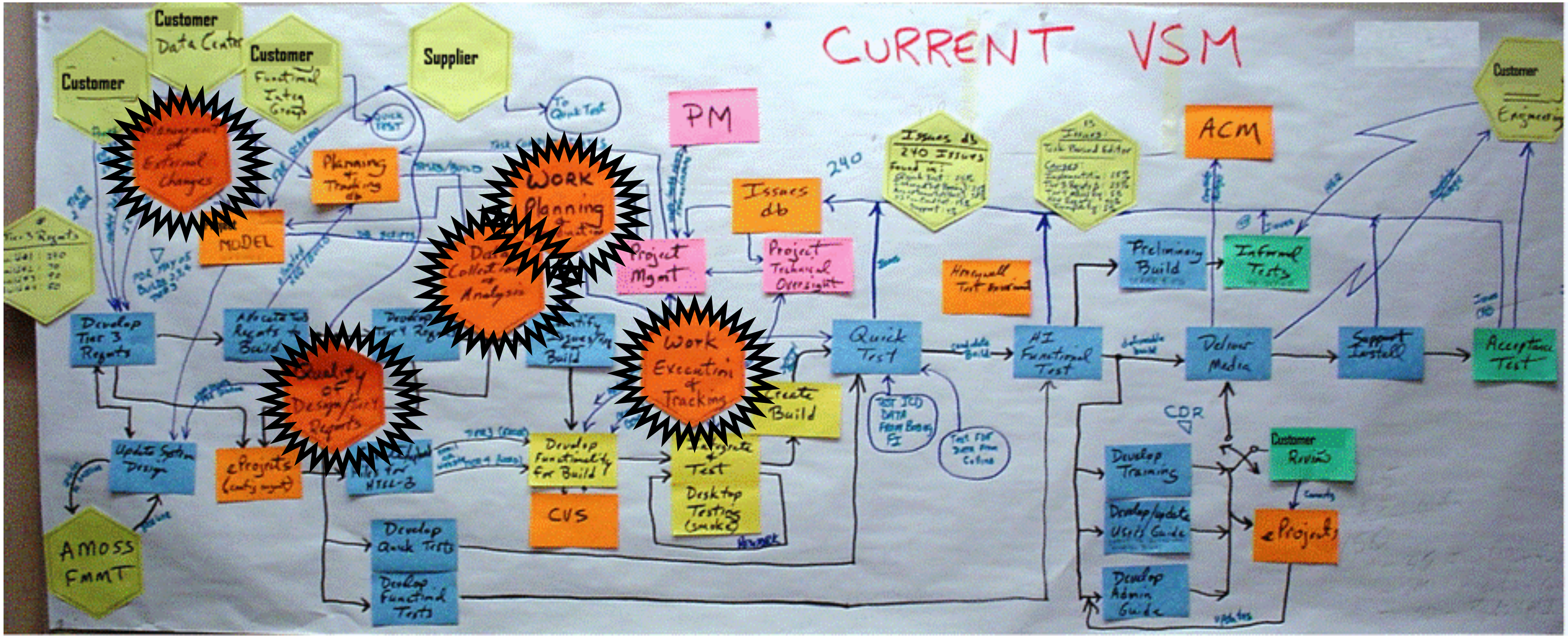
Application of the VPD^{TM} Method

- **The VPD™ Method**
  - **Uses Value Stream Mapping to create a baseline definition of the current process/practices**
  - **Assesses the current process/practices against** an industry-accepted set of lean principles while considering business needs **(e.g. development cost, and milestone performance)**
  - **Records and prioritizes any undesirable observations (UDOs)**
  - **Defines leverage points in the current process/practices**
  - **Creates future-state value stream map to address UDOs and leverage points**
  - **Defines projects to achieve future state**
- **Benefits:**
  - **Looks at business/economic model for solutions**
  - **Identifies quick hit improvements**
  - **Exposes the hidden factory by walking the value stream**

ProjD Development As-Is Value Stream Map

Why Map the Value Stream?

- Understand what’s really happening
- Identify and collect <u>U</u>n<u>D</u>esireable <u>O</u>bservations (UDOs)
- Identify Leverage Points – Where to apply effort to get desired change



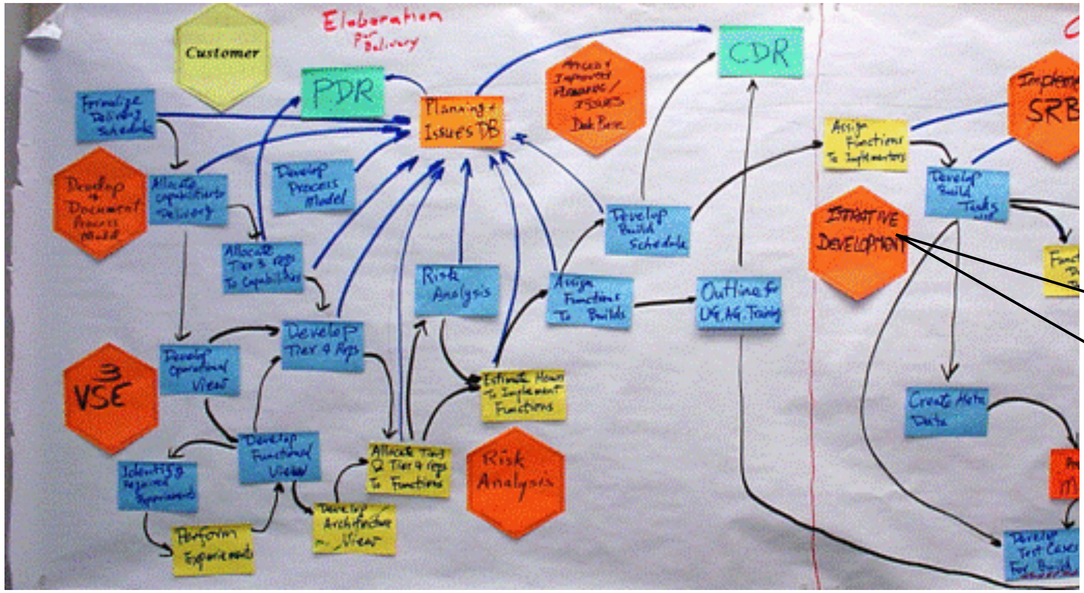
C / E Matrix – Prioritize the UDOs

Undesirable Observation	There is no formal CCB to control changes.	There is no formal SRB to control changes.	Need for Late rework identifed by customer	Too many coordination meetings	HTSL-B/CES communications are informal and decisions are not captured/documented	Inability to visualize impact of design decision on integrated system, hasty design	Baseline is not split, it means more overhead, complexity	Systems architecture / design is complex, not documented and/or is not up to date	Defect Data and Problem reports collection at HTSL-B has to be improved	Issues db does not capture attributes to support analysis	Root cause analysis of defects is not performed	Insufficient data collection to improve estimating
There is no formal CCB to control changes.		n	c	n	n	n	n	n	n	n	n	n
There is no formal SRB to control changes.	n		n	r	c	c	n	r	n	r	n	c
Need for Late rework identifed by customer	c	n		n	r	e	n	e	c	n	n	r
Too many coordination meetings	n	r	n		n	n	n	n	n	n	n	n
HTSL-B/CES communications are informal and decisions are not captured/documented	n	e	r	n		r	n	r	n	r	n	c
Inability to visualize impact of design decision on integrated system, hasty design	n	e	c	n	r		e	e	n	n	n	n
Baseline is not split, it means more overhead, complexity	n	n	n	n	n	c		r	n	n	n	n
Systems architecture / design is complex, not documented and/or is not up to date	n	r	c	n	r	c	r		n	n	n	n
Defect Data and Problem reports collection at HTSL-B has to be improved	n	n	e	n	n	n	n	n		c	c	c
Issues db does not capture attributes to support analysis	n	r	n	n	r	n	n	n	e		c	c
Root cause analysis of defects is not performed	n	n	n	n	n	n	n	n	e	e		r
Insufficient data collection to improve estimating	n	e	r	n	e	n	n	n	e	e	r	
Plan is not complete/accurate, sufficiently detailed, up-to-date nor communicated..	r	e	r	n	e	e	n	n	n	e	n	e

Prioritized UDO List

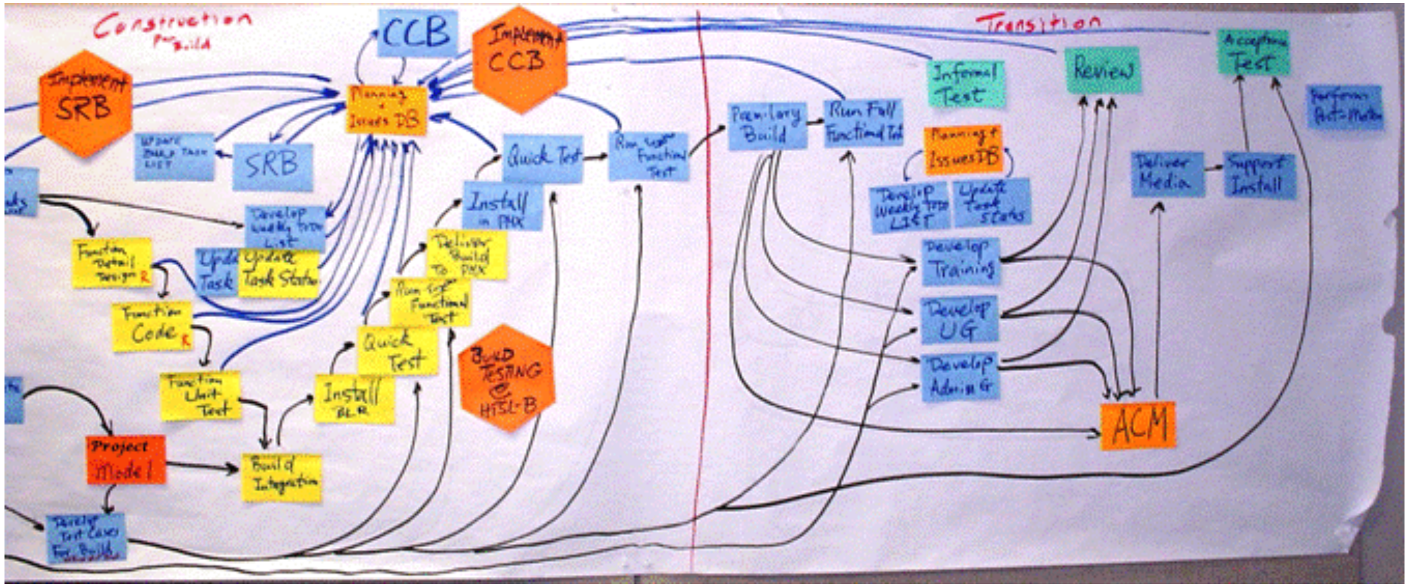
Undesirable Observation	Rating	Leverage
External requirements (ICD, FDEs, FMEA, HW/SW) are unstable and dynamic	29	Management of External Changes
The process that is followed is not documented	28	Work Execution and Tracking
HTSL-B/CES communications are informal and decisions are not captured/documented	22	Work Execution and Tracking
There is no formal SRB to control changes.	21	Work Planning and Coordination
Additional features identified late to support internal, strategic product decisions	21	Quality of Design/Tier 4 Reqmts
Tier 3 requirements are incomplete, many requirements are unstated, Customer allowed to add new requirements	21	Management of External Changes
Inability to visualize impact of design decision on integrated system, hasty design	17	Quality of Design/Tier 4 Reqmts
Weekly build content does not allow for completion of all process steps.	17	Work Planning and Coordination
Tier 4 Requirements not complete, frequently change, not updated, not reviewed with HTSL-B, not traced to tests	17	Quality of Design/Tier 4 Reqmts
Need for Late rework identifed by customer	15	Management of External Changes
Defect Data and Problem reports collection at HTSL-B has to be improved	14	Data Collection and Analysis
Issues db does not capture attributes to support analysis	14	Data Collection and Analysis
Plan is not reflective of estimates/capacity nor agreed to by all stakeholders.	14	Work Planning and Coordination
Customer Datacenter IT needs a month lock down to perform testing	14	Management of External Changes
Results of reviews are not captured and tracked	13	Work Execution and Tracking
Systems architecture / design is complex, not documented and/or is not up to date	12	Quality of Design/Tier 4 Reqmts

To Be Value Stream Map (VSM)

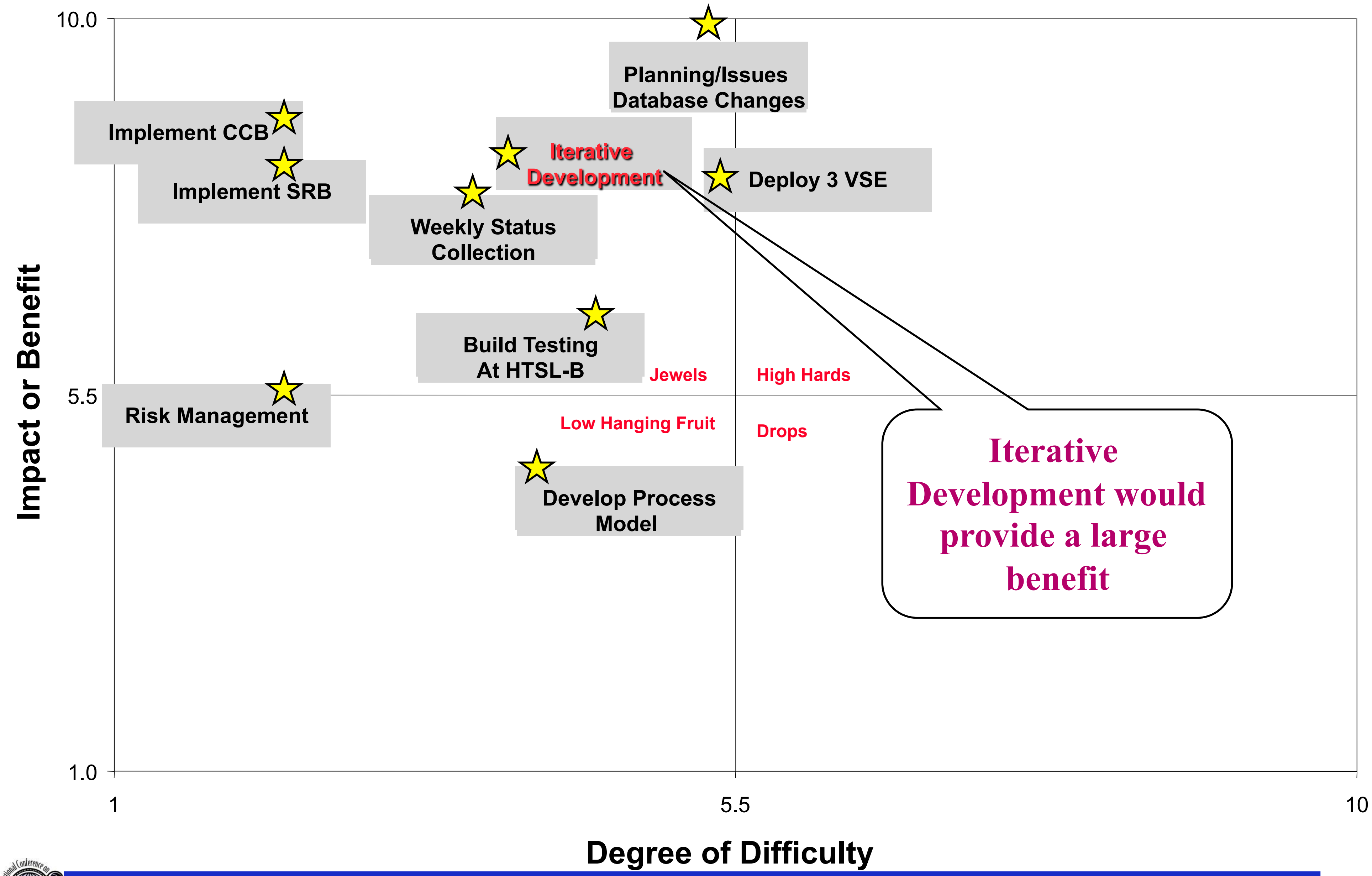

Elaboration
Customer
PDR
Planning + Issues DB
CDR
Formalize Delivery Schedule
Develop + Document Process Model
Allocate capabilities to Delivery
Develop Process Model
Allocate Tier 3 reqs To Capabilities
Risk Analysis
Develop Build Schedule
Assign Functions To Builds
Outline for UG, AG, Training
Iterative Development
Assign Functions To Implementers
Develop Build Tasks
Create Meta Data
VSE
Develop Operational View
Develop Tier 4 Reqs
Develop Functional View
Identify Required Experiments
Perform Experiments
Allocate Tier 4 reqs To Functions
Develop Architecture View
Estimate Hours To Implement Functions
Risk Analysis
Develop Test Cases For Build
SRB

The Future State VSM addresses the leverage points.

<u>Iterative Development</u> was identified as a top project to address the leverage points.



VPD^{TM} Results - ProjD



Iterative Development would provide a large benefit

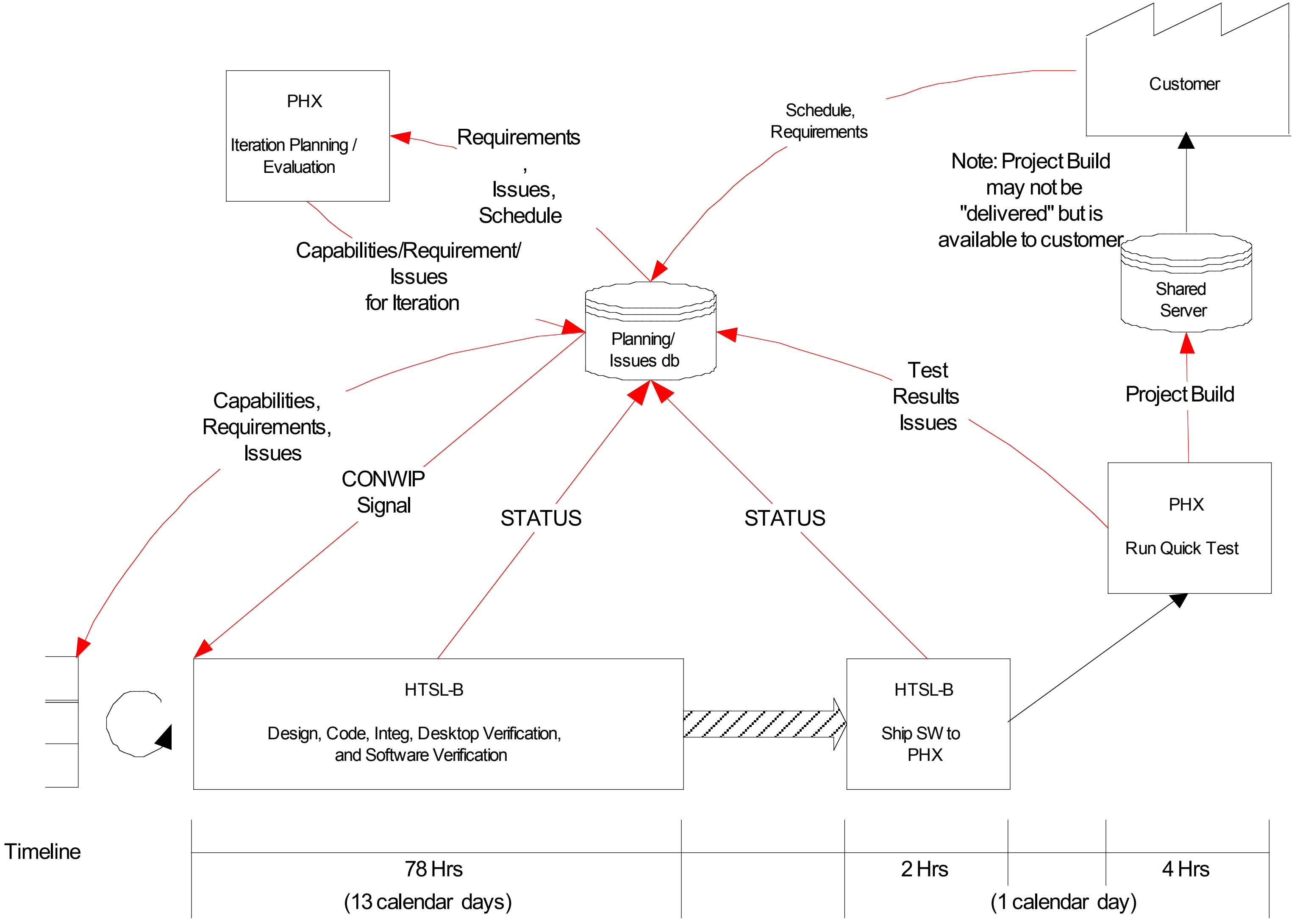
The Solution

Iterative Development
Application and Results

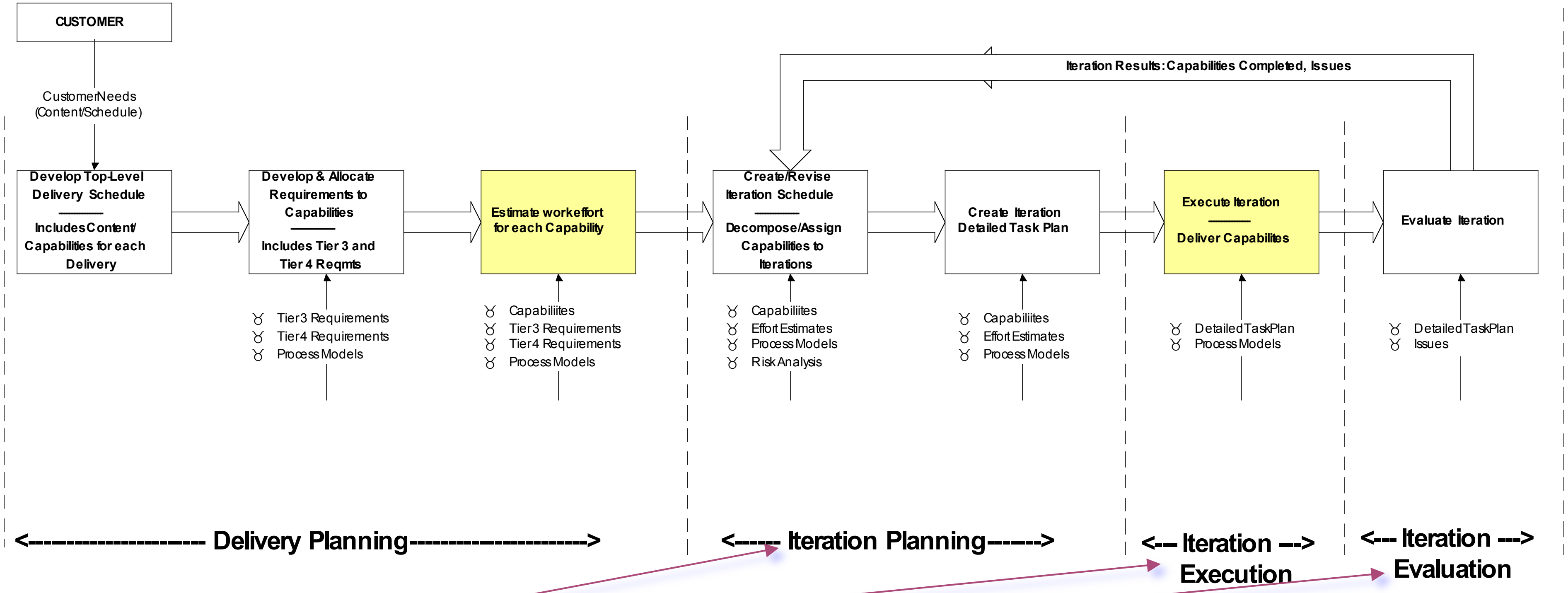
Iterative Development – Planned Approach

- Utilize RUP as the development framework
- Implement Time-boxed iterations
- Plan for several 2-week iterations followed by several 1 week iterations
- Include an empty iteration at the end to accommodate the unexpected.
- Include PHX and India in planning for each iteration
- Evaluate the results of each iteration. Use results to feed future iterations and to identify process improvements.
- Provide basic iterative development training to all team members.

ProjD Iteration Value Stream Map



ProjD Iteration Planning


CUSTOMER
Customer Needs (Content/Schedule)
Develop Top-Level Delivery Schedule
Includes Content/ Capabilities for each Delivery
Develop & Allocate Requirements to Capabilities
Includes Tier 3 and Tier 4 Reqmts
Estimate workeffort for each Capability
Create/Revise Iteration Schedule
Decompose/Assign Capabilities to Iterations
Create Iteration Detailed Task Plan
Execute Iteration
Deliver Capabilites
Evaluate Iteration
Iteration Results: Capabilities Completed, Issues
Tier3 Requirements
Tier4 Requirements
Process Models
Capabiliites
Tier3 Requirements
Tier4 Requirements
Process Models
Capabiliites
Effort Estimates
Process Models
Risk Analysis
Capabiliites
Effort Estimates
Process Models
Detailed Task Plan
Process Models
Detailed Task Plan
Issues
<--------------------- Delivery Planning--------------------->
<------ Iteration Planning------->
<--- Iteration ---> Execution
<--- Iteration ---> Evaluation

- Iteration Planning, Execution and Evaluation initially defined as serial steps.

4 hours

4 hours

80 hours

(2 weeks)

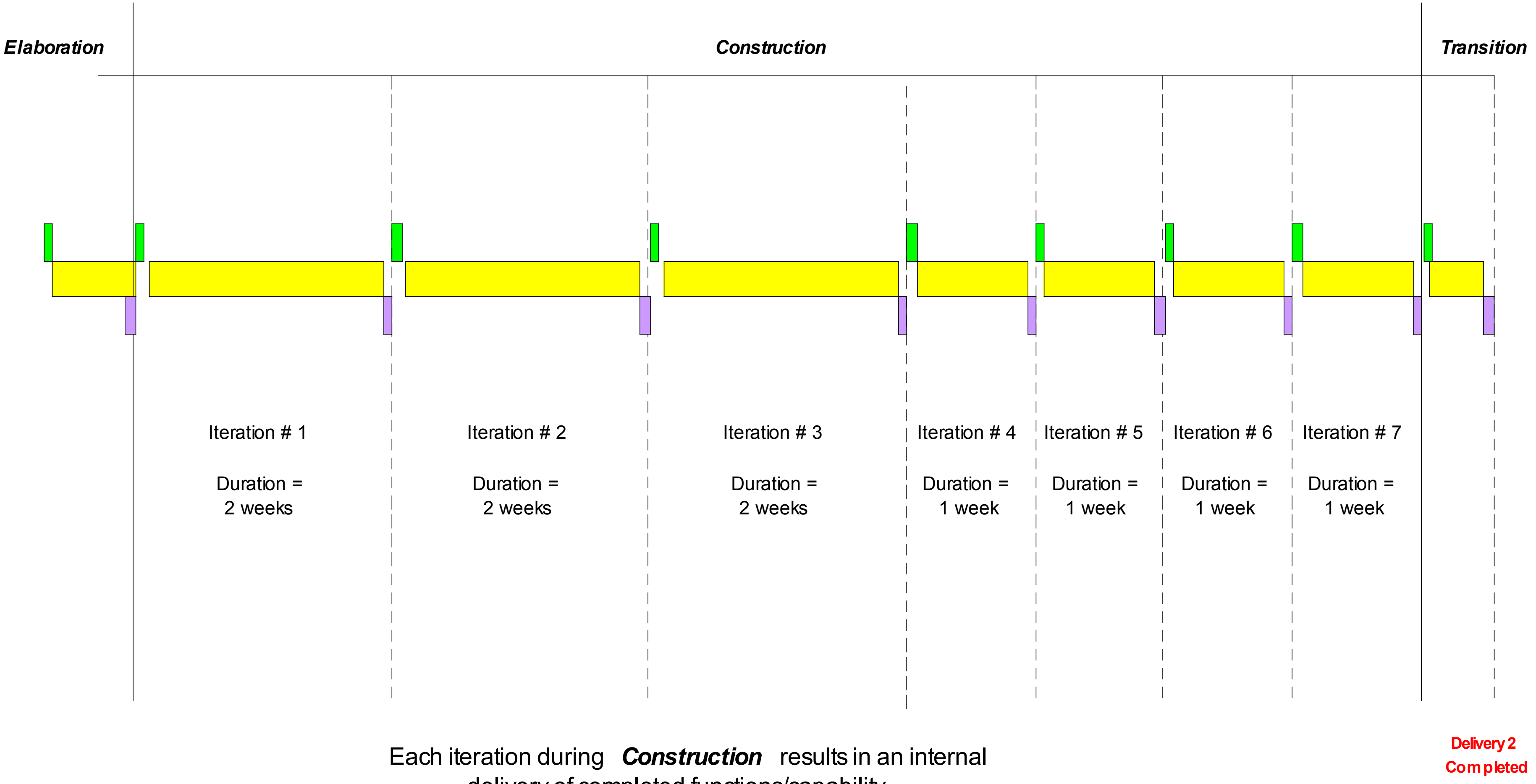
4 hours

- Development is performed during a 2-week iteration at India (HTSL-B)

PHX Activity

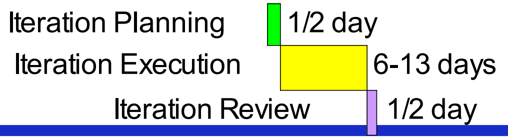
HTSL-B Activity

ProjD Planned Iterations



Each iteration during ***Construction*** results in an internal delivery of completed functions/capability.

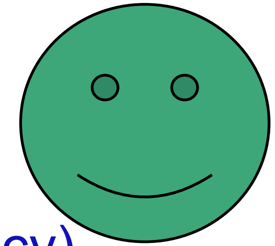
Planned for 7 iterations for Delivery 2


Iteration Planning 🟩 1/2 day
Iteration Execution 🟨 6-13 days
Iteration Review 🟪 1/2 day

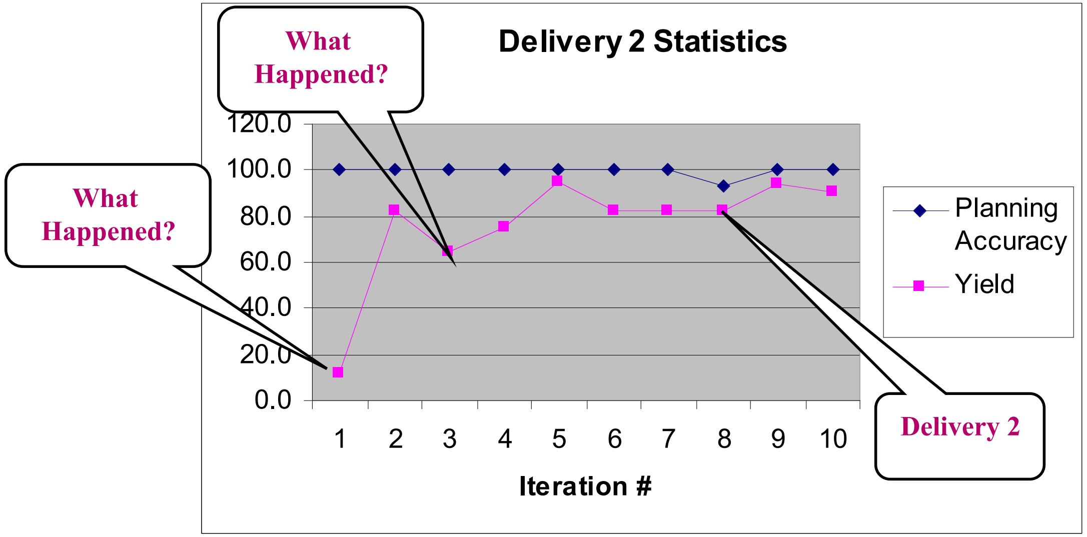
Iterative Development – Delivery 2

- Initial application of Iterative Development on project
  - Initial training for all team members on methodology and process
  - Establish clear expectations of team members
  - Active, hands-on participation and mentoring by Lean Experts
  - Collection and analysis of iteration data performed by Lean Experts
  - Root Cause Analysis of Failures facilitated by Lean Experts
  - Iteration results highly visible to managers, both in Phoenix and in India

Iterative Development – Delivery 2 Results



- Overall results: Highly Successful!
  - Improved yields, reduced rework (generally >80% yield)
  - Improved schedule performance (100% planning accuracy)
  - Delivery verifiable functionality in every iteration
  - Ability to quickly adjust to changes customer needs
  - Ability to quickly address issues in the next iteration
  - Continuous evaluation and adjustment to the process



Measures

- Planning Accuracy - % of planned work that was completed.
- Build Yield - % of completed work that passed verification testing.

Delivery 2 – Iteration Evaluations

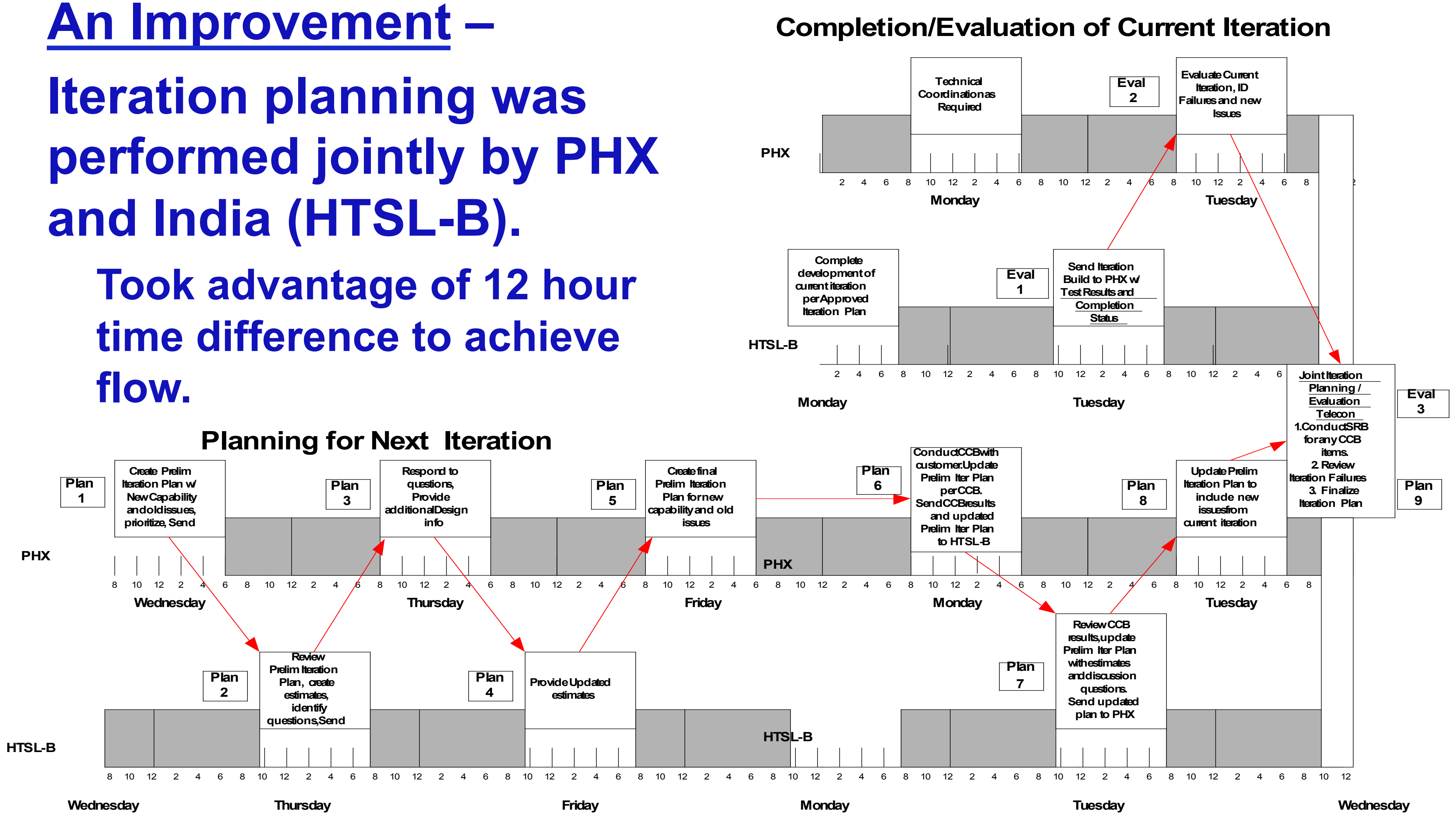
- Every iteration was evaluated to identify process improvement opportunities.
  - Iteration #1: 18.2% yield
    - Decided to spend more time during iteration planning to ensure a solid understanding of requirements and delivery expectations.
    - Reduced the content of the iteration
    - Clarified delivery expectations and measures
  - Iteration #3: 66.7% yield
    - Performed a root cause analysis of the 28 work items that failed verification to identify actions to improve the iterative development process.
    - Documented the iteration planning process between PHX and HTSL-B, create a standard work description, and leaned the process to reduce the cycle time.
- These improvements had a positive impact as shown by the performance in subsequent iterations.

Iterative Development – Iteration Planning

An Improvement –

Iteration planning was performed jointly by PHX and India (HTSL-B).

Took advantage of 12 hour time difference to achieve flow.



Completion/Evaluation of Current Iteration

Technical Coordination as Required

Evaluate Current Iteration, ID Failures and new Issues

Complete development of current iteration per Approved Iteration Plan

Send Iteration Build to PHX w/ Test Results and Completion Status

Joint Iteration Planning / Evaluation Telecon
1. Conduct SRB for any CCB items.
2. Review Iteration Failures
3. Finalize Iteration Plan

Planning for Next Iteration

Create Prelim Iteration Plan w/ New Capability and old issues, prioritize, Send

Review Prelim Iteration Plan, create estimates, identify questions, Send

Respond to questions, Provide additional Design info

Provide Updated estimates

Create final Prelim Iteration Plan for new capability and old issues

Conduct CCB with customer. Update Prelim Iter Plan per CCB. Send CCB results and updated Prelim Iter Plan to HTSL-B

Review CCB results, update Prelim Iter Plan with estimates and discussion questions. Send updated plan to PHX

Update Prelim Iteration Plan to include new issues from current iteration

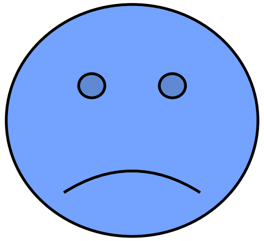
Iterative Development – Delivery 3,4

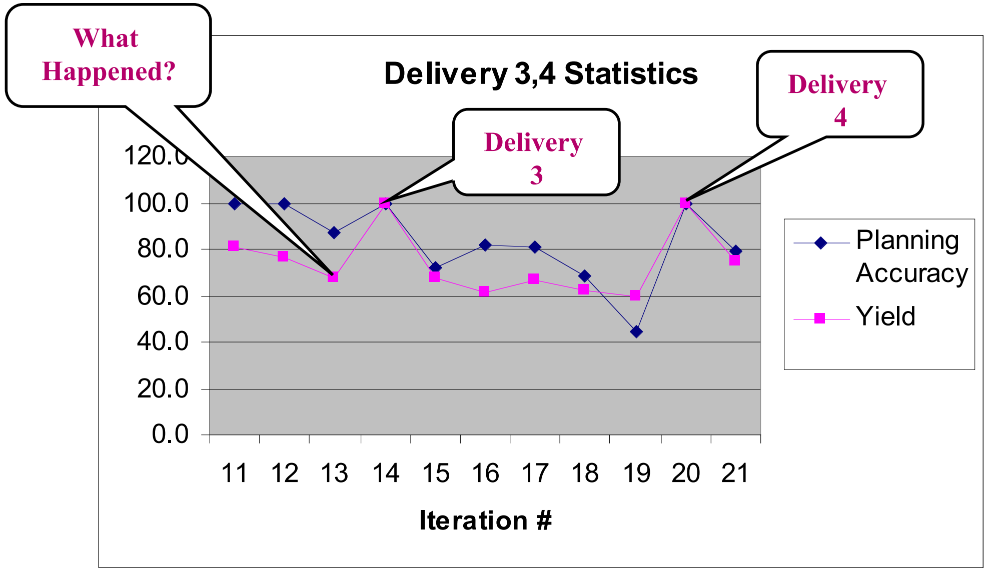
- Follow-on application of Iterative Development on project
  - Passed control to the Project Leader with the expectation that the established practices would continue
    - Collection and analysis of iteration data
    - Root Cause Analysis of Failures
    - Iteration results highly visible to managers
  - No hands-on participation and mentoring by Lean Experts

- Key Assumptions: The Iterative Development practice was well understood and the team was ready to accept control.

Iterative Development – Delivery 3,4 Results

- Overall results: Significant drop-off in gains!!
  - Planning accuracy dropped to 80%
  - Yields dropped to 60% (still better than the baseline)
  - Maintained ability to quickly adjust to changing customer needs
  - Maintained ability to quickly address issues in the next iteration
  - Continued to provide verifiable functionality every 2 weeks.





Measures

- Planning Accuracy - % of planned work that was completed.
- Build Yield - % of completed work that passed verification testing.

Iterative Development – Delivery 3,4 Analysis

- What factors caused the dramatic changes?
  - Since this project was now doing very well, India moved personnel to other projects
    - New personnel were assigned but they did not receive any training on Iterative Development
    - The expectations were not made clear to the new personnel.
- Why did the problem persist?
  - The Project Leader did not follow through with the established practices
    - Collection and analysis of iteration data stopped
    - Root Cause Analysis of Failures was not conducted
    - Iteration results were not made visible to managers
  - Had the practices been continued, the problem would have been corrected after ONE iteration!

VPD^{TM} Method and Iterative Development

- Summary:
  - VPD™ method used to identify opportunities
    - Assess current state
    - Identify leverage points
    - Create future state and identify projects to achieve.
  - Successful application of iterative development
    - Delivered verifiable functionality every iteration
    - Rapid feedback and continuous improvements to the development process.
    - Iterative Development provides the ability to quickly respond to changing needs and customer issues.
  - Improved project performance in Delivery 2
    - Improved yields
    - Reduced risk
    - Reduced rework
    - Improved performance to schedule.

VPD^{TM} Method and Iterative Development

- Summary (cont.):
  - Active mentoring by Experts is a must!
    - Premature withdrawal by Experts will likely lead to failure.
    - Continue to provide support during the transition of ownership to the project team.
  - This project was a great learning experience!

- Where do we go from here?
  - We now know that Iterative Development is the correct approach for Honeywell Aerospace software development.
  - Iterative Development has been identified as a key initiative with a goal to broadly deploy the methodology.