Synopsis of AEE Planning & Development Process Redesign: Phase I

Achieving Excellence in Engineering

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May 28,1993

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I. INTRODUCTION/EXECUTIVE SUMMARY

THE AEE INITIATIVE WAS TARGETED AT TWO MAJOR AREAS IN PHASE I

- Developing a robust interface and supporting process for the centralized engineering organization to interact with the market focused business units
  - Market-based engineering planning and budgeting process
  - Prioritization criteria and screening process for engineering projects
  - Mechanism to screen engineering projects
  - Organizational implications of new planning infrastructure

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- Re-engineering Digital's development process to create a more effective and efficient process for product development
  - Top-level architecture of how engineering interacts with all other functions
  - Identification of internal DEC development best practices
  - Identification of high leverage process improvement options
  - Quantification of impact of change
  - Organizational implications of top-level process redesign

TO TACKLE DIGITAL'S SEVERE PROBLEMS, AGGRESSIVE GOALS WERE SET FOR THE 2-3 YEAR HORIZON OF THE AEE PROGRAM

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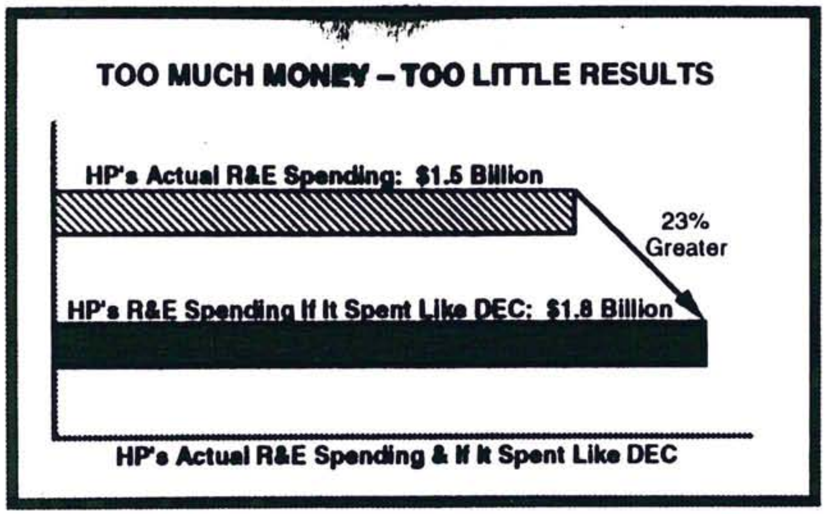

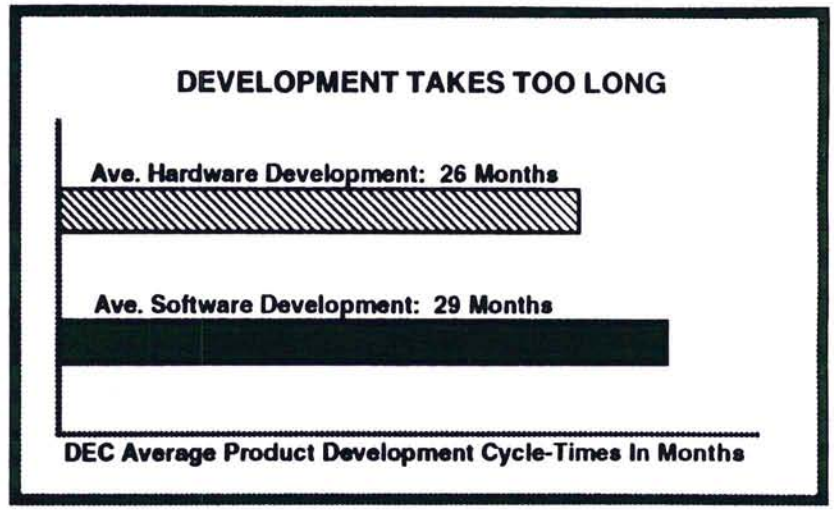

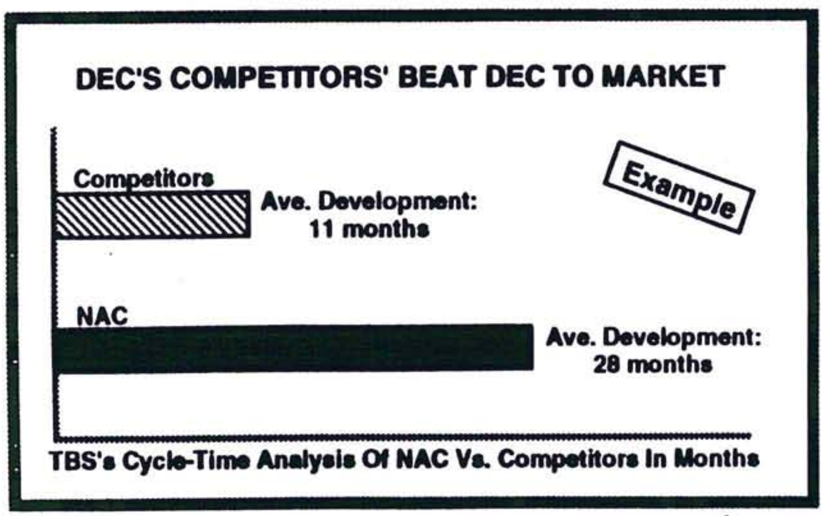

AEE'S GOALS : TWO YEARS TO ACHIEVE

- **50% Reduction In Cycle-Time**
- **50% Reduction In Applied-Time**
- **10X Improvement In Quality**

B.15/20goal drivers

THE SUBSTANTIAL CHALLENGES CONFRONTING DIGITAL ENGINEERING INDICATE THAT ACHIEVING THESE GOALS IS CRITICAL

Planning Gaps:

- No established link to the newly formed business units to drive engineering planning
- Technology driven, rather than market driven, engineering planning
- Absence of a construct to drive planning from a systems or components perspective
- Inadequate link to the "extended enterprise" to drive engineering planning

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Development Gaps:

- Development cycle-times significantly longer than competitively permissible
- Substantial requirements churn post initial product specification
- Absence of best practice and tool standardization across development groups
- Minimal discipline in the execution of design processes
- Limited attention given to part standardization and design reuse
- Inconsistent employment of concurrent engineering principles

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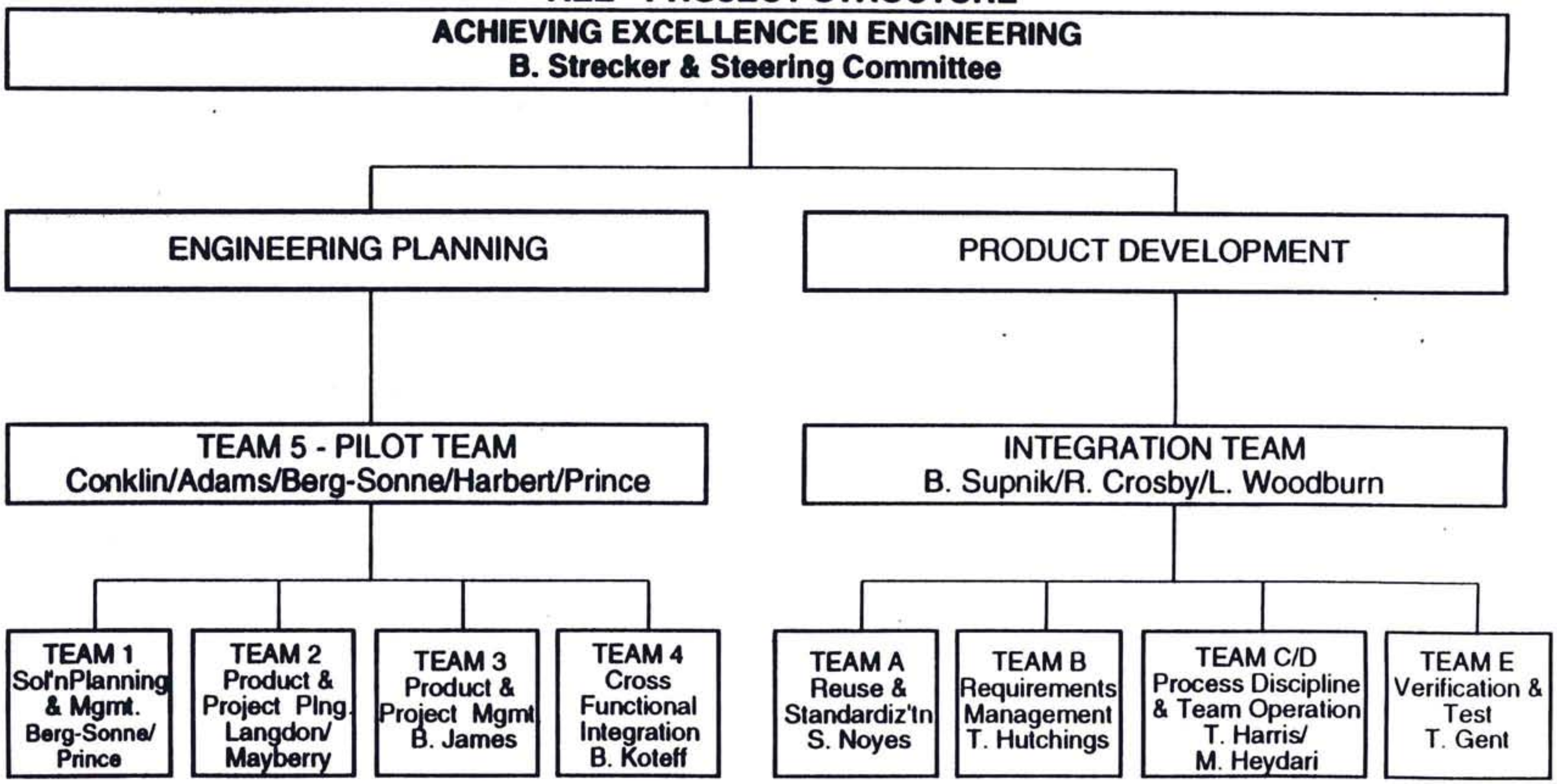
THE AEE PHASE I EFFORT CONSISTED OF TASK FORCES LED BY DEC MANAGERS WITH SUPPORT FROM BA&H — IT IS NOW TRANSITIONING TO THE AEE PMO

AEE - PROJECT STRUCTURE



RHK5/20Team Structure

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THE AEE RE-DESIGN OF DEC'S PROCESSES IS DRIVEN FROM SEVERAL BASIC PRINCIPLES

Planning Principles:

- **Minimalistic** - a simple and highly implementable process requiring minimal documentation
- **Collaborative** - a partnership based dialog between the BUs and Engineering
- **Responsive** - a continuous (i.e., not annual) process that is responsive to market changes
- **Systems Focused** - a process that drives to a systems view of interoperability requirements
- **Bilateral Contract** - schedule / cost / deliverable for committed business results

Development Principles:

- **Increasing Value-Added** - the process will be gated by demonstrable increases in value
- **Concurrent Involvement** - all relevant functions are involved as early as possible in effort
- **SE Methodology** - steps geared to addressing system considerations from the start
- **Accountability** - all requirements, deliverables, and tasks are explicitly owned
- **Decision Making** - decisions are only made by people directly participating in the process
- **Efficiency** - flexibility, scalability and standardization are balanced to optimize efficiency

SEVERAL MAJOR RECOMMENDATIONS HAVE EMERGED FROM THE PHASE I OF AEE

Planning Process Recommendations:

- **Dialog Process** - institute the dialog based planning process for Engineering and the BUs in a joint forum to determine the product development priorities of central engineering
- **Planning Templates** - employ the planning templates across all BUs to consistently capture / communicate the results of the dialog process in the form of detailed customer requirements
- **Cross-engineering Dialog** - utilize the Dialog Forum to address cross-functional issues across Design Entities — whether component or solution level, and/or driven internally or externally
- **Aggregates** - adopt the intellectual construct of 10-15 aggregations of customer desired system capabilities to drive planning for engineering as well as the management of interoperability

Development Process Recommendations:

- **Reuse** - adopt Tech Files/Aspect as the required parts selection medium and institute an assessment of design reuse opportunities through standard reuse templates and metrics
- **Checkpoint Process** - adopt a disciplined milestone based development process that integrates planning & development, but clearly distinguishes between technical & business decisions
- **Risk Based Flex** - employ specific risk criteria to flex the amount of work and oversight required, and to identify explicit responses to internal or external driven "trigger" events
- **Empowered Teams** - form teams led by an empowered Product Team Leader with full multi-functional membership, funded to deliver across all functions for the total development effort
- **Requirements Management** - institute standardized and formal procedures to document, trace, and change product specifications, plans & dependencies developed and prioritized through the customer driven Planning Process

THERE IS NO "SILVER BULLET", ACHIEVING THE GOALS WILL COME FROM DOING A VARIETY OF PLANNING & DEVELOPMENT TASKS IN NEW & BETTER WAYS

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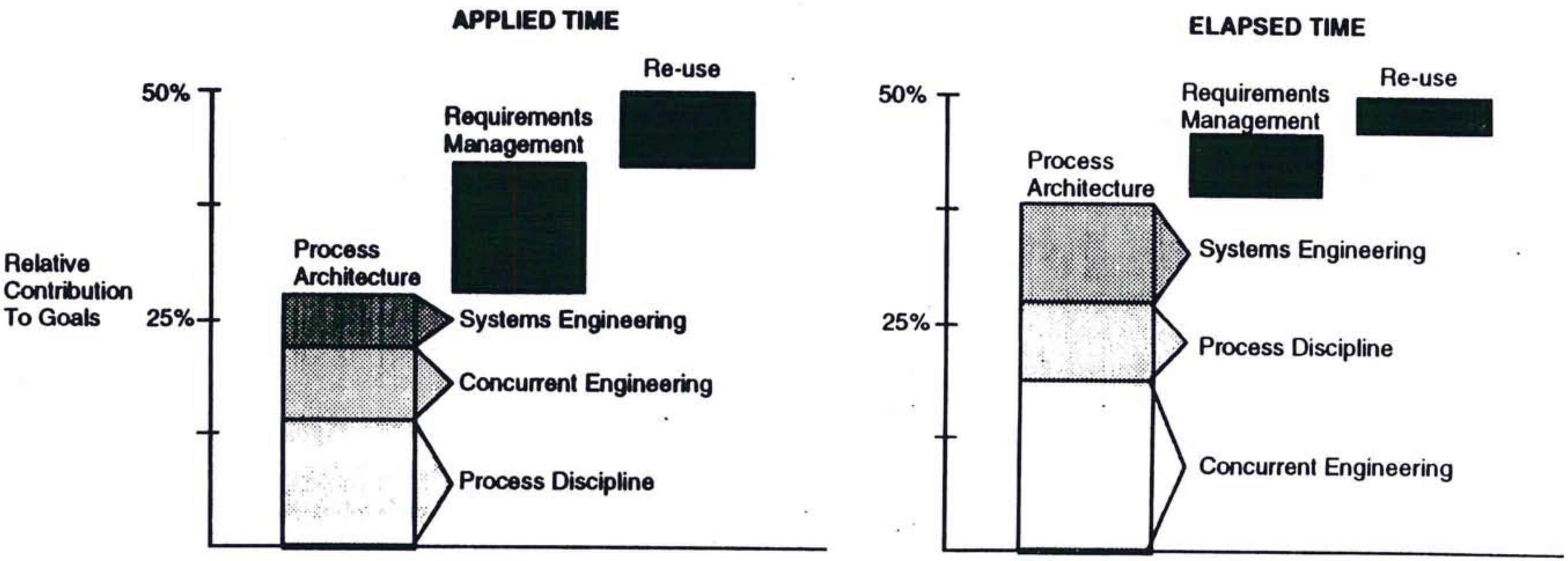
CONTRIBUTION OF AEE DEVELOPMENT PROCESS INITIATIVES TO TIME GOALS



Total Multiplicative Applied Time Reduction
2 to 1 Improvement - 50%

Total Multiplicative Elapsed Time Reduction
2 to 1 Improvement - 50%

WJL - LadCB

Note: Results are multplicative, not additive
Source: Industry benchmarks & parametric relationships from C. Jones, B. Boehm, BA&H Analysis and studies

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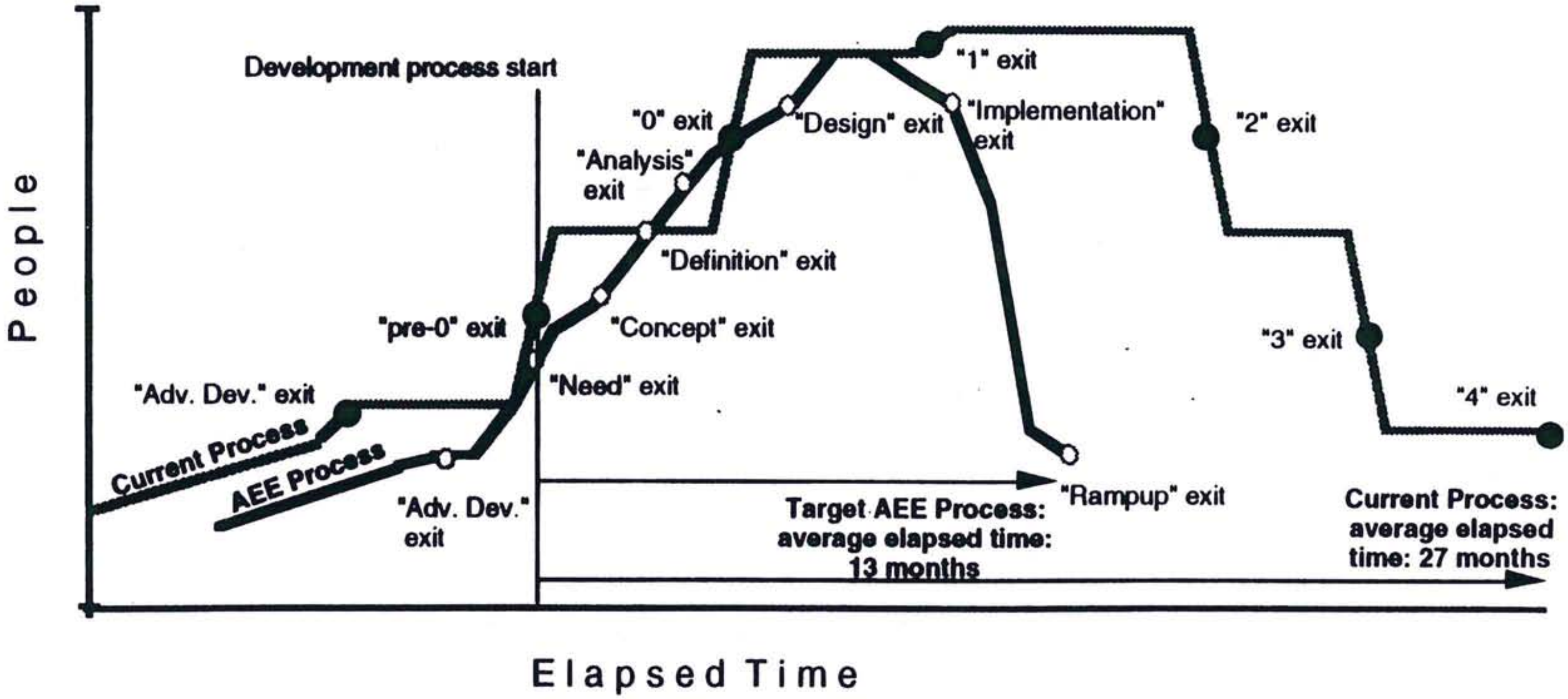
THE RECOMMENDATIONS CAN HELP DEC ACHIEVE THE AGGRESSIVE AEE GOALS OF A 50% REDUCTION IN ELAPSED AND APPLIED TIME

TARGET IMPACT OF AEE PLANNING & DEVELOPMENT PROCESS CHANGES ON AVERAGE DEC DEVELOPMENT PROJECT
Current Process vs. AEE Process



Note: Estimated impact on applied & elapsed time is the integration of planning process changes, process discipline, concurrent engineering, systems engineering, design reuse and requirements management changes Gains do not include Adv. Dvlpmnt or Need ID phases.
Source: Industry benchmarks & parametric relationships from C. Jones, USAF, B. Boehm, T.B.S. and BA&H studies to estimate implementation impact

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ACHIEVING THESE AGGRESSIVE OBJECTIVES WILL NOT BE EASY — MANY CHALLENGES NEED TO BE OVERCOME

- Many of the new approaches go against established DEC culture and practice — discipline
- Some organizations that must adopt these changes are in flux — Engineering & BUs
- These major process changes will need to occur in midst of continued downsizing
- New skills in program management, teamwork and systems engineering will be required
- There will be inadequate data to make risk free decisions
- Extensive retraining of personnel in new approaches will be needed to adopt changes
- A commitment to a "learning organization" must be instilled

WE WILL MAKE MISTAKES — BUT WE WILL LEARN FROM THEM AND MOVE FORWARD

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ASPECTS OF AEE CAN BE INSTITUTED NOW, WHILE OTHERS WILL BE ADOPTED OVER THE MID- AND LONG TERM

	IMMEDIATE	BY FALL '93	LONGER-TERM
PLANNING PROCESS	• Test, refine & document AEE process via FPPS pilot • Fully define aggregates driven from current existing business • Identify & define infrastructure / support requirements and enabling tools & techniques	• Roll-out planning process to all Business units • Drive requirements dialog against aggregates • Institute targeted training programs to support roll-out	• Redefine Aggregates from needs- based market segmentation • Execute infrastructure changes required
DEVELOPMENT PROCESS	• Simulate Processes/Practices • Adopt Techfiles/Aspect & reuse templates • Select 3 projects to pilot • Test, refine & document AEE process via pilots • Use Planning Templates to document business assumptions for current projects	• Drive all products of FPPS pilot into AEE Development process • Identify, define & document enabling tools & techniques • Implement Best Practices • Begin full roll-out to all of Engineering	• Identify & define infrastructure / support requirements • Institute targeted training programs to support roll-out • Detail Design Process Redesign • Target Advanced Development for redesign
ORGANIZATIONAL TRANSFORMATION	• Identify & define infrastructure, support, & capability reqmts • Quantify / qualify options & benefits of restructuring • Test, refine & document linkages to extended enterprise	• Institute targeted training programs to support roll-out • Implement form of Program & Product Management • Test, refine & document restructuring options	• Determine level of organizational restructuring required • Structure ongoing, continuous improvement program
INFORMATION SYSTEMS	• Refine conceptual model for highest priority system modules -- Project and Product management systems • Create logical and physical models	• Continue focus on highest priority system modules -- Project and Product management systems • Build operational prototypes • Prototype & Pilot	• Define / implement systems for budgeting, human resources (next priority) • Define / implement remaining systems (eg, assets, regulatory, etc.)

GETTING ON WITH IMPLEMENTATION WILL ALLOW DIGITAL TO GET ON WITH REALIZING AEE'S SIGNIFICANT POTENTIAL BENEFITS

THE BALANCE OF THIS DOCUMENT CONSISTS OF THE INTEGRATION OF THE PHASE I RECOMMENDATIONS FROM BA&H AND THE PROCESS REDESIGN TEAMS AS OF 5/28/93

- How the new joint BU/Engineering planning process should operate
- The nature, role, and definition of aggregates in engineering planning and execution
- Definition of a more disciplined concurrent approach to development
- How to structure flexibility based on risk into the overall process
- Identification of practices to enhance design reuse and parts standardization
- Definition of processes and practices to minimize/control requirements churn
- Definition of the team structure to drive a customer and multi-functional approach
- Design of the information infrastructure to support the overall AEE processes
- Benefits of adopting the AEE recommendations

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VII. SUMMARY OF AEE BENEFITS

Outline

A. Introduction...

Assessing the benefits of implementing the AEE recommendations are rooted in three factors

- The current state of Digital Engineering
- The goals Digital Engineering wants to set for itself
- The demonstrated impact of adopting the new approaches embodied in AEE

The following pages lay-out where Digital is today and the consequences of moving to an AEE paradigm

WHY IS CHANGE NEEDED?

WHAT IS THE VALUE OF CHANGE?

Phase I of AEE employed a variety of methods to assess the state of Digital engineering in both planning and development

B. Process Baseline... VII–2

Presently, engineering planning is broken – there are 7 unconnected planning processes, none of which satisfactorily drive market-based engineering

1. 8 Quarter Volume Planning (8QVP)
2. Corporate Phase Review Process
3. LRP"Bottom Up" Process
4. Customer Program Reviews
5. "Ad Hoc Cooperation"
6. Top Down Process
   - Board of directors decides on major market and technology targets

- Engineering budgets allocated by Strategic Technology Forum

7. "Domain" Process

Digital's current development process, although slightly different in each group, is also seriously broken

These process gaps result in nearly half of engineering funding being spent before the business plan and design specifications are completed

C. Resource Baseline... VII-5

These gaps also seem to have created an organization that spends most of its time on non-design activities

Furthermore, the organization is 1/3 management and administration

With a distribution that "bulges" at the senior levels

D. Best Practice Baseline... VII-8

Benchmarking Digital against engineering best practice standards also surfaced major gaps in execution

For example, greater use of practices like co-location could significantly improve development effectiveness

E. Cycle Time Baseline... VII-10

The result is that Digital's current development cycles, excluding advanced development and Pre-0, are very long...

... and lagging competitors' time-to-market in many areas, for example:

Digital's inability to deliver product quickly could be due to inefficiency, under loading projects early on, or other factors – but the diagnostic indicates that its process is simply less effective

F. Spending Baseline... VII-13

A less effective process with longer cycles has resulted in high Research & engineering spending relative to competitors

G. Quality Baseline... VII-14

In terms of quality, Digital spends $750 Million annually to resolve technical problems and the cld backlog has nearly doubled over the last 2 years

H. Goals... VII-15

In summary, the competitive environment and the situation revealed by diagnostics drove AEE's aggressive goals

- **Two to One** improvement of the current product development cycle – the elapsed time from concept **phase to first** quality volume ship
- **Two to One** improvement of the current product development applied time – measured as the cost in **person power** across the cycle
- **Ten to One** improvement in quality has been set as a particularly aggressive goal – defined as a reduction in defects
  - Defects in generating specifications that match customer needs
  - Defects in developing products that meet stated specifications

VII. SUMMARY OF AEE BENEFITS

WHY IS CHANGE NEEDED?

WHAT IS THE VALUE OF CHANGE?

I. Impact... VII–16

The process derived from the AEE recommendations will achieve AEE's aggressive Objectives

J. Scope... VII–17

To achieve this, the key levers in first two stages of the engineering cycle were addressed by the various Digital teams

Benefits will accrue in the later maintenance phase, but this was not explicitly addressed

The recommendations emerging from the teams fall into three categories that enable success against the AEE goals

K. Planning Impact... VII–19

The new planning process will save $90 Million annually in applied time by simplifying the current pre-0 process

L. Development Impact... VII–20

The 2 to 1 savings in the development process are driven by process architecture and engineering best practices

M. Planning... VII–21

AEE BENEFITS
- Planning -

		Elapsed Time	Applied Time (Cost)	Quality	Other
Planning	Process	• Less dead-time	• No duplication	• Needs explicit	• Auditable development work
	Aggregates	• Defined interfaces	• Capitalize Sys.Eng.	• Capitalize quality	• LRP linked to even small products
	BU/Engineering Team	• Scheduled meetings	• Minimum needed	• Broad perspective	• Resource contention optimized
Development Process	Process Discipline	• Couple products and their processes	• Interim deliverables	• Early purging of errors	• Load balancing
	Systems Eng.	• Shorter integration & testing	• Reduce risk	• Expectations explicit	• Manage complexity
	Concurrent Eng.	• Overlap work	• Raise effectiveness	• Less translation error	• Robust decisions
Eng. Best Practices	Requirements Management	• Reduce cycling	• Reduce questions	• Maintain specs	• Change management
	Re-Use & Standardization	• Reduce items in critical path	• Reduce work for a given solution	• Validation complete	• Partnering

optimizing the planning process is the key lever to reduce product development's cost and time

- Greater than 70% of a product's cost is defined by the decisions made in planning

VII. SUMMARY OF AEE BENEFITS

- Poor development planning decisions drive costs throughout the life-cycle of a product
  - Poor requirements will result in rework/redesign
  - Poor requirements will create products that don't meet customer needs
  - Changing requirements in the field is 2400X as costly as during concept according to a Software Institute study
- The AEE planning process recommendations contribute to achieving the overall goals in several ways
  - Cycle-time reduction is facilitated through the dialog process
  - Cost reduction is enabled through the use of aggregates
  - Quality improvements are achieved through the consistency of templates

The AEE planning process provides market based solutions by effectively linking the business units and engineering

the benefits of aggregates derive from their emphasis on re-use, A systems' focus, and requirements stability

The AEE planning process produces quantifiable benefits in upfront planning as well as later in the product life cycle

- Currently, activity before the Concept phase consumes $300 mil/yr. and 11+ months on average
  - Advanced Development: Costs $120 mil/yr. and adds 6+ months to an average project
  - Pre-"0": Costs $180 mil/yr. and adds 5+ months to an average project
- At minimum, the new AEE Planning Process will rationalize Pre-"0" phase work
  - Pre-"0" is replaced by "Need Identification" activities
  - Justification and integration of needs are now systematized
  - Communication problems between organizations are reduced
  - Hand-offs to no-one-in-particular are eliminated
  - The process is rationalized
    - Time between steps is lowered
    - Redundancy of steps is lowered
    - Parallelism of steps is raised
- We expect significant near term benefits in Needs Identification Phase – based on profiles of Digital projects and external benchmarks
  - Needs Identification will consume the same loading for a much shorter period
  - Some $90 Million annually could be saved in applied time out of $180 Million annually
  - Some 2-3 months could be saved in elapsed time on average

AEE BENEFITS
-- Development Process Architecture --

		Elapsed Time	Applied Time (Cost)	Quality	Other
Planning	Process	• Less dead-time	• No duplication	• Needs explicit	• Auditable development work
	Aggregates	• Defined interfaces	• Capitalize Sys.Eng.	• Capitalize quality	• LRP linked to even small products
	BU/Engineering Team	• Scheduled meetings	• Minimum needed	• Broad perspective	• Resource contention optimized
Development Process Architecture	Process Discipline	• Couple products and their processes	• Interim deliverables	• Early purging of errors	• Load balancing
	Systems Eng.	• Shorter integration & testing	• Reduce risk	• Expectations explicit	• Manage complexity
	Concurrent Eng.	• Overlap work	• Raise effectiveness	• Less translation error	• Robust decisions
Eng. Best Practices	Requirements Management	• Reduce cycling	• Reduce questions	• Maintain specs	• Change management
	Re-Use & Standardization	• Reduce items in critical path	• Reduce work for a given solution	• Validation complete	• Partnering

Most of the AEE benefits will be derived from implementing the development process architecture — process discipline, a systems engineering focus, and concurrent engineering principles

Process Architecture Benefits

- **ELAPSED TIME (CYCLE) = 35% - 40% REDUCTION**
  - **Process Discipline (10-15%)**
    - Single, shared definitions of product and process
    - Technical and business decisions linked by deliverables
    - Flex is structured, yet accommodating
    - Schedules are explicit and current
  - **Systems Engineering (10-15%)**
    - Partitioning designs makes work modular, reducing time between activities
    - Trade-offs are more effective
    - Smoother integration and test
  - **Concurrent Engineering Team (26%)**
    - Early multi-functional involvement
    - Overlapping development activities
    - Faster decision-making, single point accountability

- **APPLIED TIME (Cost) = 25% - 30% REDUCTION**
  - **Process Discipline (15-20%)**
    - Single, shared definitions of product and process
    - Single point of accountability throughout the process
    - Risk is staged and managed
    - Deliverables are understood
  - **Systems Engineering (3-7%)**
    - Maximum risk is reduced
    - Trade-offs are more efficient
    - Interfaces aggressively managed
    - Improved test planning

VII. SUMMARY OF AEE BENEFITS

- **Concurrent Engineering Team** (7-11%)
  - Improved communication and coordination from co-location
  - More efficient documentation process
  - Less time for meetings and cross-functional negotiation

- **PRODUCT/PROCESS QUALITY = 50% - 70% DEFECT REDUCTION**
  - **Process Discipline**
    - Single, shared definitions of product and process
    - Ongoing validation and verification throughout the process
    - Explicit accountability for deliverables
    - Defects/errors are identified earlier
  - **Systems Engineering**
    - Optimizes design iteration
    - provides basis for validation and verification
    - Quality is made integral to the process not added to the product
  - **Concurrent Engineering Team**
    - Multi-functional design reviews minimize downstream engineering changes and rework
    - More producable, serviceable design

Note: Estimated savings do not include design reuse and requirements management, Total percent reductions are multiplicative result of individual components
Source: Industry benchmarks & parametric relationships from C. Jones, USAF, B. Boehm, BAH studies, to estimate implementation impact

The benefits of the AEE process architecture derive from it focusing down on what must be done, by whom, at the earliest possible point

- The Checkpoint process is gated by creation of value-added deliverables and scaled by a project's inherent risk
- Systems engineering will streamline analysis and downstream implementation and test through a formal decomposition of requirements
- Concurrent engineering reduces requirements churn through earlier involvement of downstream functions/customers/supplies/partners and enhances functional accountability
- Decisions will be made with rigor to provide stability and accountability

a single, well defined process will reduce the current, ad-hoc process activities engaging approximately 25% of engineering effort

Through risk management and greater accountability, process discipline delivers significant benefits

- Checkpoints and reviews stage and curb potential risk
- Critical issues are less likely to be missed
- ISO 9001 compliance necessitates the auditable baselines of product and process that a checkpoint requires
- Single point accountability by program, product, project and function avoids the delays of the current indefinite consensus driven process

Underlying the new AEE development process is a concurrent sequencing of phases, with an emphasis on up-front planning through systems engineering

Rigorously employing system engineering discipline has significant impact at the front and back-end of the development process

The lack of early involvement of downstream functions increases requirements churn — Resulting in over runs

VII. SUMMARY OF AEE BENEFITS

While employing Concurrent engineering will boost quality and reduce development cycles — on the order of 30%

The AEE development process recommendations also support the application of key process best practices...

- Team co-location
- Standardized design review methods
- Common project management tool set and practices
- Standard development/design processes

...and lay the foundation for continuous improvement

O. Best Practices... VII–34

AEE BENEFITS
-- Engineering Best Practices --

		Elapsed Time	Applied Time (Cost)	Quality	Other
Planning	**Process**	• Less dead-time	• No duplication	• Needs explicit	• Auditable development work
	Aggregates	• Defined interfaces	• Capitalize Sys.Eng.	• Capitalize quality	• LRP linked to even small products
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Requirements churn is a major driver of budget overruns

Formal requirements management can reduce 'churn' during development

- Traceability ensures that development engineering delivers products and designs that meet expectations
- Traceability also contributes to the interoperability of products
- Disciplined change control through cost/benefit analyses increases engineering productivity potentially 10%-20%
- Should reduce total elapsed time for development by 5% based on external benchmarks

VII. SUMMARY OF AEE BENEFITS

While reuse should reduce time and cost by leveraging existing designs rather than creating them from scratch

- Reuse is explicitly identified in the product development process
- Tools and process force reuse across product teams instead of just within groups
- Engineers have easy access to existing design components

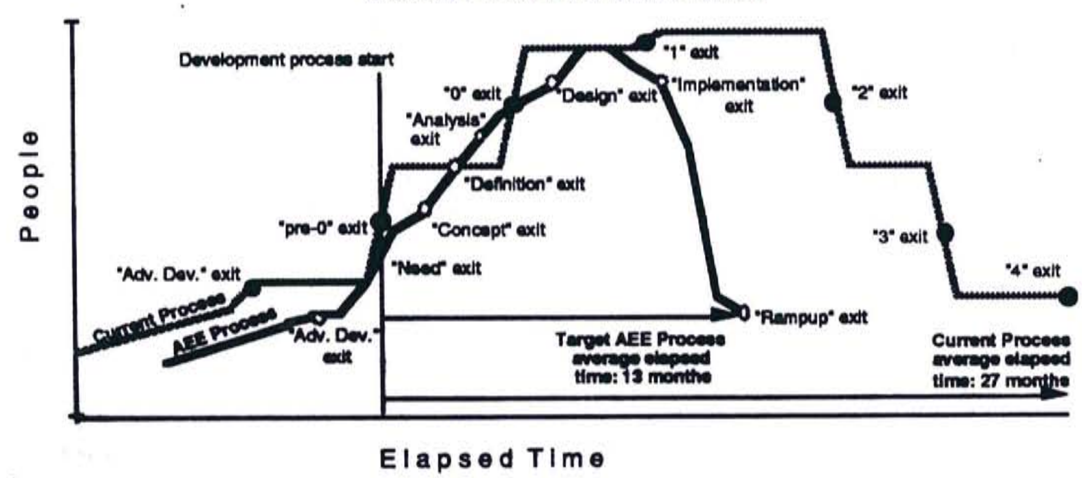
	Level I Reuse		Level II Reuse		Total Savings
	HW	SW	HW	SW	
Elapsed Time	Need to baseline reuse to accurately schedule gains, team estimate of ~5%	Increase reuse by 15% Δtime= -8% against applicable 40% of cycle = 3% total	Need to baseline reuse to accurately schedule gains, team estimate of 10%-15%	Need to baseline reuse to accurately schedule gains, team estimate of ~ 10%	~10%-15%
Cost (applied time)	• SPOC savings of $3mm • Parts verification savings TBD	Initial estimates of team indicate that total life cycle costs decrease by 5%-10%	Need to baseline reuse to accurately schedule gains, team estimate of 15%-25%	Initial estimates of team indicate that total life cycle costs decrease by 10%-20%	~10%-25%

Note: Level 1 Reuse is components for HW and common code libraries for SW.
Level 2 Reuse is subsystems for HW and object oriented technology for SW.

P. Summary... VII-37

In summary, adopting the full AEE recommendations will substantially reduce the loading and cycle time of Digital development efforts

TARGET IMPACT OF AEE PLANNING & DEVELOPMENT PROCESS CHANGES ON AVERAGE DEC DEVELOPMENT PROJECT
Current Process vs. AEE Process



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Source: Industry benchmarks & parametric relationships from C. Jones, USAF, B. Boehm, T.B.S. and BA&H studies to estimate implementation impact

VII. SUMMARY OF AEE BENEFITS

Q. Getting on with implementation will allow Digital to get on with realizing AEE's significant benefits **VII–38**

IMMEDIATE

PLANNING PROCESS
- Test, refine & document AEE process via FPPS pilot
- Fully define aggregates driven from current existing business
- Identify & define infrastructure / support requirements and enabling tools & techniques

DEVELOPMENT PROCESS
- Complete simulations of Best Practices
- Select 3 projects to pilot
- Test, refine & document AEE process via pilots
- Use Planning Templates to document business assump-tions for current projects

ORGANIZATIONAL TRANSFORMATIONS
- Identify & define infrastructure, support, & capability reqmts
- Quantify / qualify options & benefits of restructuring
- Test, refine & document link-ages to extended enterprise

INFORMATION SYSTEMS
- Refine conceptual model for highest priority system modules -- Project and Product management systems
- Create logical and physical models

BY FALL '93

PLANNING PROCESS
- Roll-out planning process to all Business units
- Drive requirements dialog against aggregates
- Institute targeted training programs to support roll-out

DEVELOPMENT PROCESS
- Drive all products of FPPS pilot into AEE Development process
- Identify, define & document enabling tools & techniques
- Implement Best Practices
- Begin full roll-out to all of Engineering

ORGANIZATIONAL TRANSFORMATIONS
- Institute targeted training programs to support roll-out
- Implement form of Program & Product Management
- Test, refine & document restructuring options

INFORMATION SYSTEMS
- Continue focus on highest priority system modules -- Project and Product management systems
- Build operational prototypes
- Prototype & Pilot

LONGER–TERM

PLANNING PROCESS

- Redefine Aggregates from needs- based market segmentation
- Execute infrastructure changes required

DEVELOPMENT PROCESS
- Identify & define infrastructure / support requirements
- Institute targeted training programs to support roll-out
- Detail Design Process Redesign
- Target Advanced Devel-opment for redesign

ORGANIZATIONAL TRANSFORMATIONS
- Determine level of organizational restructuring required
- Structure ongoing, continuous improvement program

INFORMATION SYSTEMS
- Define / implement systems for budgeting, human resources (next priority)
- Define / implement remaining systems (eg, assets, regulatory, etc.)

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VIII. NEXT STEPS

- OPERATIONALIZE AEE — 1
- TEAM RESTRUCTURING — 6
- IMPLEMENTATION TASKS — 11

SUCCESSFULLY OPERATIONALIZING THE AEE INITIATIVE IS ENGINEERING'S MOST IMPORTANT CHALLENGE, AND WILL REQUIRE SUBSTANTIAL INVOLVEMENT AND RESOURCE COMMITMENT FROM ALL OF ENGINEERING, AT EVERY LEVEL

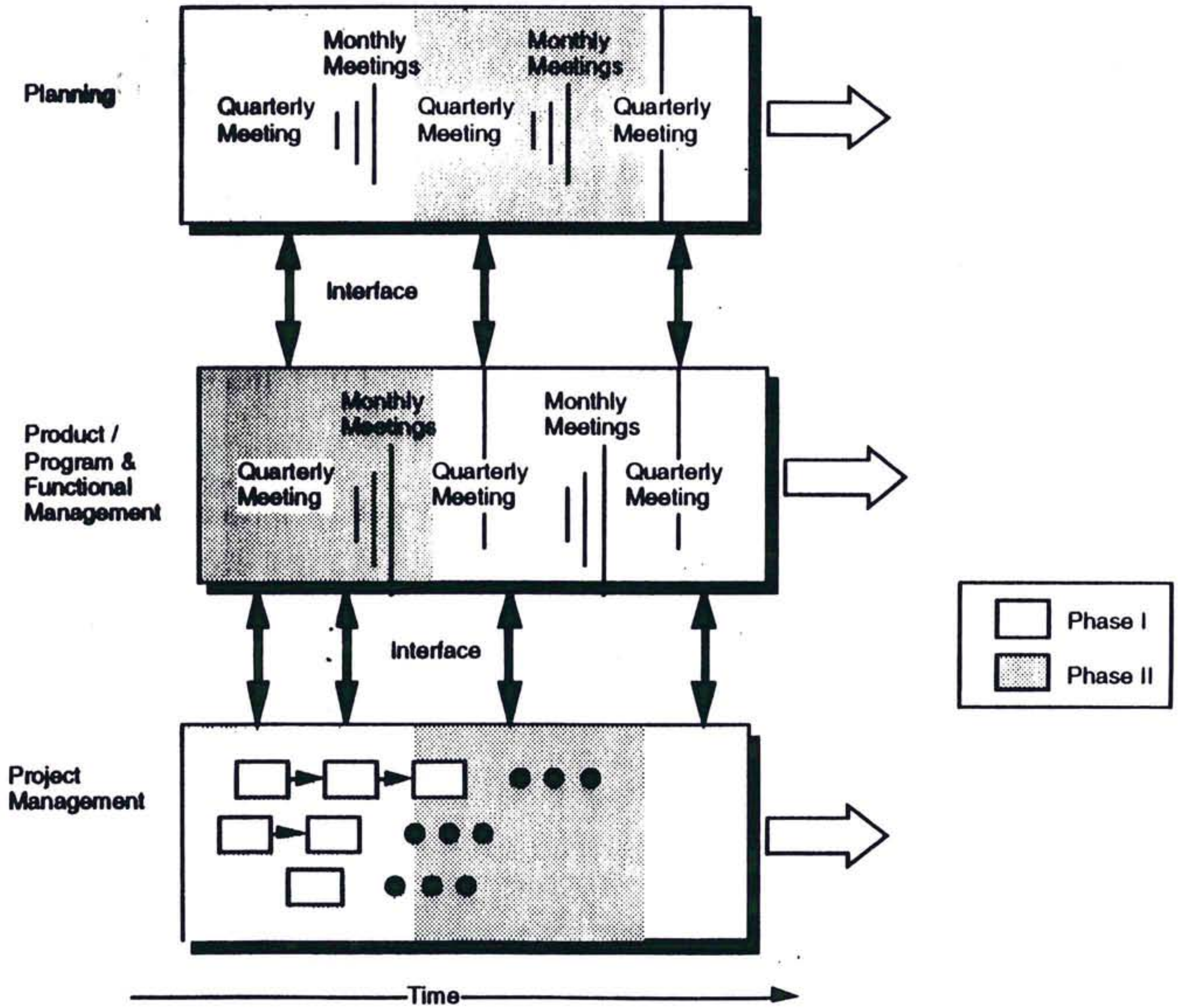
- Now that the AEE PMO has been chartered with a broadened scope, and Digital professionals made fully accountable, we must prioritize the challenges we wish to tackle
  - What are immediate, near-term, mid-term, or long-term actions?
  - What sequencing is required given the substantial interdependencies?
  - What are the implications of "integrating with the supply chain"?
  - What role will the PMO play in major tasks: measurement, training, and documentation?

- The first priority is to agree to the major milestones, then to identify / assign the key resources to achieve those objectives

- The operational structure and resources of the AEE PMO must be established quickly to ensure that momentum is not dissipated
  - Finalize the full membership of the program team
  - Identify the supporting staff for the PMO and the senior team members
  - Define role for current AEE teams: continue, restructure, or wind down?
  - Establish the operating relationship between the PMO and functional engineering

- To ensure its success the AEE PMO needs to determine how it intends to measure and track the progress of implementation as well as the impact of changes being adopted
  - Must define two categories of metrics: implementation progress and impact
  - Need to develop a mechanism to gather the data to allow ongoing tracking

PHASE II WILL OPERATIONALIZE AEE'S INTEGRATED PLANNING / DEVELOPMENT PROCESS



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AS AEE MOVES INTO PHASE II, IT WILL FOLLOW A SET OF IMPLEMENTATION PRINCIPLES

- Create a learning organization – institutionalize AEE
- Establish DEC ownership – accountability, authority, measurability
- Involve the entire organization – all disciplines, all levels
- Be customer / market driven
- Link explicitly to the Extended Enterprise – Supply Chain, cross-functional
- Follow TQM – quality focus

Next Steps...

WE HAVE TAKEN AN INITIAL CUT AT PRIORITIZING THE IMPLEMENTATION TASKS

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	IMMEDIATE	BY FALL '93	LONGER-TERM
PLANNING PROCESS	• Test, refine & document AEE process via FPPS pilot • Fully define aggregates driven from current business • Identify & define infrastructure / support requirements and enabling tools & techniques • Use Planning Templates to document business assumptions for current projects	• Roll-out planning process to all Business units • Drive requirements dialog against aggregates • Institute targeted training programs to support roll-out	• Redefine Aggregates from needs-based market segmentation • Execute infrastructure changes required
DEVELOPMENT PROCESS	• Simulate processes/practices • Adopt Tech Files/Aspect & Reuse Templates • Select 3 projects for 1st wave • Test, refine & document AEE process via pilots	• Drive all products of FPPS pilot into AEE Development process • Identify, define & document enabling tools & techniques • Implement Best Practices • Begin sequenced roll-out to all of Engr. starting with Wave 2 pilots	• Identify & define infrastructure / support requirements • Institute targeted training programs to support roll-out • Detail Design Process Redesign • Target Advanced Development for redesign
ORGANIZATIONAL TRANSFORMATION	• Identify & define infrastructure, support, & capability requirements • Quantify / qualify options & benefits of restructuring • Test, refine & document link-ages to extended enterprise	• Institute targeted training programs to support roll-out • Implement form of Program & Product Management • Test, refine & document restructuring options	• Determine level of organizational restructuring required • Structure ongoing, continuous improvement program • Determine geographic alternatives
INFORMATION SYSTEMS	• Refine conceptual model for highest priority system modules -- Project and Product management systems • Create logical and physical models	• Continue focus on highest priority system modules -- Project and Product management systems • Build operational prototypes • Prototype and Pilot	• Define / implement systems for budgeting, human resources (next priority) • Define / implement remaining systems (eg, assets, regulatory, etc.)

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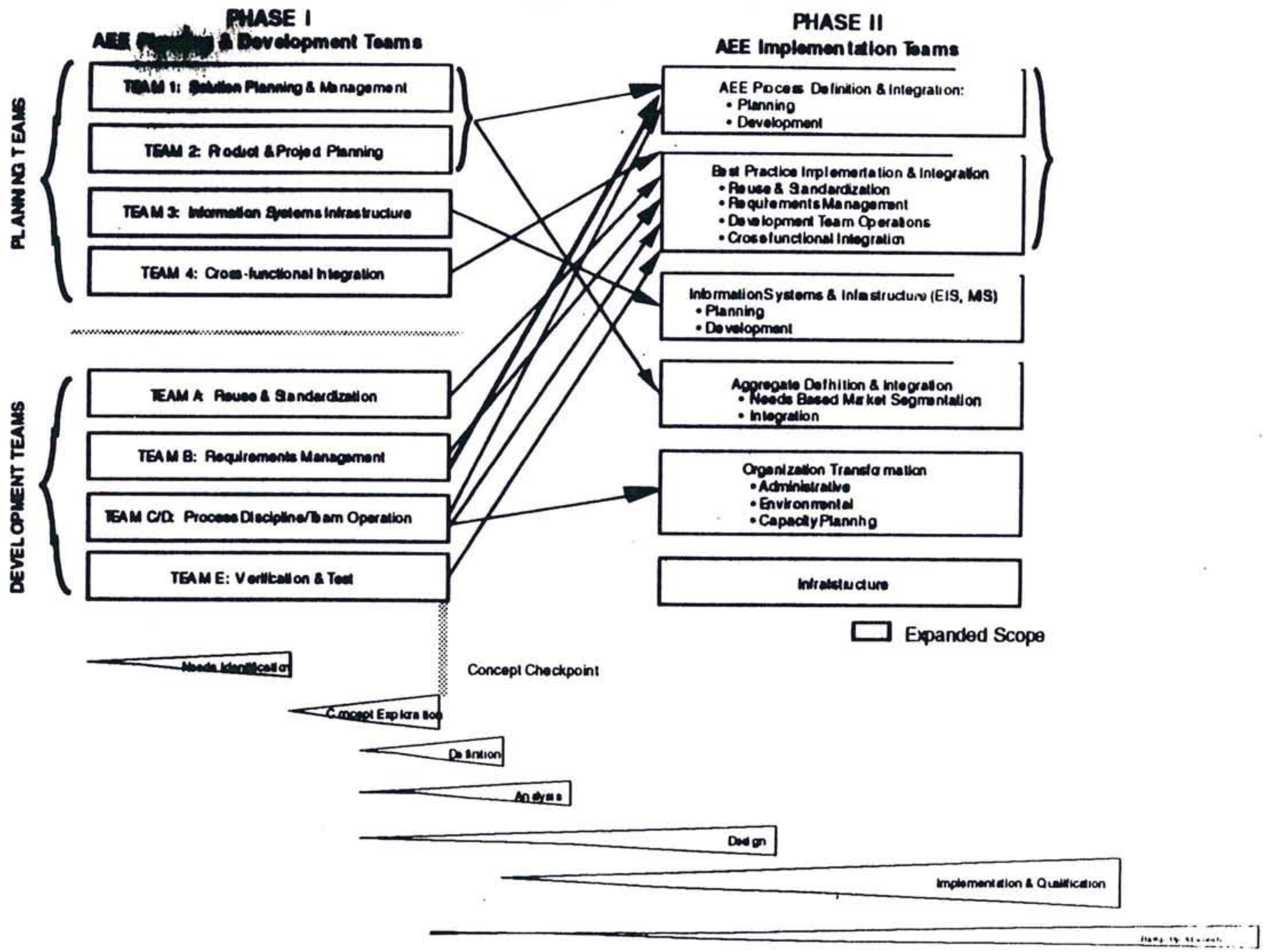
TEAM RESTRUCTURING

digital

DIGITAL CONFIDENTIAL

THE TRANSITION FROM PHASE I TO PHASE II IS AEE'S EXIT FROM THE CONCEPT PHASE

AEE TEAM STRUCTURE



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WE RESTRUCTURED OUR EFFORT TO SHIFT TO AN IMPLEMENTATION FOOTING

- During concept phase, work was arranged in manageable / digestible chunks
  - Planning by issue
  - Development by leverage point

- The transition to implementation will require several changes
  - Integrate planning & development initiatives
  - Expand the scope in selected areas and focus on critical issues
  - Launch operationalization efforts

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PHASE I INVOLVED DIAGNOSTIC EFFORTS TO IDENTIFY THE NEEDED REDESIGN ACTIONS

AEE PHASE I — NEED IDENTIFICATION AND ANALYSIS
EXPLANATION OF DEVELOPMENT PROCESS ANALYSES

Applied Time Survey	• An examination of DEC's Engineering Organization's Functional skill mix, and an assessment of how the engineering resource base applies their time — Used for structural analysis • Survey via e-mail of all Digital central and dotted line engineering personnel with responses accounting for 78% of all Engineering employees • Provided a data foundation and identified leverage points for redesign
Project Profile Surveys	• Profile of 63 actual development execution experiences to quantify the current state of engineering execution and assess extent of best practice use • Collected data on a cross section of projects representing all organizations to identify drivers of development efficiency & effectiveness
Structured Personnel Analysis	• Analysis on various engineering staff levels and distribution of headcount across profession & tenure levels • Various analyses of engineering organizational, structural, seniority levels, tenure & salary variances to provide context and identify structural deficiencies in resource base
In Depth Case Studies	• Examined, through in-depth interviews of numerous participants in 6 Digital projects noted as both successful and/or learning experiences • Identified "as is" processes and in depth experience in each of the best practice areas
Best Practices Benchmarking	• Survey of 20 Design Entity managers to understand the organization's use of engineering best practices • Compared DEC to 12 leading high technology companies on use of development best practices • Provided internal and external benchmarking of DEC engineering in a variety of key best practice areas • Identified high leverage areas for improvement and provided focus to AEE development process definition
R&E Expenditure Benchmarking	• Examined Digital's research & engineering expenditures normalized for product and service mix differences • Compared expenditures to adjusted peer groups by product / technology area
Technical Problem Reporting Analysis	• Assessment of source and volume of SPRs and CLDs • Assessed total cost of technical problem resolution to Digital

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THE AEE PLANNING PROCESS WAS DEVELOPED BY A SERIES OF DIGITAL TEAMS

AEE PHASE I — CONCEPT/DEFINITION
EXPLANATION OF PLANNING PROCESS REDESIGN EFFORTS

Team 1	**Solution Planning And Management Process**	• Define the nature of the inputs to the Program/Project planning process from the business units; and the processes for translation into solution set requirements and management of final solution set
Team 2	**Program/Project Planning Process**	• Translation of Solution Set requirements into detailed product requirements in light of capabilities and resources
Team 3	**Program/Project Management Information Systems**	• Assessment of resource skill mix and utilization. Tracking of progress against target cost, budget, schedule and quality
Team 4	**Extended Horizontal And Vertical Interfaces**	• Development and maintenance of communication bridges to extended enterprise. Roles and responsibilities for communication: content, timing, format
Aggregate Team	**Definition Of And Development Of Examples Of Aggregates**	• An "Aggregate" is, eventually, a specification of how the things DEC builds combine modularly into solutions to meet customers needs. What is required is a "structure" that segments customer needs in terms that allow Digital to define its product space in this manner. Optimally, this would be the result of a comprehensive needs based market segmentation analysis, which reflects DEC's relative core competencies and strategy
Simulation Team	**Simulation Of The Integrated Planning Process**	• Planning interface between engineering and 9 BUs and within engineering (one contact layer e.g.: high level) • Pilot test of UNIX and 2 or 3 SI platforms for healthcare and process manufacturing; and one or more products from TOEM • Foundation for decision making (e.g., investments)

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THE AEE DEVELOPMENT PROCESS WAS ALSO DEVELOPED BY A SERIES OF DIGITAL TEAMS

AEE PHASE I — CONCEPT/DEFINITION
EXPLANATION OF DEVELOPMENT PROCESS RE-ENGINEERING EFFORTS

Team A	**Design Re-Use And Standardization**	• Opportunistically reuses existing hardware and software design elements • Proactively designs for reuse to cut the design cost and time of succeeding generations • Modularizes products to simplify design process • Increases end product quality as design elements are better "scrubbed" of errors • Employs standard parts to minimize cost and part number complexity
Team B	**Requirements Management**	• Employs rigorous cost/benefit analysis of changes to minimize churn • Employs the discipline of systems engineering to structure and decompose requirements • Imposes a disciplined requirements "freeze" point to avoid "whip sawing" development effort • Uses traceability methods and tools to ensure that requirements are met
Team C	**Development Team Operation**	• Establishes an empowered project leader to ensure sufficient authority over participants • Determines extent and timing of functional involvement to maximize cross-functional input • Employs to greatest extent possible the collocation of all team members
Team D	**Development Process Discipline**	• Creates a clearly understood process to execute product development across Digital • Articulates the critical interfaces and interactions that must occur • Defines the needed levels of technical and business reviews through checkpoints • Identifies the required best practices that must be employed at each point • Embeds risk-based flex to scale process
Team E	**Qualification And Test**	• Streamline back-end qualification & test process • Balance testing value against cost
Integration Team	**Integrated Development Steering Committee**	• Integrate lessons learned and set overall direction • Integrate Best Practices recommendation into process definition

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THE RESTRUCTURED TEAMS ARE FOCUSED ON THE KEY IMPLEMENTATION TASKS

AEE TEAM STRUCTURE — TRANSITION TO IMPLEMENTATION
Explanation Of Integrated Planning Anddevelopment Redesign Efforts

Description	Supplemental Charter	Link To Concept Teams
Integrated Planning And Development Process	• Integration between planning and development processes • Develop action oriented implementation plans	1,2, B, D Integration team Simulation team
Best Practices **– Design re-use** **– Requirements management** **– Team operations** **– Qualification And test**	• Develop action oriented implementation plans • Expand scope to include procedures and policies which would affect planning and development processes	Integration team A B C E
Management Information Systems	• Expand scope to include development processes • Preliminary audit of current systems • Develop next steps and quantify resources required	3
Aggregate Definition And Development	• Identify examples of cross industry platforms • Identify examples of IT platforms and subsystems • Further educate BUs on application of aggregates	Aggregate team
Organizational Transformation **_ Support/Infrastructure** **_ Organizational Design** **_ Funding**	• Administrative systems • Human resource development • Learning organization • Management/decision flow • Explicit and separate roles and responsibilities	D, New
Operationalization	• Customize reviews and interaction across entire process • Quantify management effort for reviews, etc.	New

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IMPLEMENTATION TASKS

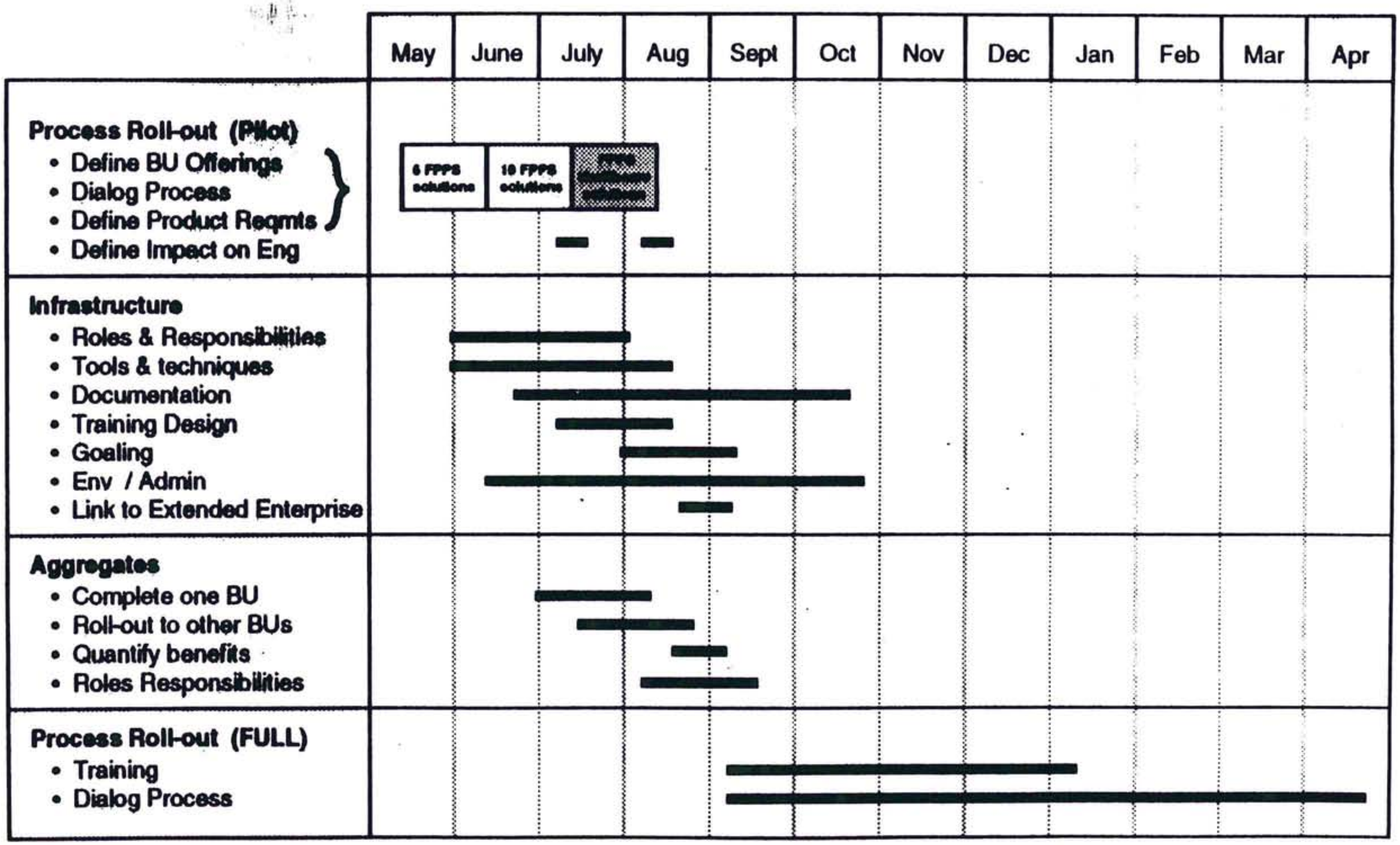
AEE PLANNING PROCESS MODULES

- Pilot
- Infrastructure
- Aggregates
- Full roll-out

Next Steps...

THE PLANNING PROCESS CAN BE READY FOR FULL ROLL-OUT BY FALL

AEE PHASE II WORKPLAN — PLANNING PROCESS IMPLEMENTATION



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Next Steps...

AEE PLANNING PROCESS — PILOT WORK MODULE

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D[illegible]

Complete Planning process for >80% of FPPS requirements*. Execution of several stages (beginning with only 6 customer solutions and escalating) to learn from the new process. Testing and refining the process through hands-on planning experience. (see also infrastructure and aggregates modules)

Objectives

- Fully characterize BU offerings
- Test & refine process thru actual situations
- Provide early / visible successes
- Provide real-time input into product strategies

Proposed Completion

Target: 8/30/93 — to employ for FY95, lead time is req'd for the rest of BU's to be trained in the new process and to undergo process w/Eng.

Resource Requirements

	Initial FTE Per Cust Soln*
• AEE Leader / facilitator	0.5
• Business Units	1.0
• Product Marketing	0.2
• Systems Engineer	0.1
• Documentation / analysis	0.5
• Engineering Content resources	2.0

Key Phase I Participants

- Anker Berg-Sonne, Health
- Paul Kyzivat, CIM
- Alan Briggs, Retail MS
- Pat Prince, Chemicals
- John Giudice, TOEM
- Don Harbert, VMS
- John Adams, NOS
- Howard Mayberry, NOS

Benefits

- Momentum / good-will in adoption of AEE planning process
- Initial, market driven feedback to technology and product strategies
- Training of a cadre of professionals in the application of the planning process
- Completion of the definition and doc- umentation of the planning process

Value

Value of AEE Planning Process
- $90 million
- 2 - 3 months elapsed time

Impact

- ⊘ Cost
- ⊘ Quality
- O Cycle-time

LEGEND

- ● High
- ⊘ Medium
- O Low

Workplan

- Engage one BU (FPPS) to work with engineering to define all BU offerings and drive to product reqmts
- Stage 1: begin with approx. 6 customer platforms
- Stage 2: 10 add'l cust platforms using aggregates
- Stage 3: complete FPPS and expand to Healthcare
- Capture / integrate learning into each successive stage
- Quantify benefits of aggregates: BU needs rationalization; reduced cost to deliver; faster / better planning, etc

Completed in Phase I

- High-level process definition
- Developed dialog / POR templates
- Tested / proved role and value of dialog process
  - Chemicals MSDS Pilot
  - Healthview Pilot
  - TOEM Pilot

Immediate Next Steps

- Finalize / assign resources
- Review market justifications of stage 1 solutions
- Initiate dialog process for stage 1
- Initiate stage 2 research as required

* approx. 25 customer solution platforms account for 80% of FPPS's business

Next Steps...

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AEE PLANNING PROCESS — INFRASTRUCTURE WORK MODULE

[redacted]

Define and charter the Engineering support infrastructure as it applies to the Planning Process. Define / assign planning roles. Develop tools & techniques, training / communications, metrics; env. / admin. reqmts. Continue to explicitly link the AEE Planning Process to the extended enterprise.

Objectives

- Define owners / decision makers and assign roles
- Define objectives / metrics for these roles
- Document process and application (training)
- Execute complementary changes in env / admin
- Develop tools & techniques

Proposed Completion

Target: 9/30/93 — needs to be 80% in place before full roll-out to remaining BUs can occur

Resource Requirements

	Total FTE
• AEE Leader / facilitator	1.0
• Documentation specialists	10
• Training Specialists	10
• HR Specialists	2.0
• Engineering Content resources	5.0
• Other Functional members	5.0

Key Phase I Participants

- Ralph Christiensen, HR
- Bill Koteff, Opns

Benefits

- Operationalize / facilitate use of Planning Process
- Capture Lessons Learned
- Maximize effectiveness of Planning Process across
- extended enterprise
- Assure smooth roll-out
- Define / direct / embed cultural change

Value

Value of AEE Planning Process
- $90 million
- 2 - 3 months elapsed time

Impact

- ○ Cost
- ⊘ Quality
- ⊘ Cycle-time

LEGEND
- ● High
- ⊘ Medium
- ○ Low

Workplan

- Define / assign planning roles & skill requirements
- Identify and address environmental / cultural issues
- Identify / develop tools & techniques
- Document process and most effective utilization
- Design targeted training programs
- Develop goals / metrics to measure success
- Link to extended enterprise thru Supply Chain
  Identify and document required infrastructure and administration

Completed in Phase I

- Capabilities gaps
- Organizational Implications
- Information systems reqmts

Immediate Next Steps

- Identify and assign resources

AEE PLANNING PROCESS — AGGREGATES WORK MODULE

[illegible]

An "Aggregate" is a specification of how the things DEC builds combine modularly into solutions to meet customer needs. What is required is a "structure" that segments customer needs in terms that allow Digital to define its product space in this manner

Objectives

- Fully characterize / operationalize aggregates
- Define aggregates based on current offerings
- Define role in planning process
- Define / charter / enroll management structure

Proposed Completion

Target: 9/30/93 — to employ for FY95, lead time is req'd for the BU's to realign their business and to define their requirements with Engineering

Resource Requirements

	FTE Per Aggregate
• AEE Leader / facilitator	0.2
• Business Units	1.0
• Product Marketing	0.2
• Systems Engineer	1.0
• AEE Process Expert	0.2
• Engineering Content resources	1.0

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Key Phase I Participants

- Paul Kyzivat, BU-CIM
- Alan Briggs, BU-Retail
- MSJackie Kahle, Prod Mktg
- Gene Hodges, Prod Mktg
- Jack Bowie, Prod Mktg
- Ladin / Langdon, CSE
- Dick Loveland, CSE
- Les Kramer, CSE

Benefits

- Rationalization across BU reqmts
- Achieve system-ness for both solutions and systems Businesses
- Reduction in operational complexity
- Reduction of risk of customer sales

Value

Value of AEE Planning Process
- $90 million
- 2 - 3 months elapsed time

Impact

- ● Cost
- ⊘ Quality
- ● Cycle-time

LEGEND

- ● High
- ⊘ Medium
- ○ Low

Workplan

- Engage one BU (FPPS) to work with engineering to map all BU offerings and relate to aggregates
- With these aggregates, work with other business units to define / align their offerings
- Quantify benefits of aggregates: BU needs rationalization; reduce cost to deliver; faster / better planning, etc
- Design & deploy management and architectural roles and responsibilities (define capabilities & gaps)

Completed in Phase I

- How to define
- Existence proven w/ examples
- Proposed ten
- Reconciled with "Domains"

Immediate Next Steps

- Define constituents of examples
- Define owners
- Engage with other BUs
- Reconcile with "Product Sets"

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AEE PLANNING PROCESS — FULL ROLL-OUT WORK MODULE

[redacted]

Fully engage all the business units in the application of the AEE Planning Process. Roll-out will require the utilization of all the participants trained throughout the Pilot(s); and will require significant training of large portions of engineering and BU professionals

Objectives

- Engage all BUs
- Training of affected professionals
- Rationalization of needs across BUs
- Direct input for technology & product strategies

Proposed Timing

Roll-out Target: 8/30/93 — to employ for FY95, lead time is req'd for the BU's to be trained in the new process and to undergo process w/Eng.

Resource Requirements

	Initial FTE Per <u>Cust Soln</u>
• AEE Leader / facilitator	0.1
• Business Units - Marketing	1.0
• Systems Engineer	0.1
• Documentation / analysis	0.1
• Aggregate agents	0.2
• Product agents	0.5
• Other functional agents	0.2

Key Phase I Participants

- Anker Berg-Sonne, Health
- Paul Kyzivat, CIM
- Alan Briggs, Retail MS
- Pat Prince, Chemicals
- John Giudice, TOEM
- Don Harbert, VMS
- John Adams, NOS
- Howard Mayberry, NOS

Benefits

- Market driven feedback to technology and product strategies
- Greater requirements stability
- Partnership with BUs
- Responsive, while stable, planning process
- Decentralization of decision making

Value

Value of AEE Planning Process
- $90 million
- 2 - 3 months elapsed time

Impact

- ● Cost
- ● Quality
- ● Cycle-time

LEGEND

- ● High
- ⊘ Medium
- ○ Low

Workplan

- Engage all BUs to work with engineering to define all BU offerings and drive to product reqmts
- Launch training program
- Define / Identify / Charter management roles & resp.
- Refine & implement product strategy process
- Quantify benefits of new AEE Planning Process and aggregates: BU needs rationalization; reduced cost to deliver; faster / better planning, etc

Completed in Phase I

- High-level process definition
- Developed dialog / POR templates
- Tested / proved role and value of dialog process
  - Chemicals MSDS Pilot
  - Healthview Pilot
  - TOEM Pilot

Immediate Next Steps

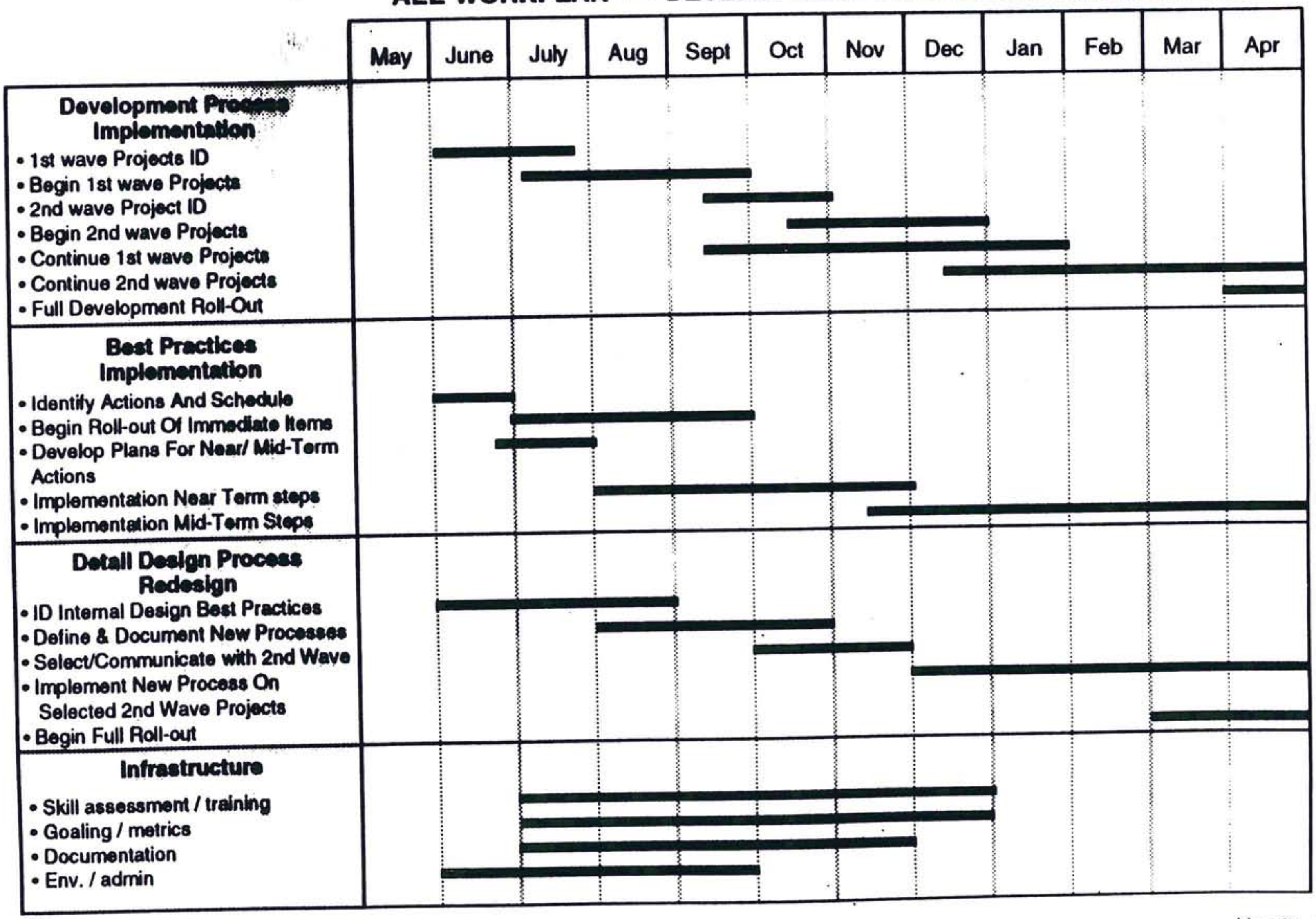
Initiate communication and buy-in program targeted at BUs and all of engineering

AEE DEVELOPMENT PROCESS MODULES

- **Process Implementation**
- **Best Practice Implementation**
- **Detail Design Process Redesign**
- **Infrastructure**

THE FOUR KEY DEVELOPMENT EFFORTS CAN BE DONE IN PARALLEL

AEE WORKPLAN — DEVELOPMENT IMPLEMENTATION SCHEDULE



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Next Steps...

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AEE DEVELOPMENT PROCESS — AEE PROCESS IMPLEMENTATION MODULE

Description	Objectives	Resource Requirements
Rolling out the new AEE development process across Digital. Executing a series of 1st and 2nd wave pilot implementations concurrently to learn from and progressively scale-up the new process. Testing and revising the Checkpoints and risk-based flex options through hands-on development experience.	• Test the process in actual development situations • Modify process as needed before full roll-out • Progressively scale-up to build experienced cadre • Provide initial focus to ensure success **Proposed Timing** • Target 9/30/93 for transition from 1st wave test • Target 3/31/94 for transition from 2nd wave test • Target 4/1/94 for beginning full roll-out	FTE's Per 1st <u>Wave Project</u> • Product Leader 1.0 • Systems Engineer 1.0 • Team Facilitator/Trainer 0.5 • AEE Process Expert 0.5 • Documentation Specialist 0.5 • Product Mgmt/Mktg 1.0 • Other Functional Members ?

Key Phase I Participants	Benefits	Value	Impact
• Tom Harris, SWG • Bill Wright, SWG • Neil Davies, CSG • Anders Overgaard, CSG • Masood Heydari, CSG • Andrew Gent, IDC • Tony Hutchings, SWG • Frank Melanson, CSG	• Shorter time and lower cost for development • Greater discipline in execution of development • Oversight based on inherent risk • Required work based on inherent risk • Less upfront churn/downstream rework • Decentralized decision making, greater accountability • Common process to allow easier roll-up of progress • Built-in systems perspective upfront in process	**Quantifiable Value** Applied-Time: 25%-30% Cycle-Time: 35%-40% **Risk Reduction Value** Shakes down process, building understanding	● Cost ⊘ Quality ● Cycle-time **Legend** ● High ⊘ Medium ○ Low

Workplan	Completed in Phase I	Immediate Next Steps
• Select 3 1st wave projects to begin the prototype testing of the AEE development process for 3 months • Select 30 2nd wave projects to scale-up the testing of the process. Initiate some based on FPPS pilot results • Cross-pollinate 2nd wave projects with experience from 1st wave projects through-out process • Initiate full roll-out to all projects after 8 months of 2nd wave experience. Continue ongoing lessons transfer	• Defined process architecture • Built in systems/CE view • Defined planning/development link • Identified major step deliverables • Defined Checkpoint operation • Identified key process responsibilities • Defined risk criteria & decision rules • Defined process flex options • Defined team structure across process	• Identify stand-out leaders for 1st wave • Define the 1st wave projects – Which BU will serve as sponsor? – Which organizations? – What size/complexity of project? • Start screening to select 2nd wave • Establish infrastructure for 1st wave • Define CM process for AEE process

Next Steps...

AEE DEVELOPMENT PROCESS — BEST PRACTICE IMPLEMENTATION MODULE

De[illegible]

Drive the adoption of development best practice across the organization in the areas of:

- Reuse & standardization
- Requirements management
- Qualification & test
- Team operation

Ensure rapid and consistent adoption of identified best practices.

Objectives

- Implement HW reuse, initiate SW reuse
- Adopt requirements management practices/tools
- Streamline qualification and test activities
- Adopt CE-based team structure & operation

Proposed Timing

- Target 6/30/93 for first set of immediate actions
- Target 7/30/93 to finalize near-mid term plans
- Target 8/1/93 to begin near-term implementation

Resource Requirements

	FTE Per Best Practice Area
• Best Practice Initiative Leader	1.0
• Documentation Specialist	1.0
• Training Expert	1.0
• Hardware Engineer	1.5
• Software Engineer	1.5
• AEE Process Expert	0.5
• Product Mgmt/Mktg	0.3
• Other Discipline/Function Reps	?

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Key Phase I Participants

- Steve Noyes, CSG
- Paul Vilcans, Mfg.
- David Hartzband, SWG
- Tony Hutchings, SWG
- Ted Gent, CSG
- Tom Harris, SWG
- Bill Wright, SWG
- Anders Overgaard, CSG

Benefits

- Shorter design time and lower design cost
- Better requirements with less churn
- Lower materials costs through standard parts
- Better requirements traceability — better products
- Better control of requirements changes — less rework
- Shorter qualification time and lower cost
- Earlier surfacing of downstream issues — less rework
- Greater accountability & faster communication

Value

Quantifiable Value

Applied-Time: 20%-25%

Cycle-Time: 10%-15%

Impact

- ● Cost
- ⊘ Quality
- ⊘ Cycle-time

Legend

- ● High
- ⊘ Medium
- ○ Low

Workplan

- Identify initiative leaders and dedicated resources
- For each initiative identify immediate, near-term, mid-term & long-term actions — prioritize work accordingly
- Establish roll-out plan for immediate changes and begin implementation planning of near and mid-term
- Segment actions by those to be rolled into pilots (team) and those to be adopted across the board (HW reuse)

Completed in Phase I

- 1st & 2nd level reuse defined
- Tech File/Aspect link established
- Reuse metrics/templates created
- Requirements Mgmt. process defined
- Traceability processes sketched out
- Verification gaps identified
- Program/product teams defined
- Team operation best practices defined

Immediate Next Steps

- Establish Tech File/Aspect funding & implementation plan with Mfg.
- Identify BP initiative leaders & staff
- Establish short & mid-term reuse template implementation plan
- Identify needed traceability tools

Next Steps...

AEE [redacted]OPMENT PROCESS — DETAIL DESIGN PROCESS REDESIGN MODULE

[redacted]

Building upon the top-level architecture of the AEE planning & development process, develop standard detail design processes for each major design discipline: software, digital, analog/microwave, mechanical, etc. The defined process will address both the steps, methods, and tools to be employed when following the standard design process for that discipline.

Objectives

- Define best practice process by design discipline
- Deploy standard design processes across groups
- Improve cost, quality, and time via standardization
- Enhance discipline and commonality with process

Proposed Timing

- Target 8/31/93 for completion of best practice ID
- Target 10/31/93 for documenting new processes
- Target 11/30/93 to start using on 2nd wave projects

Resource Requirements

	FTE's Per Target Discipline
• Team Leader	1.0
• AEE Process Expert	1.0
• Documentation Specialist	1.0
• Engineers From Discipline	6.0
• Training Expert	1.0
• Team Facilitator	0.5

Key Phase I Participants

Topic Not Specifically Addressed In Phase I

Benefits

- Shorter, lower cost, and higher quality detail design processes with greater repeatability
- Leverage the best approaches used in DEC and standardize on them raising all to DEC's best
- Easier load leveling and resource use through common process knowledge
- Lower tool acquisition and support costs through standardization of platforms and design tools

Value

Quantifiable Value

Applied-Time: 15%-20%

Cycle-Time: 10%-15%

Impact

- ● Cost
- ⊘ Quality
- ⊘ Cycle-time

Legend

- ● High
- ⊘ Medium
- ○ Low

Workplan

- Form cross-group teams for each target design discipline — led by experienced engineering manager
- Map major versions of design process, ID practices and tools used by groups across DEC
- Gather data on execution results by group to assess impact of different methods: time, cost, and quality
- Identify best elements of processes currently used
- Define new processes for each discipline

Completed In Phase I

- Top-level AEE process defined
- Some internal best practices surfaced
- Some best practice gaps identified
- Principles defined:
  - Use standard off-the-shelf tools
  - Adopt methodology first

Immediate Next Steps

- Select target design disciplines
- Select effort's leaders and form teams
- Initiate data gathering/mapping
  - Internal assessment
  - External benchmarking

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Next Steps...

AEE DEVELOPMENT PROCESS — INFRASTRUCTURE WORK MODULE

Description

Define and charter the Engineering support infrastructure as it applies to the development process. Will include documentation of the process and training & communication, goaling / metrics, and defining environmental / admin. requirements.

Objectives

- Define supporting goals / metrics
- Execute complementary changes in env./admin
- Identify and develop standard processes, tools, techniques, libraries, etc.
- Complete documentation, communication, and training

Proposed Timing

Target: 9/30/93 — needs to be implemented in conjunction with development process roll-out

Resource Requirements

	Total FTE
• AEE Leader / facilitator	1.0
• Documentation specialists	5.0
• Training Specialists	5.0
• HR Specialists	2.0
• Engineering Content resources	5.0
• Other Functional members	5.0

Key Phase I Participants

- Tom Harris
- Masood Heydari
- Tony Hutchings
- Steve Noyes

Benefits

- Communicate and facilitate the use of the new development process and best practices
- Assure smooth roll-out and implementation
- Provide standard processes, tools, and techniques
- Improved efficiency & effectiveness; provides a new base for continuous improvement

Value

Key to enabling the achievement of the AEE development process goals

Impact

- ● Cost
- ⊘ Quality
- ● Cycle-time

LEGEND

- ● High
- ⊘ Medium
- ○ Low

Workplan

- Identify & address env. / cultural issues
- Identify / develop tools & techniques
- Document process and best practices and most effective utilization
- Perform skill assessment / design training programs
- Develop goals / metrics to measure success
- Identify & document required infrastructure & admin

Completed in Phase I

- Capabilities gaps
- Organizational implications
- Information systems requirements

Immediate Next Steps

- Identify & assign resources

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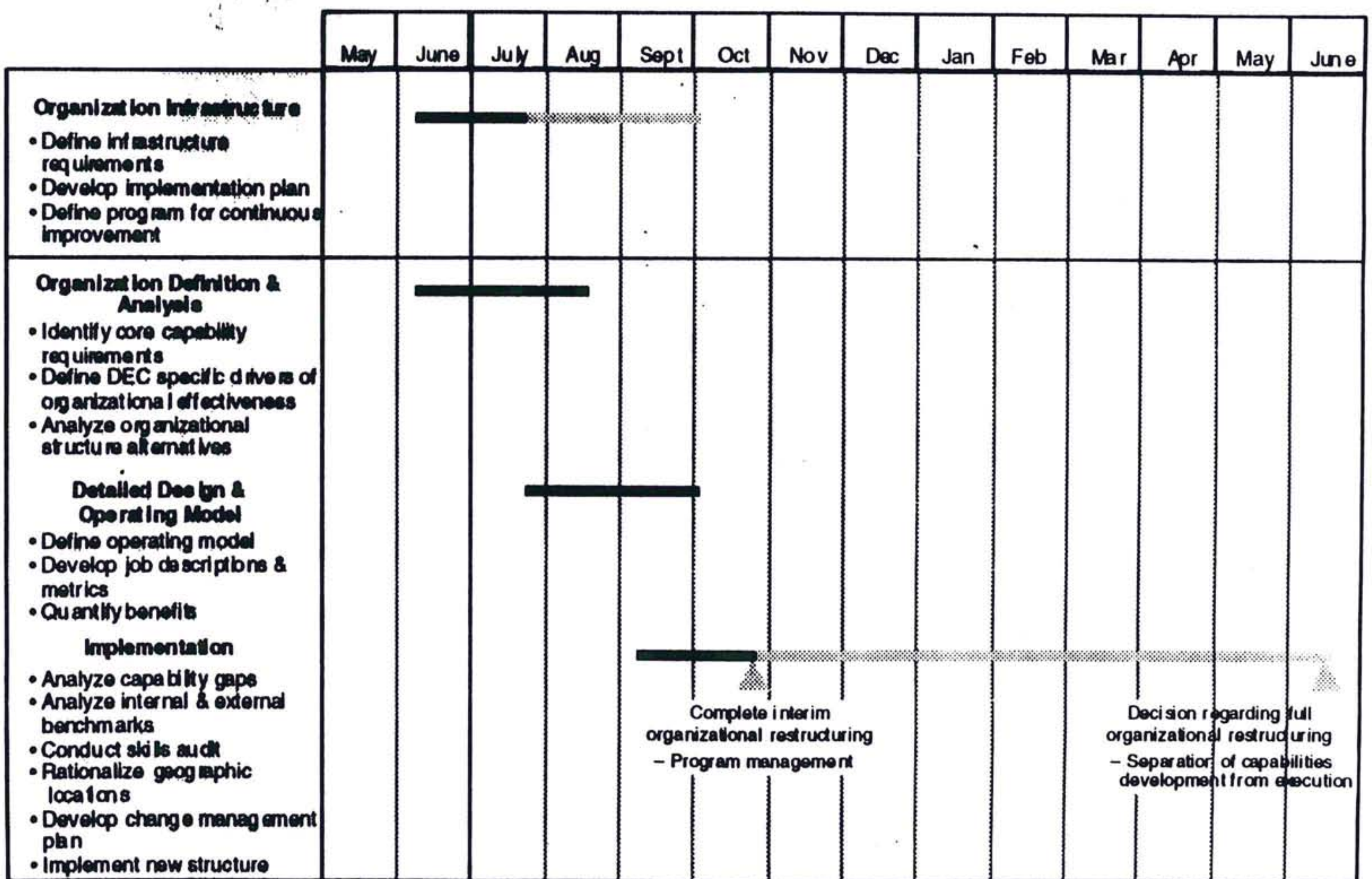
AEE ORGANIZATIONAL TRANSFORMATION

- Infrastructure
- Organizational Design

Next Steps...

THE WORK TO LAY THE FOUNDATION FOR ORGANIZATIONAL TRANSFORMATION CAN ALSO BE FINISHED BY THE FALL

AEE ORGANIZATIONAL TRANSFORMATION — WORKPLAN



Next Steps...

- 153 -

AEE [redacted]IZATION TRANSFORMATION — INFRASTRUCTURE WORK MODULE

D[redacted]

Define the engineering organization support infrastructure:
- Support organizations
- Support processes
- Information systems
- Tools & techniques

Link new organizational structure to AEE planning & development processes with appropriate supporting infrastructure.

Objectives

- Define roles & responsibilities of engineering support organizations (e.g. HR, Finance, etc.)
- Reengineer support processes
- Develop resource planning & allocation procedures

Proposed Completion

Target: 9/30/93 — significant changes need to be specified for organizational transformation steps

Resource Requirements

	Total FTE
• AEE Leader / facilitator	1.0
• HR Specialists	1.0
• Org. Design Specialists	2.0
• Engineering Content resources	10.0
• Other Functional members	10.0

Key Phase I Participants

- Ralph Christianson, HR
- Bill Koteff
- Tom Harris, Team C/D

Benefits

- Ensure congruency between AEE planning & development processes and organizational structure
- Assure smooth implementation
- Streamline interfaces and optimize informal processes
- Maximize efficiency & effectiveness of planning & develo[illegible]ent processes

Value

Key Enabler To Achieving The Savings / Value Outlined In AEE Planning And Development Modules

Impact

- ⊘ Cost
- ⊘ Quality
- ⊘ Cycle-time

LEGEND

- ● High
- ⊘ Medium
- ○ Low

Workplan

- Define support infrastructure requirements for major areas of engineering organization activity:
  - – Capability development & deployment
  - – Decision making
  - – Resource planning & allocation
  - – Budgeting & control
  - – Performance management
- Develop implementation plan
- Define program for ongoing continuous improvement

Completed in Phase I

- Capabilities gaps
- Organizational Implications
- Preliminary information systems requirements

Immediate Next Steps

- Define organization infrastructure requirements

Next Steps...

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AEE ORGANIZATIONAL TRANSFORMATION - DEFINITION, ANALYSIS, DESIGN & IMPLEMENTATION

Desc[redacted]

Engineering organization structure must be congruent with DEC's strategy to develop and deliver integrated customer solutions and be consistent with the new AEE planning & development processes. These significant changes drive a fundamental need to restructure the engineering organization.

Objectives

- Build on organizational concepts from Phase I
- Complete detailed organizational design
- Define organization operating model
- Develop detailed implementation plan

Proposed Completion

- Driven by 9/30 adoption of AEE processes
  - Target : 9/30/93 - program management
  - Target: 5/31/94 - complete transformation

Resource Requirements

	FTEs
• Team Leader	1.0
• Team Facilitator	0.2
• Senior Engineering Mgmt.	0.1
• Human Resources	0.5
• Engineering Content	2.0
• Supply Chain Functions	1.0

Phase I Participants

- Bill Strecker
- Ralph Christensen

Benefits

- Improved program/product development & delivery effectiveness
- Streamlined organization for reduced cycle and applied time
- Improved capability building - establish and maintain critical mass
- Improved responsiveness to changing market requirements
- Reduced cost for scale sensitive activities

Value

Key Enabler To Achieving The Savings / Value Outlined In AEE Planning And Development Modules

Impact

- ● Cost
- ⊘ Quality
- ● Cycle-time

LEGEND

- ● High
- ⊘ Medium
- ○ Low

Workplan

- Identify core engineering capability requirements/gaps
- Identify drivers of organizational effectiveness
- Analyze organizational alternatives
- Define organizational operating model (e.g. decision flow, job descriptions, funding, metrics, etc.)
- Rationalize geographic locations
- Quantify benefits of new organizational model
- Conduct skills audit
- Develop change management plan

Completed In Phase I

- Engineering organization concept
- Development team structure and operations
- Preliminary implementation planning

Immediate Next Steps

- Begin detailed organization analysis and design
- Near-term implementation of program organization

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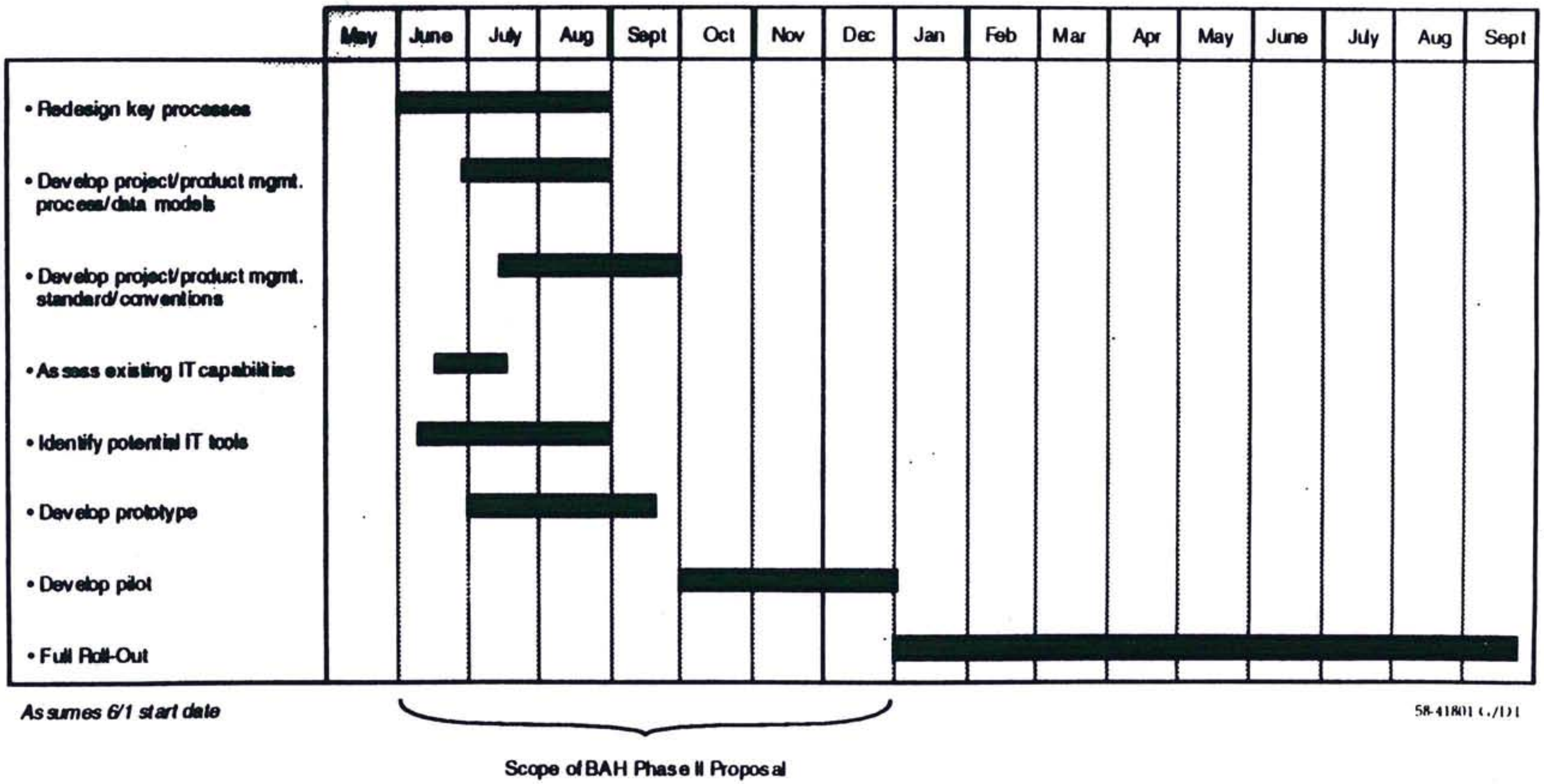
AEE ENGINEERING INFORMATION INFRASTRUCTURE

- **Project and Program / Product Management System**

THE NEW PROJECT/PRODUCT MANAGEMENT SYSTEM COULD BE READY BY THE BEGINNING OF 1994

AEE WORKPLAN — PROJECT/PRODUCT MANAGEMENT SYSTEM



Next Steps...

AEE IS INFRASTRUCTURE — PROJECT/PRODUCT MANAGEMENT SYSTEM

De[illegible]

An integrated set of IT enabled product and project management capabilities, including product and project databases, management and financial reporting, tracking, and performance measures. Leverage commercial off the shelf (COTS) software where possible.

Objectives

- Standardize project and product management data and processes, consistent with AEE
- Enable integration to other/future systems
- Ensure capture and use of key management, financial, and performance data

Proposed Completion

- Pilot deployed for one or more design entities targeted for 11/93

Resource Requirements

- Project team leaders (2)
- Models/reqm't.s team (5)
- Templates, stds., conventions (3)
- Tools and technology (prototyping) (3)
- Add'l QA/QC, steering committee, industry expert resources

Key Phase I Participants

- IM&T
  - Lou Cintron
  - Priscilla Monroe
- Bill James
- Nigel Turner
- Jim Despathy

Benefits

- Resource / capability loading and planning
- IT infrastructure to support AGE processes
- Consistent definition of data and processes
- Integrated tools and methodologies for product and project management
- Overall reduced systems costs – reduced number of systems and streamlined processes

Value

- Integration of systems and data
- Standardization of processes & information for sharing and delivery
- Tracking of metrics for processes

Impact

- Cost (Medium)
- Quality (High)
- Cycle-time (High)

LEGEND

- ● High
- ⊘ Medium
- ○ Low

Workplan

- Refine business needs/information reqm'ts.
- Develop project/product management process and data models
- Develop project/product management standards and conventions
- Assess existing IT capabilities
- Identify potential IT tools
- Develop prototype
- Develop pilot
- Refine implementation plan

Phase II Deliverables

- Prototype/pilot of new product/ project mgmt. system, piloted to one eng. entity – leveraging COTS
- Project/product management:
  - Standards and conventions
  - Project templates
  - Planning metrics
  - Perf. measures and rept'g. reqm'ts
  - Work breakdown structure
- IT capabilities requirements

Immediate Next Steps

- Collect and document info needs and reqm'ts.
- Develop templates/strawhorses for facilitated sessions
- Identify facilitated session participants

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II. Aggregates

Outline

A. Introduction...

Core to achieving excellence in engineering at digital is the convergence of Digital's market and technology strategies in driving engineering planning and development activities

...Market-based, interoperable and integrated are common themes

Realizing Digital's new strategies will require reaching a common ground between solutions demanded by the market and the engineered components which constitute those solutions

Clearly, Digital's historical approach of managing its complex product offerings at the component level is inefficient and ineffective

Importantly, whether digital builds systems or not, Digital's products will eventually comprise systems in the market and therefore must be engineered with an eye toward eventual interoperability requirements

Given the need for Digital's offerings to be interoperable with other Digital and third party products / solutions, it is critical to define the right level at which to drive a systems focus

...Defining the decision dynamics and implementing a strong management structure to support this architecture are mandatory for successfully exploiting aggregates, and discussed elsewhere

Aggregates are central to the AEE planning and development processes — a key foundation for driving efficiency and effectiveness across all the AEE recommendations

The central principle underlying the development of aggregates must be to reduce the risk of customer engagements

Aggregation into systems can be accomplished at a number of levels / dimensions...

...however, the right place is that which holds the highest value-added levers for customers and which allows Digital to capture the greatest amount of that value added

An Aggregate is a combination of products and/or capabilities that are engineered as an integrated entity to satisfy a defined need

"Aggregates" exist at every level in this chart — the cross-Industry platform level is key to supporting the CBU / SI initiatives...

Based on the analysis to-date, we believe that upwards of 10 - 20 aggregates exist in this space

... or at the IT platform level, which represents discrete technology sets

Therefore the goals of aggregate development were as follows

B. Background... II–12

Digital has done a lot of thinking around the issue of how to aggregate

Strecker / Sujnik have employed a technology driven model for defining system-level platforms...

Though not market driven, as a transition model it serves an important role in communicating to the company that digital will no longer operate at the components level

SWG has developed a similar paradigm to segment and recast their work more in line with their view of market requirements

Tthe CIM Group has proposed a paradigm which is intuitive and Customer / solution driven

The CIM framework has evolved into the current structure employed for the work of the aggregate examples team

II. Aggregates

...wherein the overlap between the stalagmite and stalactite Represents The Point Around Which market driven Aggregates Should Emerge

Specific Definitions Of These Layers Follow

C. **Examples... II–18**

Objective — To Test The Concept Of Market-Driven and technology-driven "Aggregates" Through The Development Of A "Full Set" Of Real Life Examples

A team of product marketing, business units, SE/si taskforce and Booz•Allen has been tasked with developing examples of market driven aggregates

To fully complete this charter, additional resources are needed

Specifically, the method we employed to develop the market-driven examples was as follows

<u>Step 1</u> **Analyzed industry specific requirements using:**

SI Pipeline analysis

Existing BU solutions already defined

Specific customer examples

What technology is being used; what functionality / value does it provide

<u>Step 2</u> **Looked for "patterns" of technology use across industries**

Common business process paradigms

Commonalities / patterns at all levels

<u>Step 3</u> **Further defined / exploded each aggregate** (see Appendix S)

Description

Target Customer

Industry Specific Examples

Technology Requirements

Development Environment Required

Operational Issues

In looking for "patterns" of technology use, first we identified common business process paradigms...

...then we looked for commonalities / patterns at all levels

II. Aggregates

Though still preliminary, we have described eight Cross-Industry Platforms in some detail...

Distributed Branch System - a cross-enterprise platform that supports a loosely connected set of fully or partially autonomous business entities, in which the communication enables coordination (e.g., of ordering and delivery of information) and/or control (e.g., of the operations of branch entities). (e.g.,)

Professional Data Analysis System - provides support to knowledge-workers who routinely gather and analyze large amounts of data to make critical business decisions. (e.g.,)

Case Handling System - supports the start to finish management of episodes constituting an enterprise's exchanges of goods and/or services with individual customers, clients, or suppliers. (an episode is a sequence of activities and decisions and/or actions). (e.g.,)

Control System - supports the control and/or monitoring of a process in real-time. The control system is connected to the process being controlled. (e.g.,)

On-line Library System - supports the storage, indexing, search and retrieval of large document-oriented databases. (e.g.,)

Integrated Business Operations System - a library of standard models and reusable service interfaces for accessing business operation and management functions — wrappers which make applications into clients or providers of those servers. (e.g.,)

Numeric Intensive Computing System - supports the specific requirements of computationally intensive applications, such as modeling and simulation. (e.g.,)

Proposal and Design System - supports the creation and storage of complex sets of product design information or compound documents for proposals – information may be later accessed by the Library System aggregate. (e.g.,)

Further detail can be found in Appendix S

...As well as two aggregates which can both be sold independently and probably underlie all identified cross-industry platforms

- Application Development Environment
- Network and Systems Management

this work is preliminary and less well defined than the previous Eight

further work for the generation of the market driven aggregate examples

- We have identified three potential, additional Cross-Industry Platforms which require further evaluation...
- And are aware of the potential for several more
- In order to maximize the benefit to the ongoing Planning Process

We also identified eight IT Platforms / Subsystems which the cross-industry platform aggregates require — and for simplicity mapped them as follows

- Application Integration
- Data Integration
- Workflow
- Business Process Modeling
- Repository
- Transaction Processing
- Inter-/Intra-Enterpreise Communications
- Complex Data Modeling

we repeated a similar method Starting from the technology perspective to develop a complete set of it platform / Sub-system aggregates

as a going-in hypothesis, we employed the paradigm developed by the software group

However, there is a not a simple, direct mapping of the cross-industry aggregates or identified needs to the SWG product set groupings

- Many aggregates need pieces of different Product Sets – what seems to characterize much of Digital's potential customer advantage / competitive edge are solutions that blend elements of both Workgroup and Enterprise
- Although there is significant value in products within a defined Product Set working together, there is an equal or greater need to have specific products currently in different Product Sets work together

Our analysis clearly identifies the need for IT platform / sub-system aggregates, but with significantly more granularity than the product set paradigm currently offers

D. Operationalization... II–30

In the near-term, the focus of aggregates is delivery against current needs

however, in the future aggregates should be used to drive investment

driving engineering investment from market needs will be facilitated through the application of aggregates

Specification of aggregates will likely occur over several stages

Organizationally, an important first step will be to clarify roles & responsibilities for definition and delivery of aggregates

E. Next Steps... II–34

To complete development of examples, significant buy-in / guidance and additional resources will be needed

- Business Units need to internalize and align their business needs to assist in both refining and prioritizing current examples
- Engineering, also, needs to internalize and align the product strategies
- Further, significant activities are required to operationalize aggregates

The aggregate team will pursue two activities in parallel...

...the details of which are in Appendix S

The high-level workplan summary shows the heavy reliance upon the planning process pilot now underway with FPPS

Aggressive pursuit of aggregates and the planning process pilot will be required to drive success of the AEE planning and development processes

PLANNING PROCESS | **DEVELOPMENT PROCESS**

Principles	Recommendations	Principles	Recommendations
Minimalistic	Dialog Process	Increasing Value-added	Re-use
Collaborative	Planning Templates	Concurrent Invlovement	Checkpoint Process
Responsive	Cross-engineering Dialog	SE Methodology	Risk-based Flex
Systems Focused \		Accountability	Empowered Teams
	> Aggregates		
Bilateral Contract /			
		Decision Making \	
		>	Requirements Management
		Efficiency /	

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

Outline

A. Integration... III-1

In order for Digital to achieve excellence as a corporation, an overall & integrated architecture for world-class planning and execution will be required

AEE's integrated approach to engineering planning and product development must be consistent with this overall architecture

Planning and development processes reflect each other

The integration of planning and development, through shared value and concurrency, yields an effective engineering process

The integrated process must add value — through balancing demand and supply via planning and thereby driving development

The endgame is an integrated process for driving and ensuring excellence in engineering planning and development

B. Diagnostic/Charter... III-7

Presently, engineering planning is broken – either there is no planning process or there are 7 unconnected planning processes, none of which satisfactorily drive market-based engineering

- 8 Quarter Volume Planning (8QVP)
- Corporate Phase Review Process
- LRP/"Bottom Up" Process
- Customer Program Reviews
  - Semi-annual proces involving selecting customers to discuss current products, customer needs & market trends
  - 80% of DEC technologies represented by partners programs (e.g.: UNIX, VMS, Networks, Graphics, Real Time)
- "Ad Hoc Cooperation"
- "Domain" Process

Although slightly different in each group, there is an existing development process at Digital

However, Digital's current overall process suffers from a lack of discipline that results in minimal control and predictability in engineering spending

this lack of process discipline also translates into cycle times which are too long given competitive pressures — and "advanced" development in excess of 8 months, on average

Charter... III-11

To tackle Digital's severe problems, aggressive goals were set for the 2-3 year horizon of the AEE program, establishing a clear charter for what the integrated planning and development process must deliver

The substantial challenges confronting Digital engineering indicate that achieving these goals is critical

Planning Gaps:

- No established link to the newly formed business units to drive engineering planning
- Technology driven, rather than market driven, engineering planning

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

- Absence of a construct to drive planning from a systems or components perspective
- Inadequate link to the "extended enterprise" to drive engineering planning

Development Gaps:

- Development cycle-times significantly longer than competitively permissible
- Substantial requirements churn post initial product specification
- Absence of best practice and tool standardization across development groups
- Minimal discipline in the execution of design processes
- Limited attention given to part standardization and design reuse
- Inconsistent employment of concurrent engineering principles

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

C. Principles... III-13

The AEE re-design of DEC's processes is driven from several basic principles which apply to both planning and development:

1. Minimalistic
- A simple and highly implementable process requiring minimal documentation

2. Collaborative & Concurrent Involvement
- A partnership based dialog between the BUs and Engineering
- All relevant functions are involved as early as possible in effort

3. Responsive & Flexible
- A continuous (i.e., not annual) process that is responsive to market changes and flexible

4. Systems Focused & SE Methodology
- A process that drives to a systems view of interoperability requirements
- Steps geared to addressing system considerations from the start

5. Bilateral Contract
- Schedule / cost / deliverable for committed business results

6. Increasing Value-Added
- The process will be gated by demonstrable increases in value

7. Accountability & Decision Making
- All requirements, deliverables, and tasks are explicitly owned
- Decisions are only made by people directly participating in the process

8. Efficiency
- Flexibility, scalability and standardization are balanced to optimize efficiency

It is these principles which are central to AEE. The specific recommended processes facilitate the implementation of these principles

Let's discuss each of the basic principles in turn

1. Minimalism... III-15

Providing market driven, needs based customer solutions requires effectively linking the various Digital organizations in the extended enterprise representing demand and supply – primarily the business units and engineering

The dialog process is guided by rules agreed upon by both business units and engineering

The AEE planning process promotes the most efficient & effective dialog between BU's and engineering based on a minimum amount of documentation

Fundamental to the minimalistic principle is the need for only the key information – derived from a finite set of inputs – to feed into the engineering planning process

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

More specifically, the information needed to support the business unit / engineering dialog must reflect actionable outputs for engineering

The development process is minimalist in that it provides structure, yet imposes the minimum administrative or overhead work for engineering

2. Collaborative & Concurrent Involvement... III-21

The dialog is not only minimalistic, but it also requires collaboration and enables rapid decision-making and action by both engineering and business units

The information templates, created by the business units, are the basis for initiating the BU/engineering dialog and documenting BU solutions

The overlap of the phases – from planning through development – makes their activities concurrent – involving all relevant functions as early as possible in the effort

This is accomplished by pulling phase steps forward as early as possible

strong coordination of released work output is necessary

In addition, the AEE process is linked to all relevant Digital planning activities

Key extended enterprise linkages have been categorized in eight areas to be further defined and implemented in Phase II

3. Responsive & Flexible... III-27

the engineering planning process is responsive yet stable through a repeatable series of steps

Inherent flex was designed into the AEE process to adjust for three variables: levels of risk, different propositions, and different use

these variables are explained on the following pages

A critical concept for Digital, given the broad range of activities undertaken, and the lessons learned from the phase review process, is that of risk-based process 'flex"

AEE has created a common procedure for flexing the AEE process – both planning & development

- Planning process/flex... III-30
  The planning process needs to "flex" to reflect varying degrees of risk – four types of risk have been identified to
  drive the level of planning effort
  - Financial exposure
  - Technology risk
  - Market risk
  - Execution risk
- Development process–flex... III-31

  Risk is calibrated by flexing of checkpoints for the process phases

  Checkpoints synchronize the product's definition & provide process visibility

  At the concept checkpoint, programs/products will be assessed for risk to determine the appropriate flex in the development process as well

  WE APPLY four pronged DECISION guidelines TO EVALUATE the merger of EACH RISK PARAMETER

  THESE CODES ALLOW FOR RISK LEVELS THAT ARE HISTORICALLY DISPROPORTIONATE WITH PROJECT SIZE

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

THE TYPE and degree OF RISK DETERMINE THE Types OF PROCESS FLEX APPLIED: resources applied, reviews, checkpoints and the planning contract's tasks

The AEE process provides appropriate combinations to scale projects

The range of risks leads to eight potential paths through the process, WITH AN ASSOCIATED NUMBER OF CHECKPOINTS

Though more simplicity would be preferred, Digital engineering managers feel that this is the least complex description of a complex issue

This four-pronged assessment of risk parameters results in a tailoring of the process to one path through the common backbone

This process may seem complex — but the problem is complex, this allows a one time decision on the best process for the project

These risk parameters capture inherent differences between development disciplines such as hardware vs. Software

Appropriate external inspection is declared at the concept checkpoint

Responsive / Situation... III-39

the dialog process needs to be responsive to various situational triggers – In a steady state environment, this is a "portfolio" management process – with review of limited new proposals

however, changes that impact product requirements will be regulated through formal change management

changes due to situational triggers may affect all aspects of a project including: requirements, project plan, resources applied and design

Requirements Management ... III-40

A requirements management process has been designed to track requirements and control changes over the entire the planning and development process

Formal requirements management reduces churn by screening for cost effectiveness and allocating the costs of changes appropriately

Responsive/Offering...42

The engineering planning process also needs to respond to different types of customer needs — skipping steps for certain offerings

4. Systems Focused & SE Methodolgy... III-43

Clearly, Digital's historical approach of managing its complex product offerings at the component level is inefficient and ineffective

Importantly, whether Digital builds systems or not, Digital's products will eventually comprise systems in the market and therefore must be engineered with an eye toward eventual interoperability requirements

Aggregates are central to the AEE planning and development processes — a key foundation for driving efficiency and effectiveness across all the AEE recommendations

SE Methodology...
System engineering methods organize the development process

- The SE role & responsibility is at the nexus of a communicating process
- SE's have skills to progressively drive needs into product definition
- Staging the system definition before design optimizes the overall system cost/performance
- The resulting SE contribution shifts over the product lifecycle

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

5. Bilateral Contract... III-47

At the end of concept exploration, a letter of intent is agreed upon which communicates expectations between business units and engineering and releases funds for further solution definition

at the end of the definition stage, the contract releases funds for the life cycle of the solution

Inherent in the contract are the solution / product specifications – articulated in a way to enable creativity and innovation rather than inhibit them

The solution / product space concept lays the foundation for progressively reducing risk by increasing the specificity of requirements

6. Increasing Value Added... III-49

value increases through the seamless transition from planning into development

EACH PHASE RELEASES VALUE TO OTHER PHASES by answering questions about the product and the process in formal plans and specs – "ratcheting up" in effect

an early release should be whole or partial value, not 'preliminary' work

7. Accountability / Decision Making... III-51

The planning and development processes concentrate decisions and the corresponding accountability in the hands of participants

8. Efficiency.... III-52

The planning and development processes are efficient

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

Principles / Process Recommendations... III-53

These principles led to several major recommendations on the AEE processes and tools required to drive excellence in engineering:

1. **Dialog Process** - Institute the dialog based planning process for Engineering and the BUs in a joint forum to determine the product development priorities of central engineering

2. **Planning Templates** - Employ the planning templates across all BUs to consistently capture / communicate the results of the dialog process in the form of detailed customer requirements

3. **Cross-engineering Dialog** - Utilize the Dialog Forum to address cross-functional issues across Design Entities — whether component or solution level, and/or driven internally or externally

4. **Aggregates** - Adopt the intellectual construct of 10-15 aggregations of customer desired system capabilities to drive planning for engineering as well as the management of interoperability

5. **Reuse** - Adopt Tech Files/Aspect as the required parts selection medium and institute an assessment of design reuse opportunities through standard reuse templates and metrics

6. **Checkpoint Process** - Adopt a disciplined milestone based development process that integrates planning & development, but clearly distinguishes between technical & business decisions

7. **Risk Based Flex** - Employ specific risk criteria to flex the amount of work and oversight required, and to identify explicit responses to internal or external driven "trigger" events

8. **Empowered Teams** - Form teams led by an empowered Product Team Leader with full multi-functional membership, funded to deliver across all functions for the total development effort

9. **Requirements Management** - Institute standardized and formal procedures to document, trace, and change product specifications, plans & dependencies developed and prioritized through the customer driven Planning Process

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

D. Process Definition... III-55

An overly simplistic process structure would not address the AEE principles

The AEE process provides a range from the simplest to the most robust process implementation — chiefly by institutionalizing flex

The AEE process is substantially different in three key initiative areas: process discipline, systems engineering, and concurrent engineering teams

- Process Discipline
  - Defines a disciplined process that has built in flexibility
  - Establishes a single point of accountability
- Systems Engineering
  - Creates an aggregate/systems driven approach to management
  - Drives an approach to product definition which emphasizes increasing "value-added"
  - Emphasizes management and risk assessment of dependencies
- Concurrent Engineering Teams
  - Embeds concurrent engineering into the process and team structure
  - Forces early cross-functional involvement; empowerment is commensurate with accountability
  - Creates a deliverable focus, not a functional focus

In the <u>needs identification</u> step, business units define, prioritize and rationalize customer needs for exploration III-56

In <u>concept exploration</u> the business units / engineering dialog gets refined eventually leading to a joint BU/engineering decision whether to further invest in a solution

Additional analysis needs to be undertaken in some cases to further define the concept – this step ends with a joint investment decision by BU and engineering to proceed into development (through a contract)

The <u>'analysis'</u> phase analyzes connections between definition & design phases III-59

analysis checkpoint is a business decision to refine the product definition

The <u>'design'</u> phase resolves what components the product will be built from

design checkpoint is a business decision to implement the product definition

The <u>'implementation'</u> phase builds quality components for production

implementation checkpoint is a business decision to launch the physical product

The <u>'ramp up'</u> phase deploys the product for general availability

ramp up checkpoint is a business decision to commit product to market

During the AEE planning process, phases are completed with checkpoints that map to other phases -- 3 such checkpoints exist in the AEE planning process III-63

after concept exploration, the two additional checkpoints (compared to the current phase review process) ensure that only market driven, proposed solutions are developed

During the AEE development process, complex projects (about 20% of total projects) will undergo the same number of checkpoints (4 after planning) as the current phase review process

However, because of flex in AEE development, nearly 80% of the projects will undergo fewer checkpoints than the current phase review process (see III-35)

Process Definition–Checkpoints...III-65

Key differences in the AEE checkpoints stem from a control of phase interaction

Checkpoints are a process and event that do not disrupt planning or development

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

THE PROCESS LEADING TO EACH CHECKPOINT is explicit and on-going

THIS PROCESS IS MANIFESTED IN OFFICIAL PLANS AND SPECS

THE focus of the CHECKPOINT MEETING IS DECISIONS, NOT escalation

The technical reviews propose specs of the offered products & services: they consummate best practices for work-in-process and administration

As with checkpoints, reviews are mainly for decisions, not escalation

Each checkpoint explicitly defines participants, responsibilities, and decisions–this clarity of roles is required to "operationalize" the AEE principles and processes

E. Process Operationalization... III-71

- Each step of the engineering planning process is accompanied by a set of specific decisions – culminating in checkpoint decisions

To be operationalized, these decisions need to be associated with forums and meetings that take place periodically

BU and engineering planning activities take place asynchronously as well as on periodic basis to ensure "more frequent than annual" execution of the planning process

We are recommending a BU planning forum to facilitate BU planning decision making and ensure the quality and timeliness of BU inputs into the engineering planning process

For the engineering planning activities, we are recommending an engineering planning forum to execute against all the planning activities...

...and a development portfolio forum for the execution of planning decisions

Process operationalization—EPF...
The engineering planning forum (EPF) reflects the necessary expertise/skills to successfully achieve translation of market needs into products

Process operalization—DPF...
The development portfolio forum ensures the continuity between planning and development as well as the execution of the planning activities

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

F. AEE Benefits... III-81

The AEE planning process produces quantifiable benefits in up front planning as well as later in the product life cycle

The new planning process will save $90MM over the current process

Most of the AEE benefits will be derived from implementing the development process architecture — process discipline, a systems engineering focus, and concurrent engineering principles

Process Architecture Benefits

- **ELAPSED TIME (CYCLE) = 35% - 40% REDUCTION**
  - **Process Discipline (10-15%)**
    - Single, shared definitions of product and process
    - Technical and business decisions linked by deliverables
    - Flex is structured, yet accommodating
    - Schedules are explicit and current
  - **Systems Engineering (10-15%)**
    - Partitioning designs makes work modular, reducing time between activities
    - Trade-offs are more effective
    - Smoother integration and test
  - **Concurrent Engineering Team (26%)**
    - Early multi-functional involvement
    - Overlapping development activities
    - Faster decision-making, single point accountability

- **APPLIED TIME (Cost) = 25% - 30% REDUCTION**
  - **Process Discipline (15-20%)**
    - Single, shared definitions of product and process
    - Single point of accountability throughout the process
    - Risk is staged and managed
    - Deliverables are understood
  - **Systems Engineering (3-7%)**
    - Maximum risk is reduced
    - Trade-offs are more efficient
    - Interfaces aggressively managed
    - Improved test planning
  - **Concurrent Engineering Team (7-11%)**
    - Improved communication and coordination from co-location
    - More efficient documentation process
    - Less time for meetings and cross-functional negotiation

- **PRODUCT/PROCESS QUALITY = 50% - 70% DEFECT REDUCTION**
  - **Process Discipline**
    - Single, shared definitions of product and process
    - Ongoing validation and verification throughout the process
    - Explicit accountability for deliverables
    - Defects/errors are identified earlier
  - **Systems Engineering**
    - Optimizes design iteration
    - provides basis for validation and verification

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

- Quality is made integral to the process not added to the product
- **Concurrent Engineering Team**
  - Multi-functional design reviews minimize downstream engineering changes and rework
  - More producable, serviceable design

Note: Estimated savings do not include design reuse and requirements management, Total percent reductions are multiplicative result of individual components
Source: Industry benchmarks & parametric relationships from C. Jones, USAF, B. Boehm, BAH studies, to estimate implementation impact

The benefits of the AEE process architecture are derived from focusing attention on what must be done, by whom, at the earliest possible point

The AEE process should consume one-sixth of the time which the current, ad-hoc process utilizes in meetings and wasted effort

When AEE is fully implemented, products / solutions will be planned and developed in half the time

IV. MANAGEMENT STRUCTURE / TEAM OPERATIONS

Outline

A. Introduction... **IV–1**

Although the AEE initiative explicitly placed organizational issues secondary to process re-design in Phase I – organization must assume a prominent role in Phase II in order to fully realize AEE objectives the organization must be congruent with the process

Aligned with the concept that process & structure are explicitly linked, the AEE recommendations have major implications for engineering's organizational structure

- Organizational structure is a key element in a dynamic framework that defines a company's success
- To maintain or improve the level of efficiency/effectiveness, a change in one element must be followed by a change in one or more of the remaining elements
  - Significant changes in the market have re-focused Digital's strategy on the customer and to delivering integrated solutions
  - Management must place increasing emphasis on building and deploying competitive capabilities in this environment
  - To date, AEE has focused primarily on a complete re-engineering of the existing planning and development processes
- Given the significant changes in strategy, capabilities, and processes concurrent with AEE, there will be an increasing need to change the organizational structure as well

The current organizational structure is not consistent with a number of the driving principles and recommendations from AEE's Phase I

- Significant capability gaps exist which bound Engineering's ability to achieve market and AEE objectives
- Product development teams were re-defined to address the principles of AEE development process
- Several principles which have driven the AEE initiative are not supported by the current organizational structure
  - Concurrent Involvement - relevant functions are involved as early as appropriate
  - Accountability - all requirements, deliverables, and tasks are explicitly owned
  - Decision making - decisions made only by people directly participating in the process
  - Efficiency - flexibility, scalability, and standardization are balanced to optimize efficiency and effectiveness

the overall objectives of this chapter are threefold:

1. Characterize the current organizational structure and perceived gaps in light of AEE's objectives and recommendations
2. Identify optimal organizational alternatives given the expected changes in strategy, process, and capabilities from AEE Phase I recommendations
3. Identify interim/migration options and highlight the implementation implications of the proposed change

Detailed organizational design was not within the scope of AEE Phase I – however, it will become a critical part of successful implementation

B. Issues/Principles... **IV–5**

AEE objectives and recommendations drive a clear set of organizational implications and principles

IV. MANAGEMENT STRUCTURE / TEAM OPERATIONS

These organizational principles are consistent with AEE's objectives and recommendations – their implications will be discussed in turn

1. Strategy/Structure/Process consistency
2. Aggregate management
3. Decentralized decision making
4. Clear authority, accountability, measurability – explicit responsibility for deliverables
5. Facilitates concurrent engineering and multi-functional involvement

1. Strategy/Structure Congruency
   - the leanest organizations are structured in a vertically congruent fashion so that response time, applied time, and informal processes are minimized
   - At this point in its evolution, Digital should structure itself to manage the formal processes that AEE recommends
2. Aggregate Management...
   - Given Digital's strategy to deliver integrated solutions, a higher order segmentation framework and management structure is required to resolve interoperability and interdependency issues
   - We recognize that integrated solutions currently account for a small portion of Digital's business – however, the market and Digital's strategy are moving increasingly in that direction
3. Decision Making
   - to achieve faster / better decision making, decisions must be streamlined and driven to the lowest appropriate level
   - palmer has stated that faster/better decision making is the most significant challenge for engineering
4. Authority/Accountability

   to support, improve, and speed lower level decisions, Responsibility for deliverables must be clear – with authority commensurate with accountability
5. Concurrent Engineering...

   further, concurrency and multi-functional involvement in both planning & development are key AEE recommendations which the current organizational structure does not support

C. **Capabilities Requirements/Gaps IV–12**

Changes in market/business requirements are driving Digital to focus on building and deploying highly competitive capabilities

- Capabilities are a company's unique combinations of know-how *and* business processes that it uses to innovate and deliver customer value
- Capabilities are a critical source of competitive advantage
- The leverage from capabilities is maximized when capabilities are used to *change the basis of customer choice*
- **Externally, future customer relationships will be structured on the basis of capabilities performance instead of positional assets**
- **Internally, capabilities** will interface with positional assets to determine economies of scale, focus, and **critical mass**
- **Capabilities** performance underpins continuous improvement in cost, quality, and time

We have identified several added capabilities required to implement the AEE planning and development process...

Systems engineering — development of system / technical architectural specs, at all levels

Program/ management — integration / resolution between business and technology issues; manage for inter-operability requirements and dependency implications

Product management — resolution of business requirements and technology issues; coordination of development and delivery of product against requirements

Project management — management of projects against difficult constraints of product and system requirements, as well as complex inter-dependencies

Engineering functional expertise — Focus on building, maintaining, and ensuring the usage of highly productive and competitive capabilities

Systems engineering... IV–14

Systems engineers are critical to the development of complex products across extended organizations

Program/product management... IV–15

- Program & product teams will execute the planning & development process with single point accountability for deliverables
- the focus of program management is somewhat more "definitional" while product management is focused on "execution"
- cross-industry and information technology platforms can be most effectively managed through program management...
- ...while product management is emphasized for subsystems and components
- a small empowered program office for each cross-industry and information technology platform could optimize across the multiple constituents of the "aggregate"
- the skill and activities above would be part of the program management office

Gaps... IV–19

- looking across the organization, Systems Engineering, and Program & Product management skills are scarce
- Compared to the resource mix of peers, DEC has a very limited systems engineering resource base

Implications... IV–21

Organizational design could have a major impact on the effectiveness and efficiency of engineering by following several key principles

- The role of functional organizations would be to select and build capabilities
- The role of a program/product organization would be to deploy and apply these capabilities
- Digital engineering falls short in execution of some of these principles
- An important first step would be to clarify roles and responsibilities within the engineering organizations

D. Team Operations... IV–22

1. Team Structure & Operations...
   a. A key module of AEE Phase I was defining a team structure for execution of development activities...
      - Focus was product management and team structure
      - Product development team definition was connected to the organizational principles
      - In order to fully develop product management and the role of the product team leader, it was necessary to understand – at a crude level – the interfaces

      ...this work has clear impact on the overall organizational design
   b. requirements and deliverables map directly to team structure to focus efforts and boost accountability
   c. The product team should be multi-functional and co-located to the greatest extent practical
      - Product team is composed of the product team leader PTL and appropriate multi-functional representation (i.e. Functional Product Leaders - engineering, manufacturing, etc.)
      - The product team should be co-located to the greatest extent practical; for example, a rule of thumb that any team member >50% on team for at least six months should be co-located

IV. MANAGEMENT STRUCTURE / TEAM OPERATIONS

- The product team executes cross-functional planning and development activities
- Measured on meeting team goals and objectives in addition to individual performance and contribution

d. early multi-functional involvement is a critical success factor for reducing applied time and cycle time by decreasing requirements churn

e. Co-location also has a positive impact on reducing requirements churn through better communications – thus, improving program performance

f. this approach provides single-point accountability by function for a product, and empowers the multi-functional team to focus on its collective goals

g. the full program/product team will evolve at discrete points in the development process of a system or product

h. this model implies a shift in decision making from functional management to program/product management

2. Roles & Responsibilities... IV–30

Roles and responsibilities would need to be significantly different with this new approach to team structure – many of which currently do not exist

- Matrix of responsibility driving both cross-functional program/product execution and functional expertise & capability development
- Cross-functional program/product execution roles:
  - a. VP of Programs
  - b. Program Manager
  - c. Product Leader
  - d. Functional Product Leader (e.g. Engineering Product Leader, EPL)
- Engineering functional expertise roles:
  - e. Project Manager
  - f. Functional Manager (e.g. Design Entity Manager)

a. VP of Programs...

The VP of Programs is accountable for optimizing the execution of all program development activities

b. Program Management...

Program Management provides accountability and coordination at the aggregate level

c. Product Leader...

Product Management is required to rationalize needs of various internal and external customers and is embodied in the product team leader

d. Functional Product Leader...

A Functional Product Leader, which reports to the ptl, is responsible for coordinating and delivering all respective functional project work

e. Project Leader...

Project Leaders are responsible for delivering specified functionality to a product

f. Functional Manager...

Further, this structure identifies the explicit need for Functional Managers who are responsible for building and maintaining competitive capabilities

E. Organizational Implications... IV–37

Matrix Organizations...

Matrix organizations should only be employed when pure product-oriented or pure function-oriented models are sub-optimal

the most significant challenge to successfully implementing a matrix organization is to ensure explicit leadership/authority

IV. MANAGEMENT STRUCTURE / TEAM OPERATIONS

decision conflicts can be minimized in a matrix structure by clearly delineating explicit and mutually exclusive roles & responsibilities between entities

- Engineering functional organization focuses on building highly productive capabilities
- Program organizations lead application of capabilities through multi-functional teams

The principle advantage of a matrix structure for Digital is the dual focus on both effectiveness and efficiency

- Explicit links to the market (for market-driven) and engineering skills (for scale & critical mass)
- Separates and balances capabilities development and capabilities deployment consistent with overall company strategy
- Ensures interoperability and interdependency issues are addressed by establishing clear accountability for program/product management across engineering disciplines
- Provides clear responsibility for deliverables within the program/product organization
- Program/function matrix supports concurrent planning & development process

Organizational Alternatives... IV–40

There are at least four matrix organizational alternatives to consider for Digital engineering – each will be discussed in turn

Alternative A – Product/Functional Mix
Alternative B – Weak Program Management
Alternative C – Strong Program Management
Alternative D – Dual Product Focus

Alternative A... IV–41

the current organization is a mixture of product and discipline focus
product development is embedded in the functional organization and reports through engineering line management
A similar structure could be used to incorporate some aspects of the AEE planning & development process; however, program management effectiveness would be limited
Alternative "A" does not clearly delineate between capabilities building and deployment
Alternative "A" is similar to the current organizational structure

Alternative B... IV–46

Alternative "B" provides clear accountability for aggregate management, but maintains the mixed product/discipline focus in functional engineering
Responsibility for base product delivery remains in the functional engineering organization
Alternative "B" could provide a logical transition to a pure product/functional matrix, but does not represent the optimal long-term solution
the new program organization could be established right away; without significant central engineering disruption near-term

Alternative C... IV–50

Alternative "C" clearly separates program/product execution & delivery from functional capabilities development via a product/function matrix
Responsibility and control for planning & development activities would shift to the program organization...
...while engineering functional disciplines would be clearly focused on building and maintaining functional engineering capabilities
a pure product/functional matrix, with clearly defined responsibilities, is the recommended structure for product planning & development at DEC
Alternative "C" would require significant organizational change across the entire engineering organization

IV. MANAGEMENT STRUCTURE / TEAM OPERATIONS

Alternative D... IV–55

Alternative "D" overlays the proposed program/product management structure on the existing engineering organization

this mixes product delivery on both dimensions of the matrix

Alternative "D" is suboptimal and should not be viewed as a viable organizational structure

Alternative "D" would create a dual product focus in both the program and functional organizations – accountability could be blurred

Implications... IV-59

comparing the options against the organizational principles clearly demonstrates the need to adopt a new organizational design

We believe alternative "C" is clearly superior...

...however, because of the magnitude of change, a logical, sequenced implementation has the best chance of success

this approach would establish a program organization in the near-term, while providing a transition to a strong product/function matrix in the medium-term

The transition to "weak-form" program management could begin almost immediately

Moving to "strong-form" program management would require a number of additional actions

A detailed study is required to determine the best way of implementing "strong-form" program management at Digital

the organizational design effort would include three major activities

F. Selected Operationalization Issues... IV–66

Operationalization of the principles, frameworks, and concepts discussed in the preceding sections will be a central challenge of Phase II

- Exploration of existing, successful implementation of these concepts in other companies (for lessons learned)
- Development of a working model to pilot
- Migration and transition issues

We have explored selected implementation issues – summaries follow:

Decision decentralization

Multiple masters = f(matrix organization, market & product complexity, decision decentralization)

Funding, for instance, should support decision decentralization and multiple master fixes

Decision Making... IV–68

Although product & market complexity may require centralization of strategy and planning decisions,...

...operational decision making should be decentralized and distributed throughout the program/product management structure

Decentralized decision making requires clearly defined roles and responsibilities for each layer / level of management leading to faster, better decisions...

...as well as clear objectives from above

Clear authority & accountability for decision making is critical to the proposed organizational structure and consistent with the AEE planning & development process

Multiple Masters... IV–71

Given the complexity of Digital's product strategy, it is difficult to completely eliminate the "multiple master" problem

The multiple master problem this creates for management can be minimized, through organizational design

Funding... IV–73

Funding is a good operationalization example, as it should support decision decentralization and multiple master fixes – there are three key issues

IV. MANAGEMENT STRUCTURE / TEAM OPERATIONS

1. Development activities should be funded "directly"
2. Base" vs "variant" product development
3. Paying for indirect activities
   - Unallocatable investment
   - Architectural, Centers of Excellence, Functional Disciplines
   - Overhead

The biggest challenge for Digital regarding funding is solving the "public goods" issue — allocating costs among the BUs for baseline development

We identified three options for the funding process between the business units and central engineering:

- **Option 1**: BUs fund engineering "line" functions (SW, HW, Networks), Corporate funds the remaining near and long term engineering "product strategy" activities inclusive of Strecker and staff ("product strategy" activities include: SE, product mktg, HR, finance, bus ops and long term technology strategy)
- **Option 2**: BUs fund Design Entities (i.e.; Windows NT, Open VMS...), Corporate funds near and long term engineering product strategy activities inclusive of Strecker and staff and senior line managers
- **Option 3**: BUs fund either Aggregate/Program managers or Product Team Leaders depending on the type of solution (point product or SI solution), Corporate funds near and long term engineering product strategy activities inclusive of Strecker and staff and senior line managers

There is a detailed discussion of each alternative in the planning appendix

AEE principles mandate that funding should be direct – this is consistent with option 3

For direct activities, the solution to resolving conflicts to drive baseline development from the primary market for each product and justify variants individually

However, it is unclear how to fund "indirect" activities

There are at least two approaches for funding indirect activities:

1. Tax" levied on project
   - Costs for indirect activities applied directly to appropriate projects
   - For example:

     TOTAL COST(PROJECT) = DIRECT COST + INDIRECT COST
2. Lump sum "tax" on the BUs
   - Costs for all engineering indirect activities are totaled
   - BUs would collectively be charged a lump sum for all activities
   - Indirect funding would be distributed to appropriate engineering functions

There are clear choices for each type of indirect funding

G. Next Steps... **IV–81**

The organizational transformation should begin near-term in order to build on the momentum of AEE

Implement the program management organization

Kick-off detailed organization design initiative

Define requirements for organizational infrastructure to support the AEE processes

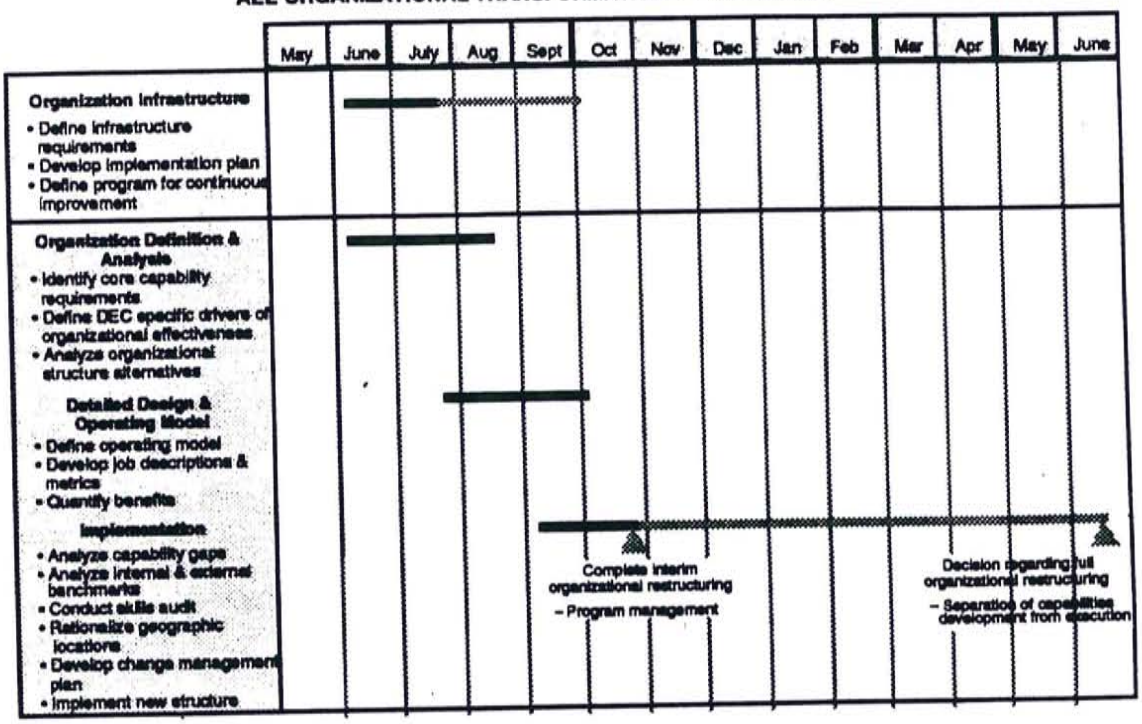
the key first module is organizational design

it would be supported by the creation of the appropriate infrastructure

the key initial steps could be taken by this fall

IV. MANAGEMENT STRUCTURE / TEAM OPERATIONS

AEE ORGANIZATIONAL TRANSFORMATION — WORKPLAN



V. BEST PRACTICES INTRODUCTION

Recommended Target Areas

- **Requirements Management**
- **Re-use and Standardization**
- **Verification & Test**

The AEE process diagnostic identified a variety of areas of engineering where Digital could significantly improve it effectiveness

This diagnostic analysis, coupled with input from Digital management, drove the selection of three target areas for best practice definition

- **Requirements Management:**
  - Employs the tools of systems engineering to structure and decompose requirements
  - Imposes a disciplined requirements "freeze" point to avoid "whip sawing" development effort
  - Employs stringent cost benefit analyses to limit unneeded requirements' churn
  - Uses traceability methods and tools to ensure that requirements are met
- **Reuse & Standardization:**
  - Opportunistically reuses existing hardware & software design elements
  - Proactively designs for reuse to cut the design cost and time of succeeding generations
  - Modularizes products to simplify design process
  - Increases end product quality as design elements are better "scrubbed" of errors
  - Employs standard parts to minimize cost and part number complexity
- **Verification & Test:**
  - Standardizes on a common set of value-added tests
  - Eliminates redundant testing steps
  - Centralizes common testing across multiple organizations
  - Balances value of tests performed against cost and cycle-time required

These practice areas address the beginning, middle, and end of the process

Teams were establsihed to address practices in each major phase

Each of the these categories of development best practice operates within the overall structure of the AEE process

The following three sub-sections lay-out the phase i findings and recommendations of teams A, B, and C in development best practices

- **Va - Requirements Management:** Team B
  - Definition
  - Control
  - Traceability
- **Vb - Reuse & Standardization:** Team A
  - Standard parts system
  - Reuse metrics
  - Templates
- **Vc - Verification & Test:** Team E
  - Redundant testing
  - Standardization

V.a. BEST PRACTICES — REQUIREMENTS MANAGEMENT

Outline

A. Background... Va-1

The AEE diagnostic surveys identified requirements management as a high leverage improvement opportunity for engineering and resulted in the formation of the requirements management team

The team's objective was to develop a rigorous requirements management process to reverse typical "back-end" heavy Digital development process

the team identified requirements churn as one of the biggest problems with an average of 40% of product requirements redefined from the end of phase zero through product release

this requirements churn is positively correlated to budget overruns

churn drives up costs since A CHANGE TO the Requirements impacts all aspects of the project – Requirements, project plan, resources applied and design

The process manages the evolution of the product contract within the constraints of product strategy, product performance, existing technology, and economics

B. Overview... Va-6

the REQUIREMENTS MANAGEMENT process IS A SET OF best practices within both the planning and development processes which help define the linkages between the two

specifically, the process focuses on the creation of needs, requirements, and concept and the management of changes to these deliverables

The objectives of the new requirements management process are to ensure development of the right products on schedule and within budget

- Requirements definition activities ensure development of the right products
  - Gathering needs from the customer
  - Incorporating input via product team representation from all relevant Digital organizations – bus, service, manufacturing, etc...
  - Deriving requirements and specifications directly from these needs
  - Evaluating changes to requirements through cost / benefit analysis
- Requirements control activities enable development teams to meet budget and schedule commitments
  - Reducing requirements churn by:
    - Setting control/freeze points

      - Recognizing full impact of change through dependency tracking
      - Rigorously assessing the costs/benefits of changes
    - Managing the scope of work through traceability
      - Explicitly addressing all needs
      - Limiting development work to functionality specified by requirements

C. **Benefits...** **Va-10**

The benefits of designing and implementing a new formal requirements management process are significant

- Ensures that development engineering delivers products and designs that meet expectations
  - That customers want
  - That fit into the corporate strategy defined in the planning process
- Contributes to interoperability of products
  - Increases visibility of dependencies through formal contracting process
  - Involves representatives from other dependent engineering projects in requirements definition
- Increases engineering productivity – potentially 10% - 20%
  - Reduction in requirements volatility in software development from "very high" to "high" results in a reduction in applied time of 15% (COCOMO Study)
  - Consistent with a reduction in cumulative post phase-0 churn from 40% to approximately 20%
- Reduces time to market by about 5%
  - Based on COCOMO development schedule equations for "semidetached" software product
  - Assumes similar development schedule relationship for the average hardware project

THE PROCESS incorporates many elements of recognized best practices to achieve these benefits

- Defining and negotiating requirements
  - Considers long term vision of product and addresses full customer solution
  - Cross functional kickoff teams (DEC includes customers where possible)
  - Single designated point of contact from each group
  - Greater up-front effort to get requirements right – reducing back-end churn
- Requirements content
  - Complete, unambiguous, non-conflicting, verifiable and testable
  - Includes both business and technical requirements
  - Identifies mandatory requirements and prioritizes others
- Requirements change control
  - Methods well defined for agreeing on requirements and approving changes
  - Requirements are "frozen" early on – after which changes are difficult
  - Post freeze changes are analyzed for cost and schedule impact before approval
  - All dependent groups alerted in advance of possible changes
- Requirements tracking
  - Configuration management used for requirements documents
  - Each requirement tagged uniquely

V.a. BEST PRACTICES — REQUIREMENTS MANAGEMENT

D. **Process... Va-12**

The requirements management process consists of four steps that fit within the planning and development process framework:

- Gather Needs
- Develop Requirements & Concept
- Define Dependencies
- Manage Change

these steps are repeated at each level of the product hierarchy as specifications are allocated downstream AND COMMITMENTS MADE UPSTREAM

each of the four steps contains activities that both refine the requirements definition and control the process

Benefits — Each step of the process overcomes weaknesses in current practices identified by the team through interviews with engineering managers

All members of the cross functional product / program team are involved in the requirements management process...

...but the product leader / program manager and the engineering leader retain direct responsibility and accountability

the process covers all engineering requirements, but does not address requirements on other functions unless they impact engineering

E. **Gather Needs... Va-19**

in the first step the product team gathers and prioritizes specific needs from customers, business units and upstream projects

needs must be uniquely tagged, prioritized, and associated with the source of the need or its beneficiary to enable traceability and Upstream dependency mapping

F. **Develop Requirements and Concept... Va-21**

in the second step, needs are translated into requirements which are used to develop the product concept

Requirements are derived directly from needs using QFD

the correlation matrix from the qfd also serves as a critical link for traceability between needs and requirements

the requirements are used as input to a pugh matrix analysis to evaluate and compare alternative concepts for key features

the selected concept is then compared to competitive offerings to evaluate the product's marketability

G. **Define Dependencies... Va-26**

as specifications are developed in the definition phase, downstream dependencies are defined and the requirements are frozen

THE SPECIFICATION DERIVED FROM THE CONCEPT ARE MAPPED AGAINST THE REQUIREMENTS FOR TRACEABILITY

dependencies are THEN linked directly to specifications indicating the downstream commitments needed to deliver against the requirements

H. **Manage Change... Va-29**

after the requirements are frozen, changes are managed according to a configuration management model

V.a. BEST PRACTICES — REQUIREMENTS MANAGEMENT

the change management process reduces requirements churn by screening for cost effectiveness and allocating the costs of changes appropriately

the IMPACTS OF A CHANGE on dependent organizations are made apparent by the requirements management process

similarly, the matrices linking different stages of the product definition provide traceability in both directions over the entire cycle

I. Tools Va–34

there are three categories of tools available to assist in the definition and control of requirements

Requirements Definition

Requirements Traceability

Configuration Management

requirements traceability tools provide the greatest leverage for implementing the requirements management process

J. Process Verification... Va–35

to verify the process, the team has already solicited feedback from a number of development teams and is planning a simulation to be followed by a pilot

K. Simulation... Va–36

the quality and quantity of artifacts from the sable project make it an ideal candidate for the simulation

L. Next Steps... Va–37

We have laid out an implementation workplan for the next 12 months. Over the next several weeks, the team will refine the process and prepare for the pilot and roll-out

M. Issues... Va–38

A few issues regarding verification and implementation of the process need to be addressed as work progresses:

- Recommendations for incorporating process "flex" based on feedback from simulation
- Appropriate timing for selection and implementation of requirements traceability tools
- Degree to which pilot and roll-out is incorporated with pilot and roll-out of overall AEE process
- Whether to apply new process only to new projects or to existing projects as well
  - Roll out to new projects only is easier but delays benefits
  - Applying process to existing projects adds overhead in the short term
- Role of requirements management team post-simulation

Vb. BEST PRACTICES — REUSE AND STANDARDIZATION

Reuse and standardization, team A, was formed based on AN EARLIER AEE diagnostic of DEC against best practices

- Surveys of design entities and projects indicated limited design reuse
  - Ad hoc reuse programs
  - Lack of focus on reuse in the development process
  - NIH syndrome
- The AEE surveys of design entity leaders identified the area of reuse as being critical for DEC's engineering success
- Best practice benchmarking also indicated that product family structure and standard parts programs were having limited effect in both software and hardware
  - Little commonality between software programs or hardware families
  - Hardware components proliferation, with large numbers of dated or redundant parts–
    - 120,000 with only 30% active and less than 10% preferred for present products.
    - Spending $100mm per year on new part qualification, 10,500 new parts last year
  - Catastrophic software program failures using "from scratch" code generation
  - Approximately 200 million lines of code – implying 100k LOC for each SW engineer in maintenance duties

The reuse team has set aggressive goals:

Integrate Reuse metrics and review points into new phase process

<u>HARDWARE</u>

- Preferred parts reduced by 90% of current active list within 3 months, for IC and electrical components
- Eliminate Spoc System (~$3 mm year DEC savings vs. Aspect) in one and one-half years

<u>SOFTWARE</u>

- Develop business plan case for reuse — initial results indicate potential savings of $10-$30 mm per year through lower development and maintenance costs
- Draft initial implementation plan against current projects

Specific analysis and recommendations of the team;

- Initial im[illegible]ation road maps, and a schedule to arrive at a full implementation plan
- Segment[illegible] issues – levels of reuse, SW, HW, to support in implementation stages
- Associated [illegible]ics and the hooks for reuse into the new development process

Vb. BEST PRACTICES — REUSE AND STANDARDIZATION

Recommendations

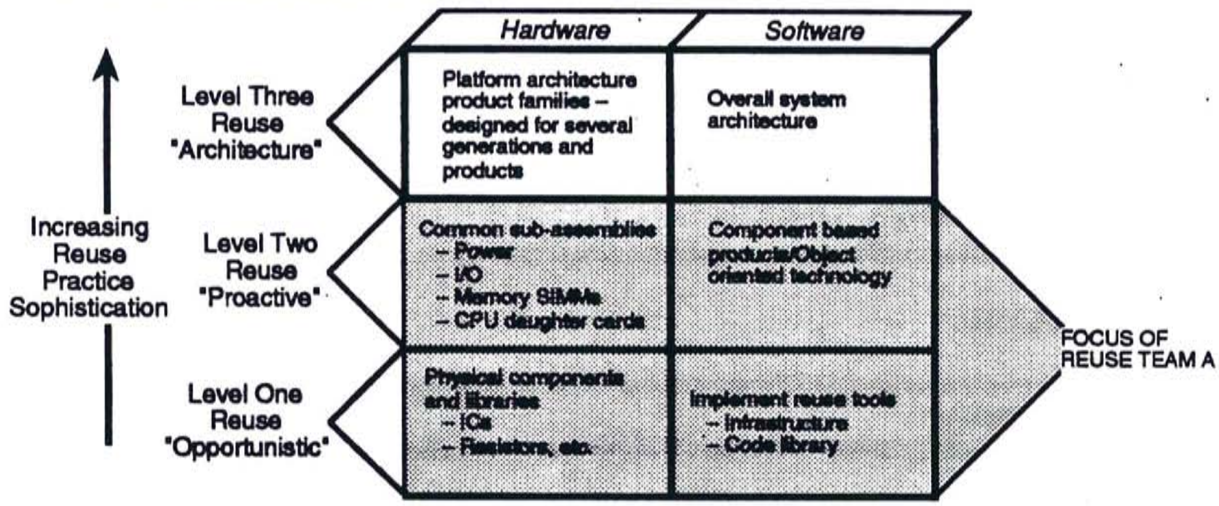
HARDWARE

- Implementation of Tech Files/Aspect system
- Begin metrics/justification for non-reuse with new phase development process using templates

SOFTWARE

- Large gains may be achieved through software reuse, however, implementation requires project level analysis (coming out of the current LRP process) and the involvement of line engineering managers to understand payback, as ye

Scope: reuse can be structured along three levels of increasing sophistication



the team focused on levels one and two

level one reuse is the first step, minimizing the sheer numbers of component parts or modules in software and hardware

level two reuse extends the impact into subsystems and methodologies – Specific templates have been developed for hardware subassembly reuse (see the devlopment section appendix)

analysis of several projects reveals a wide divergence in the degree of level 2 hardware reuse currently employed

Level 3 requires [redacted] program/product management activities be modified

Reuse issues for [redacted]:

Reuse issues for software:

The reuse implementation "Hooks" into the process through the measurement system and checkpoint exit criteria

Enforcement will be achieved initially through rigorous review standards – different from today's practices

- Level I – Product teams sign off on non-preferred parts for hardware during reviews and checkpoint exits

Vb. BEST PRACTICES — REUSE AND STANDARDIZATION

- Level II – Product teams list and justify rationale for non-reuse for reviews and checkpoint exits
  - ensure metrics for reuse are in place
- Today little attention is paid to reuse at any level in the current business or technical reviews
- Within 2 years specific goals or hurdles can be set based on experience gained

Implementation plan for HW

Expected benefits against AEE goals are 10%-15% decrease in elapsed time and 10-25% reduction in development cost for level II reuse

Expected benefits are driven from the differences from today's practices

- Reuse is explicitly identified in the product development process
- Tools and process force reuse across product teams instead of just within groups
- Engineers have easy access to existing design components

	Level I Reuse		Level II Reuse		Total Savings
	HW	SW	HW	SW	
Elapsed Time	Need to baseline reuse to accurately schedule gains, team estimate of ~5%	Increase reuse by 15% Δtime= -8% against applicable 40% of cycle = 3% total	Need to baseline reuse to accurately schedule gains, team estimate of 10%-15%	Need to baseline reuse to accurately schedule gains, team estimate of ~10%	~10%-15%
Cost (applied time)	• SPOC savings of $3mm • Parts verification savings TBD	Initial estimates of team indicate that total life cycle costs decrease by 5%-10%	Need to baseline reuse to accurately schedule gains, team estimate of 15%-25%	Initial estimates of team indicate that total life cycle costs decrease by 10%-20%	~10%-25%

Next steps in reuse implementation...

- SW team to define proposals for implementation, requires increased direction from engineering management and stability in budget process, and increased line-manager population on the team
- Implementation requires on-going effort - level II metric goals need to be established over the next year
- AEE implementation team for reuse to provide monitoring, metrics goals, training and other implementation steps

Vc. BEST PRACTICES - VERIFICATION & TEST

- Team E was initiated by Digital management to address practices to improve the cost effectiveness of the back-end of the development process
- The overall size of the verification process is heavily driven by the quality & stability of requirements — defined & managed in earlier Phases
- Qual time & cost is heavily a symptom of problems in the development process
- Though heavily driven by factors earlier in the process, there are aspects of the V&T process itself that warrant attention

  a. The current qualification process is too long — ranging from 4 to 18 months

  b. Qualifying products with the existing process is too costly — much higher than competitors

  c. The current process has grown up ad hoc

  d. The process is inconsistent across engineering groups for comparable activities

  e. It's difficult to determine the cost of qualification since the resources also perform other roles

- Team E was given an explicit charter by Digital management
- A variety of factors drive the perceived high cost of the qual process

  a. The large group of people executing the hardware qual process perform far more tasks than just DVT and qual — upon inspection, qual cost is probably only 50% of the conventional wisdom

  b. Lack of standardization of CAD tools exacerbates qual problems, there is a need to standardize on PC tool environment and move away from the current dual environments

  c. The biggest drivers of bugs in hardware are from layered products and firmware

  d. The RQT process does not apply to the semiconductor process employing Tech Files. As Tech Files are extended up to modules and systems, stress testing needs to replace RQT

  e. Design groups do not perform rigorous BOM analysis to understand problems with parts, like material compatibility, part limits, etc.

  f. Field test as currently performed is ineffective and very expensive

- An initial series of near, mid, and long-term recommendations have been developed by the team
  - **Near-Term Actions:**
    - Eliminate External Hardware Field Test
    - Eliminate Reliability Qualification Test string
  - **Mid-Term Actions:**
    - Consolidate and form a common hardware testing group
    - Design a common qualification process across all hardware platform groups
    - Review Digital standards against current and emerging industry standards

Vc. BEST PRACTICES - VERIFICATION & TEST

- **Long-Term Actions:**
  - Institute a feedback mechanism in the design process to create a closed loop process
- Preliminary estimates of the impact of the near-term actions indicate that they would save $10-$20 million/year and reduce cycle-time by about 6 weeks
- The team has several more work steps to reach its June 30th milestone
  1. Further explore opportunities to streamline process in layered products area
  2. Finalize emerging recommendations
  3. Quantify baseline and in detail assess the impact of process changes
     - Time
     - Cost

VI. INFORMATION INFRASTRUCTURE

A. Overview VI-1

Needs Identification... VI-1

Engineering needs a standard engineering information infrastructure (EII) to plan, communicate, track, and direct the engineering processes

Objectives... VI-2

To this end, our objectives were to specify the required information infrastructure and assist in analyzing existing systems

Once the system specification is completed, the plan is to work with im&t to plan implementation

Existing Systems... VI-3

Existing systems handle some of this functionality but fall short in several areas:

- Overall system is not addressing problems in information management and information sharing
- EPIC is not effective in supporting product and project management
- Financial system is not effectively linked with EPIC
- Key project management disciplines are not enabled or supported by current systems
- Other systems, such as problem tracking and product change, are not integrated into product and project management system

Benefits... VI-4

The AEE engineering information infrastructure (EII) is being designed to offer a number of advantages over existing systems including epic

Architecture... VI-5

The conceptual design of EII is driven by the principle of supporting high level business management processes while interfacing with tools supporting lower level processes

Under this architecture, high level process data will be shared across engineering – more detailed, group specific data will have limited distribution

Scope...7

The AEE team recommends that DEC focus on designing the common infrastructure and implementing the planning and project management modules first to derive the greatest near term benefit

B. Approach... VI-8

Development of EII is a major effort – the AEE phase 1 effort focused on needs identification and concept exploration

Work Flow... VI-8

The AEE team has successfully completed needs identification and concept exploration and has begun preparation for definition and analysis

Identify Needs... VI-10

The conceptual design of EII is derived from the information needs for six high level business processes

1. Product/Program Management & Planning
2. Project Management
3. Human Resource Management (Resource Management)
4. Asset Management (Resource Management)
5. Budgeting (Resource Management)
6. Technology Resource Management

VI. INFORMATION INFRASTRUCTURE

Categorize/Prioritize Needs... VI-11

The information needed to support these processes was categorized into six data entities (corresponding to the six business processes)

Define Business Processes VI-12

Integrating the detailed analyses of the six business processes results in a high level process model describing all engineering activity

Define Business Data VI-13

The detailed process analysis also leads to a high level graphical description of key data relationships

Existing Systems... VI-14

A parallel effort to understand the existing system infrastructure indicated that it does provide basic support for the engineering functions

However, information critical to engineering management is missing and/or inconsistent

Gap Analysis... VI-16

As a result, the engineering information infrastructure requires significant added capability beyond that of existing systems

There are many commercial-off-the-shelf (cots) products that can provide pieces of the missing functionality...

...commercial off-the-shelf products (continued)

Detailed analysis in the next phase will help determine the appropriate mix of cots products and internal development to provide an integrated solution

High Level Work Plan... VI-19

Team 3 involvement should continue as Planning, Analysis, And Design activities will be required throughout the development life cycle

The immediate next steps include the detailed definition and analysis for the engineering information infrastructure

The definition and analysis phase will detail the models, assess existing i/t capabilities, identify tools, and architect an integrated EII

Booz•Allen has proposed a workplan for implementing the two highest priority engineering processes as the first part of the longer term implementation plan

VI. INFORMATION INFRASTRUCTURE

C. Conceptual Design... VI-23

Link to AEE... VI-23

The AEE engineering processes form the foundation of the data and process model of the engineering information infrastructure

- The process for Engineering planning and development provides the fundamental framework for the process model
  - The planning and development phases map the work flow
  - The process model determines the data flow for each phase
  - The process model is adaptable for process flex
- The data model is based on the information flow to support the Engineering processes
  - Major deliverables at each phase of planning and development
  - Metrics for each phase (encompassed in major deliverables)
- The data and process models link the extended enterprise to the AEE Engineering Information Infrastructure
  - Links to other corporate functions
  - Links to outside suppliers and alliances

Note: See Appendix Q for explanation of conceptual design

Processes... VI-24

A conceptual process model describes the primary activities within engineering

Lower Level Processes... VI-25

The conceptual process model decomposes each group of activities into lower level processes...

Data... VI-31

Linking these processes together at the highest level are seven data entities

1. Assets
2. Human Resources
3. Engineering Budget
4. Project
5. Technology Artifacts
6. Business Units
7. Solution / Product

SYNOPSIS
OF

AEE Planning & Development Process Redesign: Phase I
Reflects Progress As Of 5/28/93

ACHIEVING EXCELLENCE IN ENGINEERING

digital

DIGITAL EQUIPMENT CORPORATION

May 28, 1993
Maynard, Massachusetts

Table Of Contents

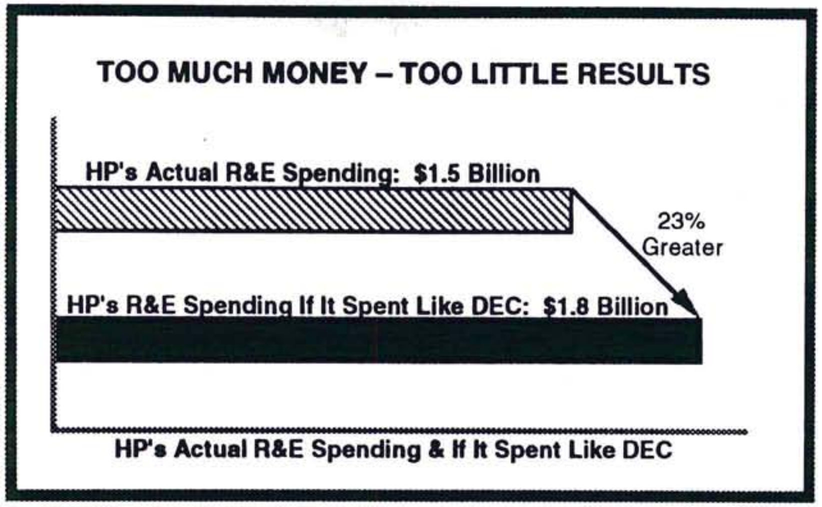
I. INTRODUCTION/EXECUTIVE SUMMARY

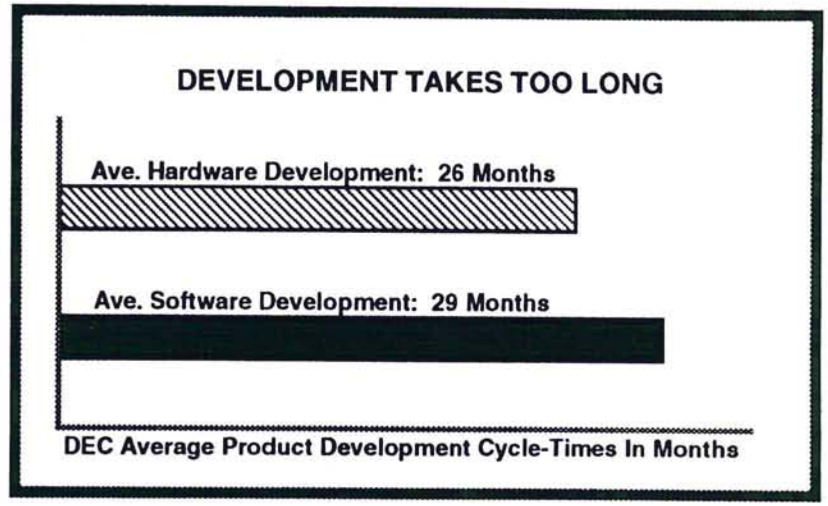
THE AEE INITIATIVE WAS TARGETED AT TWO MAJOR AREAS IN PHASE I

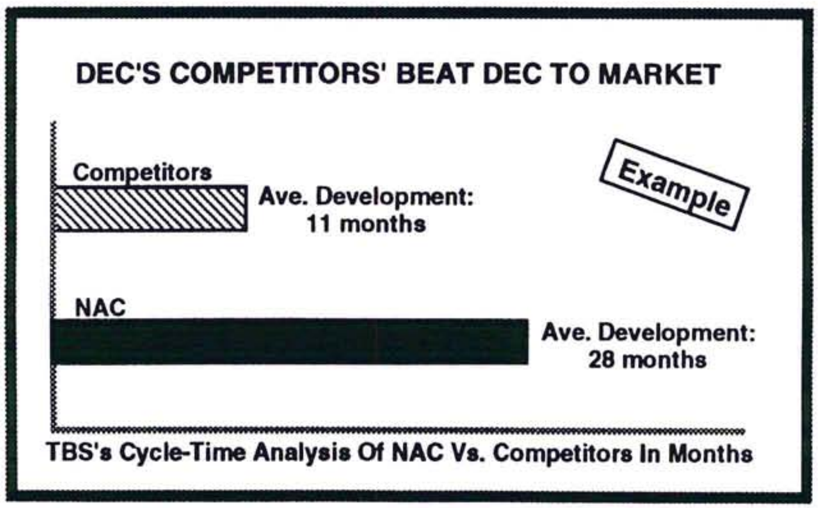
- Developing a robust interface and supporting process for the centralized engineering organization to interact with the market focused business units
  - Market-based engineering planning and budgeting process
  - Prioritization criteria and screening process for engineering projects
  - Mechanism to screen engineering projects
  - Organizational implications of new planning infrastructure

- Re-engineering Digital's development process to create a more effective and efficient process for product development
  - Top-level architecture of how engineering interacts with all other functions
  - Identification of internal DEC development best practices
  - Identification of high leverage process improvement options
  - Quantification of impact of change
  - Organizational implications of top-level process redesign

TO TACKLE DIGITAL'S SEVERE PROBLEMS, AGGRESSIVE GOALS WERE SET FOR THE 2-3 YEAR HORIZON OF THE AEE PROGRAM







AEE'S GOALS : TWO YEARS TO ACHIEVE

- **50% Reduction In Cycle-Time**
- **50% Reduction In Applied-Time**
- **10X Improvement In Quality**

BJ5/20goal drivers

THE SUBSTANTIAL CHALLENGES CONFRONTING DIGITAL ENGINEERING INDICATE THAT ACHIEVING THESE GOALS IS CRITICAL

Planning Gaps:

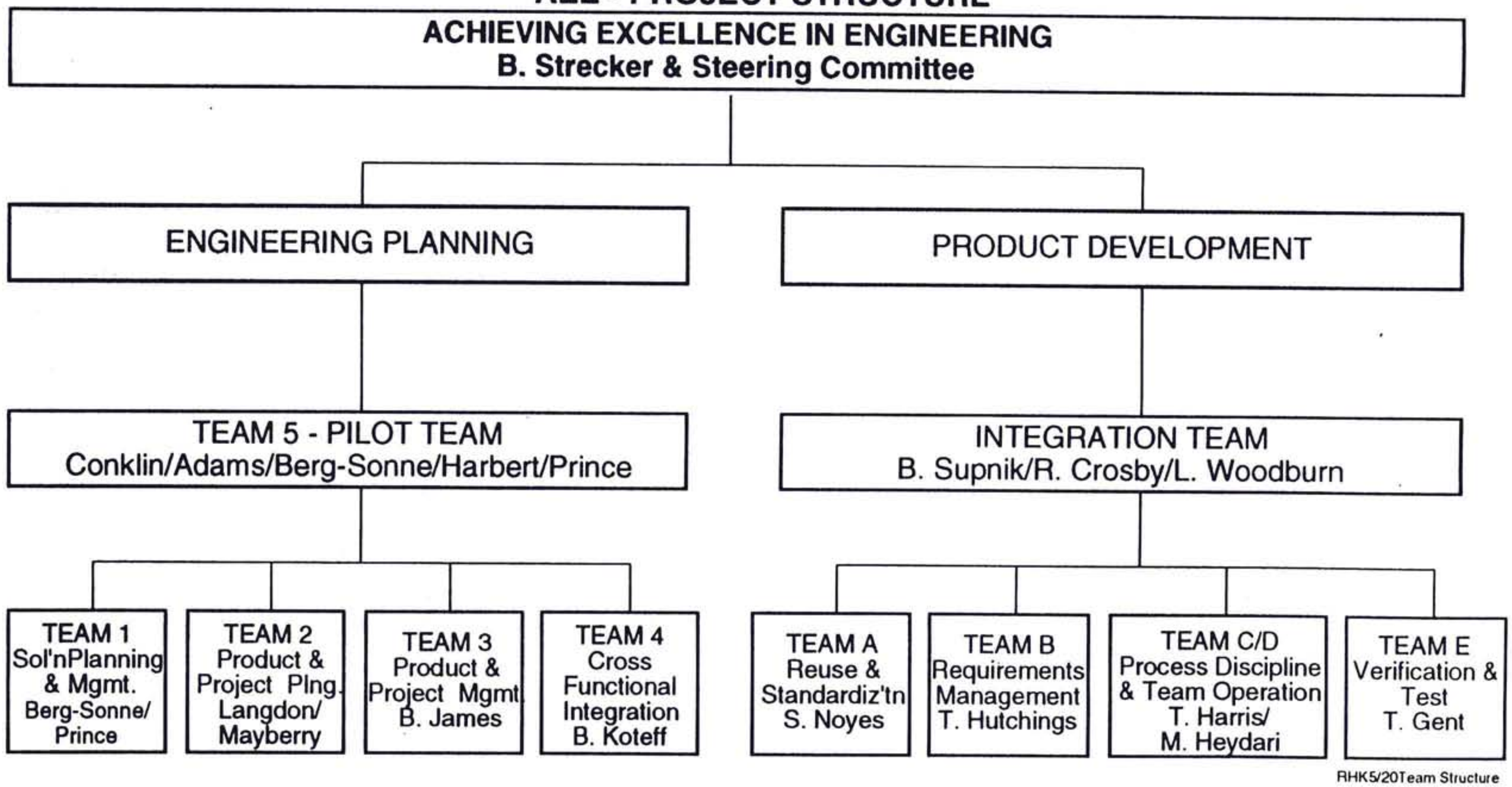
- No established link to the newly formed business units to drive engineering planning
- Technology driven, rather than market driven, engineering planning
- Absence of a construct to drive planning from a systems or components perspective
- Inadequate link to the "extended enterprise" to drive engineering planning

Development Gaps:

- Development cycle-times significantly longer than competitively permissible
- Substantial requirements churn post initial product specification
- Absence of best practice and tool standardization across development groups
- Minimal discipline in the execution of design processes
- Limited attention given to part standardization and design reuse
- Inconsistent employment of concurrent engineering principles

THE AEE PHASE I EFFORT CONSISTED OF TASK FORCES LED BY DEC MANAGERS WITH SUPPORT FROM BA&H — IT IS NOW TRANSITIONING TO THE AEE PMO

AEE - PROJECT STRUCTURE



THE AEE RE-DESIGN OF DEC'S PROCESSES IS DRIVEN FROM SEVERAL BASIC PRINCIPLES

Planning Principles:

- **Minimalistic** - a simple and highly implementable process requiring minimal documentation
- **Collaborative** - a partnership based dialog between the BUs and Engineering
- **Responsive** - a continuous (i.e., not annual) process that is responsive to market changes
- **Systems Focused** - a process that drives to a systems view of interoperability requirements
- **Bilateral Contract** - schedule / cost / deliverable for committed business results

Development Principles:

- **Increasing Value-Added** - the process will be gated by demonstrable increases in value
- **Concurrent Involvement** - all relevant functions are involved as early as possible in effort
- **SE Methodology** - steps geared to addressing system considerations from the start
- **Accountability** - all requirements, deliverables, and tasks are explicitly owned
- **Decision Making** - decisions are only made by people directly participating in the process
- **Efficiency** - flexibility, scalability and standardization are balanced to optimize efficiency

SEVERAL MAJOR RECOMMENDATIONS HAVE EMERGED FROM THE PHASE I OF AEE

Planning Process Recommendations:

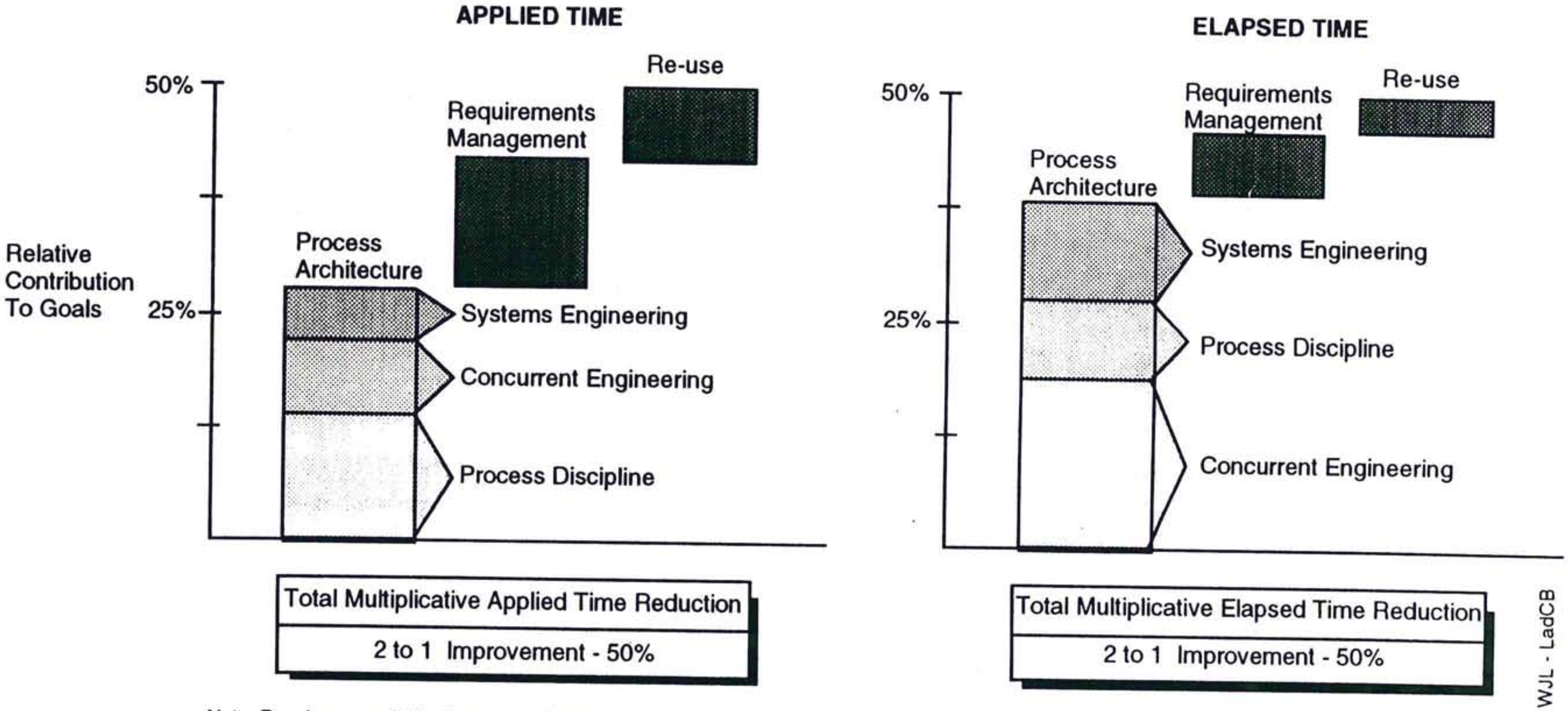
- **Dialog Process** - institute the dialog based planning process for Engineering and the BUs in a joint forum to determine the product development priorities of central engineering
- **Planning Templates** - employ the planning templates across all BUs to consistently capture / communicate the results of the dialog process in the form of detailed customer requirements
- **Cross-engineering Dialog** - utilize the Dialog Forum to address cross-functional issues across Design Entities — whether component or solution level, and/or driven internally or externally
- **Aggregates** - adopt the intellectual construct of 10-15 aggregations of customer desired system capabilities to drive planning for engineering as well as the management of interoperability

Development Process Recommendations:

- **Reuse** - adopt Tech Files/Aspect as the required parts selection medium and institute an assessment of design reuse opportunities through standard reuse templates and metrics
- **Checkpoint Process** - adopt a disciplined milestone based development process that integrates planning & development, but clearly distinguishes between technical & business decisions
- **Risk Based Flex** - employ specific risk criteria to flex the amount of work and oversight required, and to identify explicit responses to internal or external driven "trigger" events
- **Empowered Teams** - form teams led by an empowered Product Team Leader with full multi-functional membership, funded to deliver across all functions for the total development effort
- **Requirements Management** - institute standardized and formal procedures to document, trace, and change product specifications, plans & dependencies developed and prioritized through the customer driven Planning Process

THERE IS NO "SILVER BULLET", ACHIEVING THE GOALS WILL COME FROM DOING A VARIETY OF PLANNING & DEVELOPMENT TASKS IN NEW & BETTER WAYS

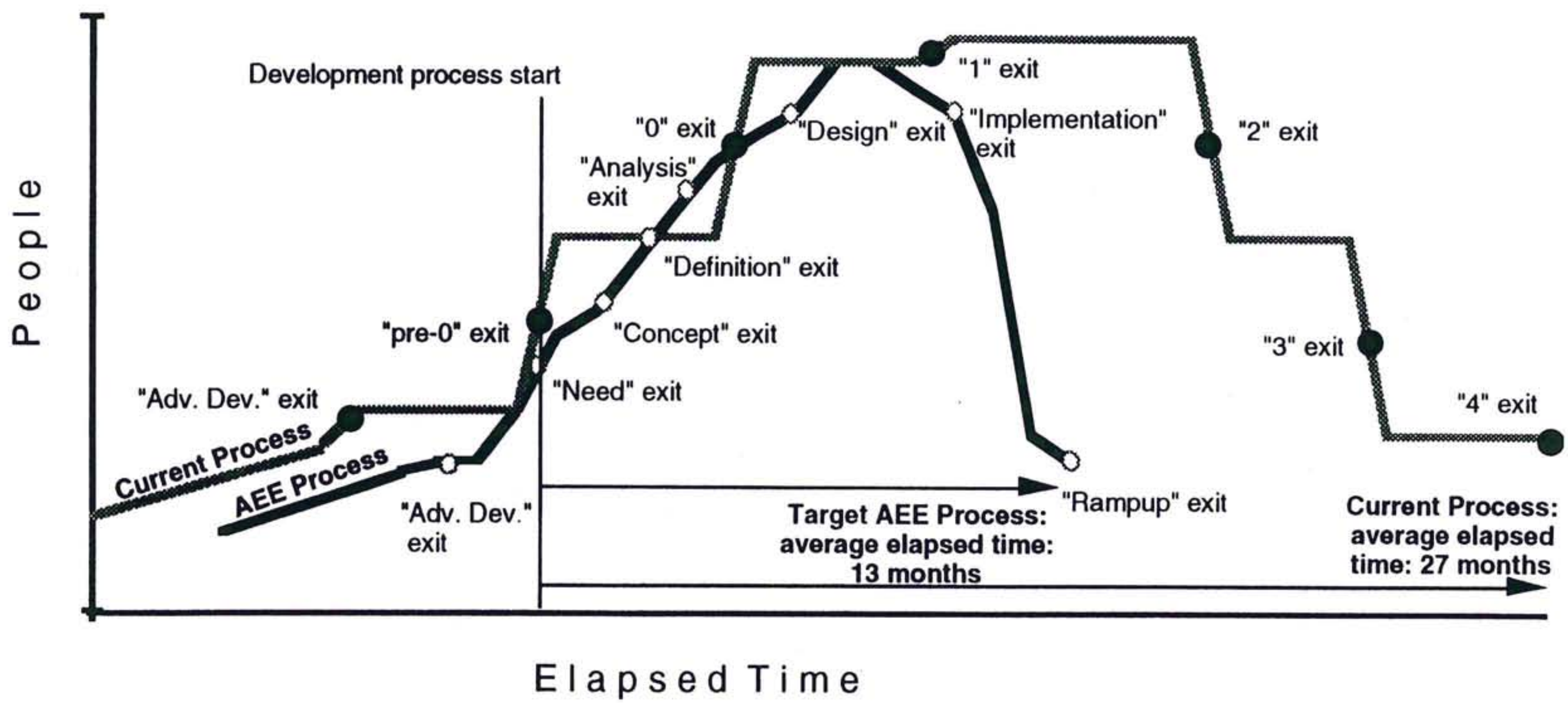
CONTRIBUTION OF AEE DEVELOPMENT PROCESS INITIATIVES TO TIME GOALS



Note: Results are multplicative, not additive
Source: Industry benchmarks & parametric relationships from C. Jones, B. Boehm, BA&H Analysis and studies

THE RECOMMENDATIONS CAN HELP DEC ACHIEVE THE AGGRESSIVE AEE GOALS OF A 50% REDUCTION IN ELAPSED AND APPLIED TIME

TARGET IMPACT OF AEE PLANNING & DEVELOPMENT PROCESS CHANGES ON AVERAGE DEC DEVELOPMENT PROJECT
Current Process vs. AEE Process



Note: Estimated impact on applied & elapsed time is the integration of planning process changes, process discipline, concurrent engineering, systems engineering, design reuse and requirements management changes Gains do not include Adv. Dvlpmnt or Need ID phases.
Source: Industry benchmarks & parametric relationships from C. Jones, USAF, B. Boehm, T.B.S. and BA&H studies to estimate implementation impact

ACHIEVING THESE AGGRESSIVE OBJECTIVES WILL NOT BE EASY — MANY CHALLENGES NEED TO BE OVERCOME

- Many of the new approaches go against established DEC culture and practice — discipline
- Some organizations that must adopt these changes are in flux — Engineering & BUs
- These major process changes will need to occur in midst of continued downsizing
- New skills in program management, teamwork and systems engineering will be required
- There will be inadequate data to make risk free decisions
- Extensive retraining of personnel in new approaches will be needed to adopt changes
- A commitment to a "learning organization" must be instilled

WE WILL MAKE MISTAKES — BUT WE WILL LEARN FROM THEM AND MOVE FORWARD

ASPECTS OF AEE CAN BE INSTITUTED NOW, WHILE OTHERS WILL BE ADOPTED OVER THE MID- AND LONG TERM

	IMMEDIATE	BY FALL '93	LONGER–TERM
PLANNING PROCESS	• Test, refine & document AEE process via FPPS pilot • Fully define aggregates driven from current existing business • Identify & define infrastructure / support requirements and enabling tools & techniques	• Roll-out planning process to all Business units • Drive requirements dialog against aggregates • Institute targeted training programs to support roll-out	• Redefine Aggregates from needs- based market segmentation • Execute infrastructure changes required
DEVELOPMENT PROCESS	• Simulate Processes/Practices • Adopt Techfiles/Aspect & reuse templates • Select 3 projects to pilot • Test, refine & document AEE process via pilots • Use Planning Templates to document business assumptions for current projects	• Drive all products of FPPS pilot into AEE Development process • Identify, define & document enabling tools & techniques • Implement Best Practices • Begin full roll-out to all of Engineering	• Identify & define infrastructure / support requirements • Institute targeted training programs to support roll-out • Detail Design Process Redesign • Target Advanced Development for redesign
ORGANIZATIONAL TRANSFORMATION	• Identify & define infrastructure, support, & capability reqmts • Quantify / qualify options & benefits of restructuring • Test, refine & document linkages to extended enterprise	• Institute targeted training programs to support roll-out • Implement form of Program & Product Management • Test, refine & document restructuring options	• Determine level of organizational restructuring required • Structure ongoing, continuous improvement program
INFORMATION SYSTEMS	• Refine conceptual model for highest priority system modules -- Project and Product management systems • Create logical and physical models	• Continue focus on highest priority system modules -- Project and Product management systems • Build operational prototypes • Prototype & Pilot	• Define / implement systems for budgeting, human resources (next priority) • Define / implement remaining systems (eg, assets, regulatory, etc.)

GETTING ON WITH IMPLEMENTATION WILL ALLOW DIGITAL TO GET ON WITH REALIZING AEE'S SIGNIFICANT POTENTIAL BENEFITS

THE BALANCE OF THIS DOCUMENT CONSISTS OF THE INTEGRATION OF THE PHASE I RECOMMENDATIONS FROM BA&H AND THE PROCESS REDESIGN TEAMS AS OF 5/28/93

- How the new joint BU/Engineering planning process should operate
- The nature, role, and definition of aggregates in engineering planning and execution
- Definition of a more disciplined concurrent approach to development
- How to structure flexibility based on risk into the overall process
- Identification of practices to enhance design reuse and parts standardization
- Definition of processes and practices to minimize/control requirements churn
- Definition of the team structure to drive a customer and multi-functional approach
- Design of the information infrastructure to support the overall AEE processes
- Benefits of adopting the AEE recommendations

Outline

A. Introduction...

Assessing the benefits of implementing the AEE recommendations are rooted in three factors

- The current state of Digital Engineering
- The goals Digital Engineering wants to set for itself
- The demonstrated impact of adopting the new approaches embodied in AEE

The following pages lay-out where Digital is today and the consequences of moving to an AEE paradigm

WHY IS CHANGE NEEDED?

WHAT IS THE VALUE OF CHANGE?

Phase I of AEE employed a variety of methods to assess the state of Digital engineering in both planning and development

B. Process Baseline... VII–2

Presently, engineering planning is broken – there are 7 unconnected planning processes, none of which satisfactorily drive market-based engineering

1. 8 Quarter Volume Planning (8QVP)
2. Corporate Phase Review Process
3. LRP"Bottom Up" Process
4. Customer Program Reviews
5. "Ad Hoc Cooperation"
6. Top Down Process
   - Board of directors decides on major market and technology targets

- Engineering budgets allocated by Strategic Technology Forum

7. "Domain" Process

Digital's current development process, although slightly different in each group, is also seriously broken

These process gaps result in nearly half of engineering funding being spent before the business plan and design specifications are completed

C. Resource Baseline... VII-5

These gaps also seem to have created an organization that spends most of its time on non-design activities

Furthermore, the organization is 1/3 management and administration

With a distribution that "bulges" at the senior levels

D. Best Practice Baseline... VII-8

Benchmarking Digital against engineering best practice standards also surfaced major gaps in execution

For example, greater use of practices like co-location could significantly improve development effectiveness

E. Cycle Time Baseline... VII-10

The result is that Digital's current development cycles, excluding advanced development and Pre-0, are very long...

... and lagging competitors' time-to-market in many areas, for example:

Digital's inability to deliver product quickly could be due to inefficiency, under loading projects early on, or other factors – but the diagnostic indicates that its process is simply less effective

F. Spending Baseline... VII-13

A less effective process with longer cycles has resulted in high Research & engineering spending relative to competitors

G. Quality Baseline... VII-14

In terms of quality, Digital spends $750 Million annually to resolve technical problems and the cld backlog has nearly doubled over the last 2 years

H. Goals... VII-15

In summary, the competitive environment and the situation revealed by diagnostics drove AEE's aggressive goals

- **Two to One** improvement of the current product development cycle – the elapsed time from concept phase to first quality volume ship
- **Two to One** improvement of the current product development applied time – measured as the cost in person power across the cycle
- **Ten to One** improvement in quality has been set as a particularly aggressive goal – defined as a reduction in defects
  - Defects in generating specifications that match customer needs
  - Defects in developing products that meet stated specifications

VII. SUMMARY OF AEE BENEFITS

WHY IS CHANGE NEEDED?

WHAT IS THE VALUE OF CHANGE?

I. **Impact... VII–16**

The process derived from the AEE recommendations will achieve AEE's aggressive Objectives

J. **Scope... VII–17**

To achieve this, the key levers in first two stages of the engineering cycle were addressed by the various Digital teams

Benefits will accrue in the later maintenance phase, but this was not explicitly addressed

The recommendations emerging from the teams fall into three categories that enable success against the AEE goals

K. **Planning Impact... VII–19**
The new planning process will save $90 Million annually in applied time by simplifying the current pre-0 process

L. **Development Impact... VII–20**
The 2 to 1 savings in the development process are driven by process architecture and engineering best practices

M. **Planning... VII–21**

AEE BENEFITS
- Planning -

		Elapsed Time	Applied Time (Cost)	Quality	Other
Planning	Process	• Less dead-time	• No duplication	• Needs explicit	• Auditable development work
	Aggregates	• Defined interfaces	• Capitalize Sys.Eng.	• Capitalize quality	• LRP linked to even small products
	BU/Engineering Team	• Scheduled meetings	• Minimum needed	• Broad perspective	• Resource contention optimized
Development Process Architecture	Process Discipline	• Couple products and their processes	• Interim deliverables	• Early purging of errors	• Load balancing
	Systems Eng.	• Shorter integration & testing	• Reduce risk	• Expectations explicit	• Manage complexity
	Concurrent Eng.	• Overlap work	• Raise effectiveness	• Less translation error	• Robust decisions
Eng. Best Practices	Requirements Management	• Reduce cycling	• Reduce questions	• Maintain specs	• Change management
	Re-Use & Standardization	• Reduce items in critical path	• Reduce work for a given solution	• Validation complete	• Partnering

RHK5/12Benefits summary chart

optimizing the planning process is the key lever to reduce product development's cost and time

- Greater than 70% of a product's cost is defined by the decisions made in planning

VII. SUMMARY OF AEE BENEFITS

- Poor development planning decisions drive costs throughout the life-cycle of a product
  - Poor requirements will result in rework/redesign
  - Poor requirements will create products that don't meet customer needs
  - Changing requirements in the field is 2400X as costly as during concept according to a Software Institute study
- The AEE planning process recommendations contribute to achieving the overall goals in several ways
  - Cycle-time reduction is facilitated through the dialog process
  - Cost reduction is enabled through the use of aggregates
  - Quality improvements are achieved through the consistency of templates

The AEE planning process provides market based solutions by effectively linking the business units and engineering

the benefits of aggregates derive from their emphasis on re-use, A systems' focus, and requirements stability

The AEE planning process produces quantifiable benefits in upfront planning as well as later in the product life cycle

- Currently, activity before the Concept phase consumes $300 mil/yr. and 11+ months on average
  - Advanced Development: Costs $120 mil/yr. and adds 6+ months to an average project
  - Pre-"0": Costs $180 mil/yr. and adds 5+ months to an average project
- At minimum, the new AEE Planning Process will rationalize Pre-"0" phase work
  - Pre-"0" is replaced by "Need Identification" activities
  - Justification and integration of needs are now systematized
  - Communication problems between organizations are reduced
  - Hand-offs to no-one-in-particular are eliminated
  - The process is rationalized
    - Time between steps is lowered
    - Redundancy of steps is lowered
    - Parallelism of steps is raised
- We expect significant near term benefits in Needs Identification Phase – based on profiles of Digital projects and external benchmarks
  - Needs Identification will consume the same loading for a much shorter period
  - Some $90 Million annually could be saved in applied time out of $180 Million annually
  - Some 2-3 months could be saved in elapsed time on average

N. Development... VII–25

AEE BENEFITS
-- Development Process Architecture --

		Elapsed Time	Applied Time (Cost)	Quality	Other
Planning	Process	• Less dead-time	• No duplication	• Needs explicit	• Auditable development work
	Aggregates	• Defined interfaces	• Capitalize Sys.Eng.	• Capitalize quality	• LRP linked to even small products
	BU/Engineering Team	• Scheduled meetings	• Minimum needed	• Broad perspective	• Resource contention optimized
Development Process Architecture	Process Discipline	• Couple products and their processes	• Interim deliverables	• Early purging of errors	• Load balancing
	Systems Eng.	• Shorter integration & testing	• Reduce risk	• Expectations explicit	• Manage complexity
	Concurrent Eng.	• Overlap work	• Raise effectiveness	• Less translation error	• Robust decisions
Eng. Best Practices	Requirements Management	• Reduce cycling	• Reduce questions	• Maintain specs	• Change management
	Re-Use & Standardization	• Reduce items in critical path	• Reduce work for a given solution	• Validation complete	• Partnering

RHK5/12Benefits summary chart

Most of the AEE benefits will be derived from implementing the development process architecture — process discipline, a systems engineering focus, and concurrent engineering principles

Process Architecture Benefits

- **ELAPSED TIME (CYCLE) = 35% - 40% REDUCTION**
  - **Process Discipline (10-15%)**
    - Single, shared definitions of product and process
    - Technical and business decisions linked by deliverables
    - Flex is structured, yet accommodating
    - Schedules are explicit and current
  - **Systems Engineering (10-15%)**
    - Partitioning designs makes work modular, reducing time between activities
    - Trade-offs are more effective
    - Smoother integration and test
  - **Concurrent Engineering Team (26%)**
    - Early multi-functional involvement
    - Overlapping development activities
    - Faster decision-making, single point accountability

- **APPLIED TIME (Cost) = 25% - 30% REDUCTION**
  - **Process Discipline (15-20%)**
    - Single, shared definitions of product and process
    - Single point of accountability throughout the process
    - Risk is staged and managed
    - Deliverables are understood
  - **Systems Engineering (3-7%)**
    - Maximum risk is reduced
    - Trade-offs are more efficient
    - Interfaces aggressively managed
    - Improved test planning

VII. SUMMARY OF AEE BENEFITS

- **Concurrent Engineering Team (7-11%)**
  - Improved communication and coordination from co-location
  - More efficient documentation process
  - Less time for meetings and cross-functional negotiation

- **PRODUCT/PROCESS QUALITY = 50% - 70% DEFECT REDUCTION**
  - **Process Discipline**
    - Single, shared definitions of product and process
    - Ongoing validation and verification throughout the process
    - Explicit accountability for deliverables
    - Defects/errors are identified earlier
  - **Systems Engineering**
    - Optimizes design iteration
    - provides basis for validation and verification
    - Quality is made integral to the process not added to the product
  - **Concurrent Engineering Team**
    - Multi-functional design reviews minimize downstream engineering changes and rework
    - More producable, serviceable design

Note: Estimated savings do not include design reuse and requirements management, Total percent reductions are multiplicative result of individual components
Source: Industry benchmarks & parametric relationships from C. Jones, USAF, B. Boehm, BAH studies, to estimate implementation impact

The benefits of the AEE process architecture derive from it focusing down on what must be done, by whom, at the earliest possible point

- The Checkpoint process is gated by creation of value-added deliverables and scaled by a project's inherent risk
- Systems engineering will streamline analysis and downstream implementation and test through a formal decomposition of requirements
- Concurrent engineering reduces requirements churn through earlier involvement of downstream functions/customers/supplies/partners and enhances functional accountability
- Decisions will be made with rigor to provide stability and accountability

a single, well defined process will reduce the current, ad-hoc process activities engaging approximately 25% of engineering effort

Through risk management and greater accountability, process discipline delivers significant benefits

- Checkpoints and reviews stage and curb potential risk
- Critical issues are less likely to be missed
- ISO 9001 compliance necessitates the auditable baselines of product and process that a checkpoint requires
- Single point accountability by program, product, project and function avoids the delays of the current indefinite consensus driven process

Underlying the new AEE development process is a concurrent sequencing of phases, with an emphasis on up-front planning through systems engineering

Rigorously employing system engineering discipline has significant impact at the front and back-end of the development process

The lack of early involvement of downstream functions increases requirements churn — Resulting in over runs

While employing Concurrent engineering will boost quality and reduce development cycles — on the order of 30%

The AEE development process recommendations also support the application of key process best practices...

- Team co-location
- Standardized design review methods
- Common project management tool set and practices
- Standard development/design processes

...and lay the foundation for continuous improvement

O. **Best Practices...** **VII–34**

AEE BENEFITS
-- Engineering Best Practices --

		Elapsed Time	Applied Time (Cost)	Quality	Other
Planning	**Process**	• Less dead-time	• No duplication	• Needs explicit	• Auditable development work
	Aggregates	• Defined interfaces	• Capitalize Sys.Eng.	• Capitalize quality	• LRP linked to even small products
	BU/Engineering Team	• Scheduled meetings	• Minimum needed	• Broad perspective	• Resource contention optimized
Development Process Architecture	**Process Discipline**	• Couple products and their processes	• Interim deliverables	• Early purging of errors	• Load balancing
	Systems Eng.	• Shorter integration & testing	• Reduce risk	• Expectations explicit	• Manage complexity
	Concurrent Eng.	• Overlap work	• Raise effectiveness	• Less translation error	• Robust decisions
Eng. Best Practices	**Requirements Management**	• Reduce cycling	• Reduce questions	• Maintain specs	• Change management
	Re-Use & Standardization	• Reduce items in critical path	• Reduce work for a given solution	• Validation complete	• Partnering

Requirements churn is a major driver of budget overruns

Formal requirements management can reduce 'churn' during development

- Traceability ensures that development engineering delivers products and designs that meet expectations
- Traceability also contributes to the interoperability of products
- Disciplined change control through cost/benefit analyses increases engineering productivity potentially 10%-20%
- Should reduce total elapsed time for development by 5% based on external benchmarks

While reuse should reduce time and cost by leveraging existing designs rather than creating them from scratch

- Reuse is explicitly identified in the product development process
- Tools and process force reuse across product teams instead of just within groups
- Engineers have easy access to existing design components

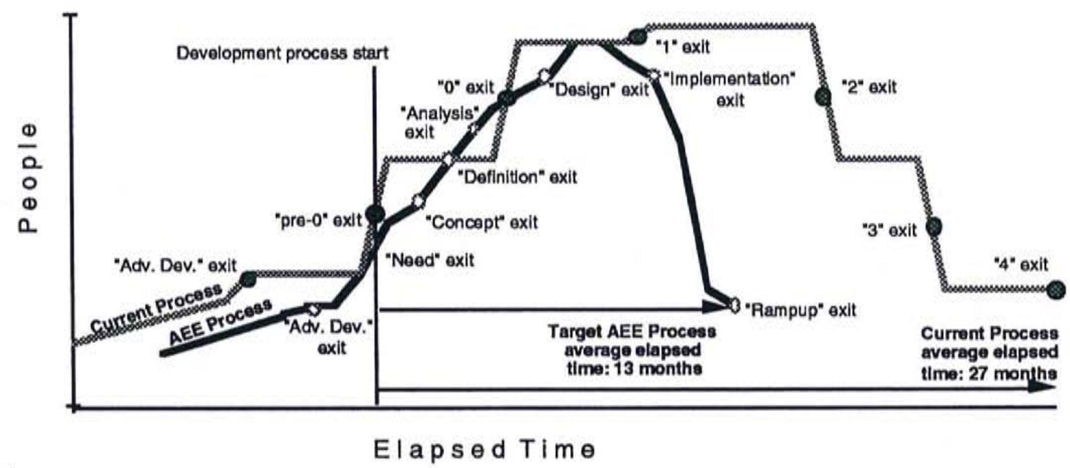
	Level I Reuse		Level II Reuse		Total Savings
	HW	SW	HW	SW	
Elapsed Time	Need to baseline reuse to accurately schedule gains, team estimate of ~5%	Increase reuse by 15% Δtime= -8% against applicable 40% of cycle = **3% total**	Need to baseline reuse to accurately schedule gains, team estimate of **10%-15%**	Need to baseline reuse to accurately schedule gains, team estimate of ~ **10%**	**~10%-15%**
Cost (applied time)	• SPOC savings of $3mm • Parts verification savings TBD	Initial estimates of team indicate that total life cycle costs decrease by **5%-10%**	Need to baseline reuse to accurately schedule gains, team estimate of **15%-25%**	Initial estimates of team indicate that total life cycle costs decrease by **10%-20%**	**~10%-25%**

Note: Level 1 Reuse is components for HW and common code libraries for SW.
Level 2 Reuse is subsystems for HW and object oriented technology for SW.

P. Summary... VII–37

In summary, adopting the full AEE recommendations will substantially reduce the loading and cycle time of Digital development efforts

TARGET IMPACT OF AEE PLANNING & DEVELOPMENT PROCESS CHANGES ON AVERAGE DEC DEVELOPMENT PROJECT
Current Process vs. AEE Process



Note: Estimated impact on applied & elapsed time is the integration of planning process changes, process discipline, concurrent engineering, systems engineering, design reuse and requirements management changes. Gains do not include Adv. Dvlpmnt or Need ID phases.
Source: Industry benchmarks & parametric relationships from C. Jones, USAF, B. Boehm, T.B.S. and BA&H studies to estimate implementation impact

Q. Getting on with implementation will allow Digital to get on with realizing AEE's significant benefits **VII–38**

IMMEDIATE

PLANNING PROCESS
- Test, refine & document AEE process via FPPS pilot
- Fully define aggregates driven from current existing business
- Identify & define infrastructure / support requirements and enabling tools & techniques

DEVELOPMENT PROCESS
- Complete simulations of Best Practices
- Select 3 projects to pilot
- Test, refine & document AEE process via pilots
- Use Planning Templates to document business assump-tions for current projects

ORGANIZATIONAL TRANSFORMATIONS
- Identify & define infrastructure, support, & capability reqmts
- Quantify / qualify options & benefits of restructuring
- Test, refine & document link-ages to extended enterprise

INFORMATION SYSTEMS
- Refine conceptual model for highest priority system modules -- Project and Product management systems
- Create logical and physical models

BY FALL '93

PLANNING PROCESS
- Roll-out planning process to all Business units
- Drive requirements dialog against aggregates
- Institute targeted training programs to support roll-out

DEVELOPMENT PROCESS
- Drive all products of FPPS pilot into AEE Development process
- Identify, define & document enabling tools & techniques
- Implement Best Practices
- Begin full roll-out to all of Engineering

ORGANIZATIONAL TRANSFORMATIONS
- Institute targeted training programs to support roll-out
- Implement form of Program & Product Management
- Test, refine & document restructuring options

INFORMATION SYSTEMS
- Continue focus on highest priority system modules -- Project and Product management systems
- Build operational prototypes
- Prototype & Pilot

LONGER–TERM

PLANNING PROCESS

VII. SUMMARY OF AEE BENEFITS

- Redefine Aggregates from needs- based market segmentation
- Execute infrastructure changes required

DEVELOPMENT PROCESS

- Identify & define infrastructure / support requirements
- Institute targeted training programs to support roll-out
- Detail Design Process Redesign
- Target Advanced Devel-opment for redesign

ORGANIZATIONAL TRANSFORMATIONS

- Determine level of organizational restructuring required
- Structure ongoing, continuous improvement program

INFORMATION SYSTEMS

- Define / implement systems for budgeting, human resources (next priority)
- Define / implement remaining systems (eg, assets, regulatory, etc.)

VIII. NEXT STEPS

- OPERATIONALIZE AEE — 1
- TEAM RESTRUCTURING — 6
- IMPLEMENTATION TASKS — 11

SUCCESSFULLY OPERATIONALIZING THE AEE INITIATIVE IS ENGINEERING'S MOST IMPORTANT CHALLENGE, AND WILL REQUIRE SUBSTANTIAL INVOLVEMENT AND RESOURCE COMMITMENT FROM ALL OF ENGINEERING, AT EVERY LEVEL

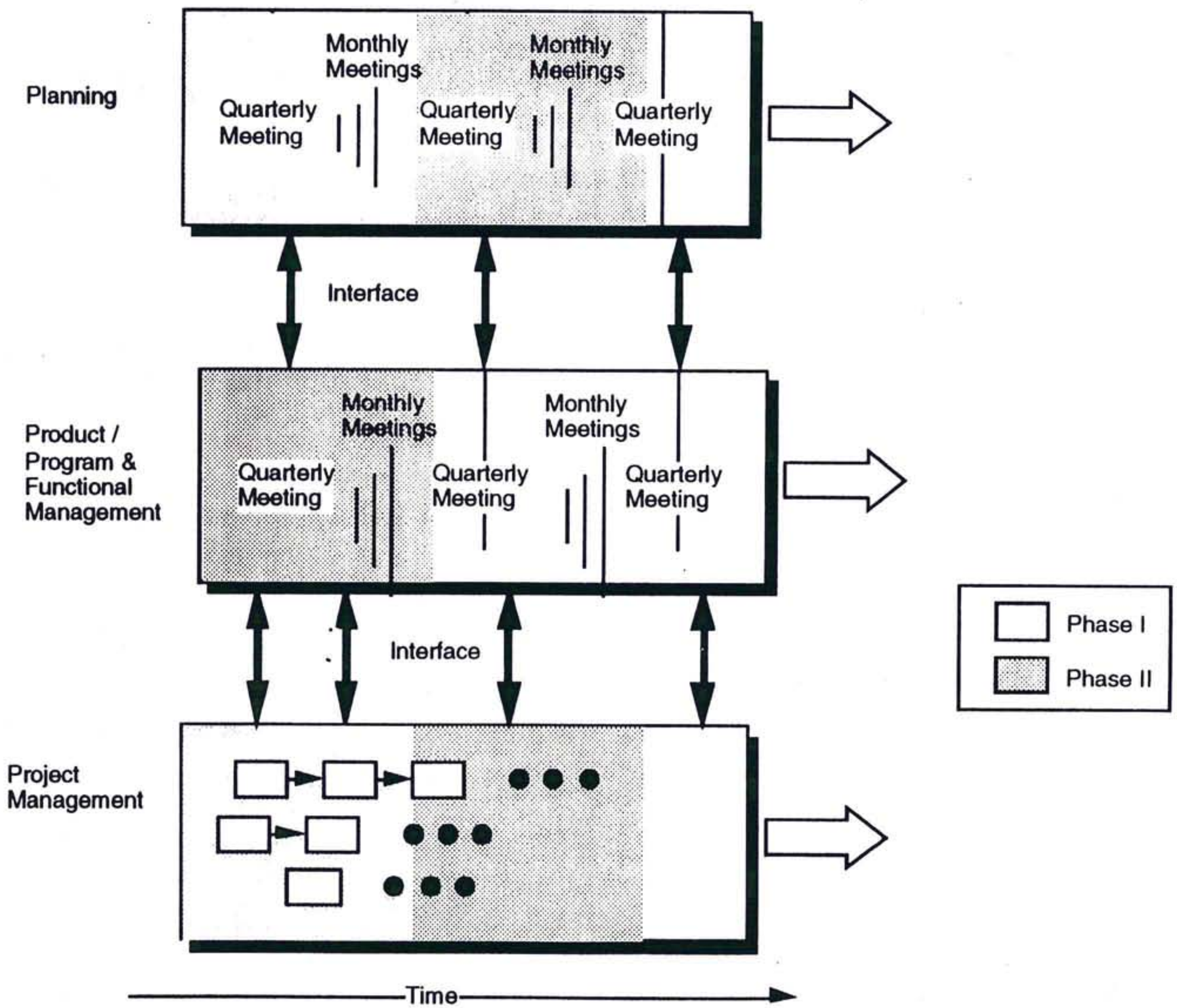
- Now that the AEE PMO has been chartered with a broadened scope, and Digital professionals made fully accountable, we must prioritize the challenges we wish to tackle
  - What are immediate, near-term, mid-term, or long-term actions?
  - What sequencing is required given the substantial interdependencies?
  - What are the implications of "integrating with the supply chain"?
  - What role will the PMO play in major tasks: measurement, training, and documentation?

- The first priority is to agree to the major milestones, then to identify / assign the key resources to achieve those objectives

- The operational structure and resources of the AEE PMO must be established quickly to ensure that momentum is not dissipated
  - Finalize the full membership of the program team
  - Identify the supporting staff for the PMO and the senior team members
  - Define role for current AEE teams: continue, restructure, or wind down?
  - Establish the operating relationship between the PMO and functional engineering

- To ensure its success the AEE PMO needs to determine how it intends to measure and track the progress of implementation as well as the impact of changes being adopted
  - Must define two categories of metrics: implementation progress and impact
  - Need to develop a mechanism to gather the data to allow ongoing tracking

PHASE II WILL OPERATIONALIZE AEE'S INTEGRATED PLANNING / DEVELOPMENT PROCESS



AS AEE MOVES INTO PHASE II, IT WILL FOLLOW A SET OF IMPLEMENTATION PRINCIPLES

- Create a learning organization – institutionalize AEE
- Establish DEC ownership – accountability, authority, measurability
- Involve the entire organization – all disciplines, all levels
- Be customer / market driven
- Link explicitly to the Extended Enterprise – Supply Chain, cross-functional
- Follow TQM – quality focus

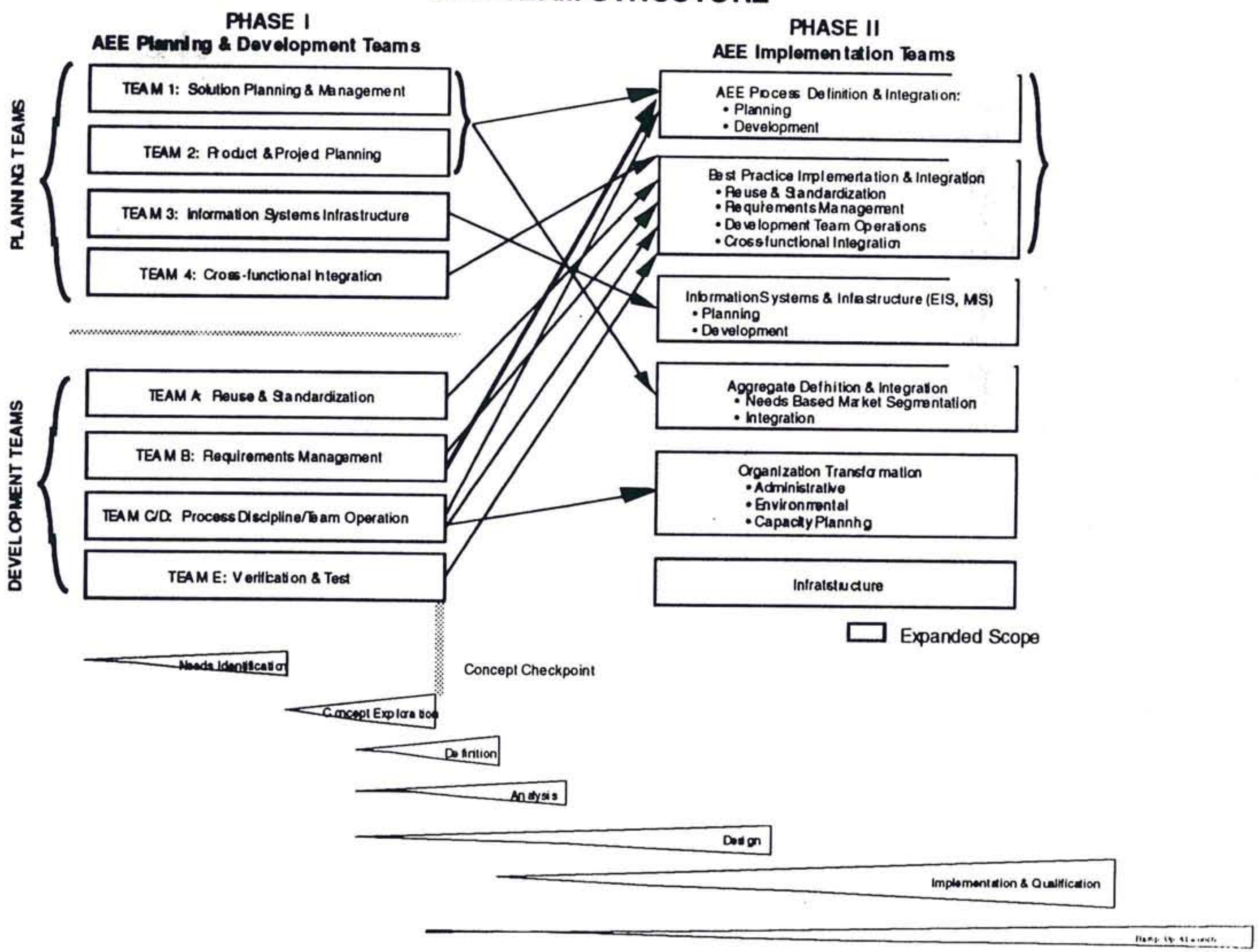
WE HAVE TAKEN AN INITIAL CUT AT PRIORITIZING THE IMPLEMENTATION TASKS

	IMMEDIATE	BY FALL '93	LONGER-TERM
PLANNING PROCESS	• Test, refine & document AEE process via FPPS pilot • Fully define aggregates driven from current business • Identify & define infrastructure / support requirements and enabling tools & techniques • Use Planning Templates to document business assumptions for current projects	• Roll-out planning process to all Business units • Drive requirements dialog against aggregates • Institute targeted training programs to support roll-out	• Redefine Aggregates from needs-based market segmentation • Execute infrastructure changes required
DEVELOPMENT PROCESS	• Simulate processes/practices • Adopt Tech Files/Aspect & Reuse Templates • Select 3 projects for 1st wave • Test, refine & document AEE process via pilots	• Drive all products of FPPS pilot into AEE Development process • Identify, define & document enabling tools & techniques • Implement Best Practices • Begin sequenced roll-out to all of Engr. starting with Wave 2 pilots	• Identify & define infrastructure / support requirements • Institute targeted training programs to support roll-out • Detail Design Process Redesign • Target Advanced Development for redesign
ORGANIZATIONAL TRANSFORMATION	• Identify & define infrastructure, support, & capability requirements • Quantify / qualify options & benefits of restructuring • Test, refine & document link-ages to extended enterprise	• Institute targeted training programs to support roll-out • Implement form of Program & Product Management • Test, refine & document restructuring options	• Determine level of organizational restructuring required • Structure ongoing, continuous improvement program • Determine geographic alternatives
INFORMATION SYSTEMS	• Refine conceptual model for highest priority system modules -- Project and Product management systems • Create logical and physical models	• Continue focus on highest priority system modules -- Project and Product management systems • Build operational prototypes • Prototype and Pilot	• Define / implement systems for budgeting, human resources (next priority) • Define / implement remaining systems (eg, assets, regulatory, etc.)

TEAM RESTRUCTURING

THE TRANSITION FROM PHASE I TO PHASE II IS AEE'S EXIT FROM THE CONCEPT PHASE

AEE TEAM STRUCTURE



WE RESTRUCTURED OUR EFFORT TO SHIFT TO AN IMPLEMENTATION FOOTING

- During concept phase, work was arranged in manageable / digestible chunks
  - Planning by issue
  - Development by leverage point

- The transition to implementation will require several changes
  - Integrate planning & development initiatives
  - Expand the scope in selected areas and focus on critical issues
  - Launch operationalization efforts

PHASE I INVOLVED DIAGNOSTIC EFFORTS TO IDENTIFY THE NEEDED REDESIGN ACTIONS

AEE PHASE I — NEED IDENTIFICATION AND ANALYSIS
EXPLANATION OF DEVELOPMENT PROCESS ANALYSES

Applied Time Survey	• An examination of DEC's Engineering Organization's Functional skill mix, and an assessment of how the engineering resource base applies their time — Used for structural analysis • Survey via e-mail of all Digital central and dotted line engineering personnel with responses accounting for 78% of all Engineering employees • Provided a data foundation and identified leverage points for redesign
Project Profile Surveys	• Profile of 63 actual development execution experiences to quantify the current state of engineering execution and assess extent of best practice use • Collected data on a cross section of projects representing all organizations to identify drivers of development efficiency & effectiveness
Structured Personnel Analysis	• Analysis on various engineering staff levels and distribution of headcount across profession & tenure levels • Various analyses of engineering organizational, structural, seniority levels, tenure & salary variances to provide context and identify structural deficiencies in resource base
In Depth Case Studies	• Examined, through in-depth interviews of numerous participants in 6 Digital projects noted as both successful and/or learning experiences • Identified "as is" processes and in depth experience in each of the best practice areas
Best Practices Benchmarking	• Survey of 20 Design Entity managers to understand the organization's use of engineering best practices • Compared DEC to 12 leading high technology companies on use of development best practices • Provided internal and external benchmarking of DEC engineering in a variety of key best practice areas • Identified high leverage areas for improvement and provided focus to AEE development process definition
R&E Expenditure Benchmarking	• Examined Digital's research & engineering expenditures normalized for product and service mix differences • Compared expenditures to adjusted peer groups by product / technology area
Technical Problem Reporting Analysis	• Assessment of source and volume of SPRs and CLDs • Assessed total cost of technical problem resolution to Digital

THE AEE PLANNING PROCESS WAS DEVELOPED BY A SERIES OF DIGITAL TEAMS

AEE PHASE I — CONCEPT/DEFINITION
EXPLANATION OF PLANNING PROCESS REDESIGN EFFORTS

Team 1	Solution Planning And Management Process	• Define the nature of the inputs to the Program/Project planning process from the business units; and the processes for translation into solution set requirements and management of final solution set
Team 2	Program/Project Planning Process	• Translation of Solution Set requirements into detailed product requirements in light of capabilities and resources
Team 3	Program/Project Management Information Systems	• Assessment of resource skill mix and utilization. Tracking of progress against target cost, budget, schedule and quality
Team 4	Extended Horizontal And Vertical Interfaces	• Development and maintenance of communication bridges to extended enterprise. Roles and responsibilities for communication: content, timing, format
Aggregate Team	Definition Of And Development Of Examples Of Aggregates	• An "Aggregate" is, eventually, a specification of how the things DEC builds combine modularly into solutions to meet customers needs. What is required is a "structure" that segments customer needs in terms that allow Digital to define its product space in this manner. Optimally, this would be the result of a comprehensive needs based market segmentation analysis, which reflects DEC's relative core competencies and strategy
Simulation Team	Simulation Of The Integrated Planning Process	• Planning interface between engineering and 9 BUs and within engineering (one contact layer e.g.: high level) • Pilot test of UNIX and 2 or 3 SI platforms for healthcare and process manufacturing; and one or more products from TOEM • Foundation for decision making (e.g., investments)

DIGDC K002/NY

THE AEE DEVELOPMENT PROCESS WAS ALSO DEVELOPED BY A SERIES OF DIGITAL TEAMS

AEE PHASE I — CONCEPT/DEFINITION
EXPLANATION OF DEVELOPMENT PROCESS RE-ENGINEERING EFFORTS

Team A	Design Re-Use And Standardization	• Opportunistically reuses existing hardware and software design elements • Proactively designs for reuse to cut the design cost and time of succeeding generations • Modularizes products to simplify design process • Increases end product quality as design elements are better "scrubbed" of errors • Employs standard parts to minimize cost and part number complexity
Team B	Requirements Management	• Employs rigorous cost/benefit analysis of changes to minimize churn • Employs the discipline of systems engineering to structure and decompose requirements • Imposes a disciplined requirements "freeze" point to avoid "whip sawing" development effort • Uses traceability methods and tools to ensure that requirements are met
Team C	Development Team Operation	• Establishes an empowered project leader to ensure sufficient authority over participants • Determines extent and timing of functional involvement to maximize cross-functional input • Employs to greatest extent possible the collocation of all team members
Team D	Development Process Discipline	• Creates a clearly understood process to execute product development across Digital • Articulates the critical interfaces and interactions that must occur • Defines the needed levels of technical and business reviews through checkpoints • Identifies the required best practices that must be employed at each point • Embeds risk-based flex to scale process
Team E	Qualification And Test	• Streamline back-end qualification & test process • Balance testing value against cost
Integration Team	Integrated Development Steering Committee	• Integrate lessons learned and set overall direction • Integrate Best Practices recommendation into process definition

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THE RESTRUCTURED TEAMS ARE FOCUSED ON THE KEY IMPLEMENTATION TASKS

AEE TEAM STRUCTURE — TRANSITION TO IMPLEMENTATION
Explanation Of Integrated Planning Anddevelopment Redesign Efforts

Description	Supplemental Charter	Link To Concept Teams
Integrated Planning And Development Process	• Integration between planning and development processes • Develop action oriented implementation plans	1,2, B, D Integration team Simulation team
Best Practices **– Design re-use** **– Requirements management** **– Team operations** **– Qualification And test**	• Develop action oriented implementation plans • Expand scope to include procedures and policies which would affect planning and development processes	Integration team A B C E
Management Information Systems	• Expand scope to include development processes • Preliminary audit of current systems • Develop next steps and quantify resources required	3
Aggregate Definition And Development	• Identify examples of cross industry platforms • Identify examples of IT platforms and subsystems • Further educate BUs on application of aggregates	Aggregate team
Organizational Transformation **– Support/Infrastructure** **– Organizational Design** **– Funding**	• Administrative systems • Human resource development • Learning organization • Management/decision flow • Explicit and separate roles and responsibilities	D, New
Operationalization	• Customize reviews and interaction across entire process • Quantify management effort for reviews, etc.	New

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IMPLEMENTATION TASKS

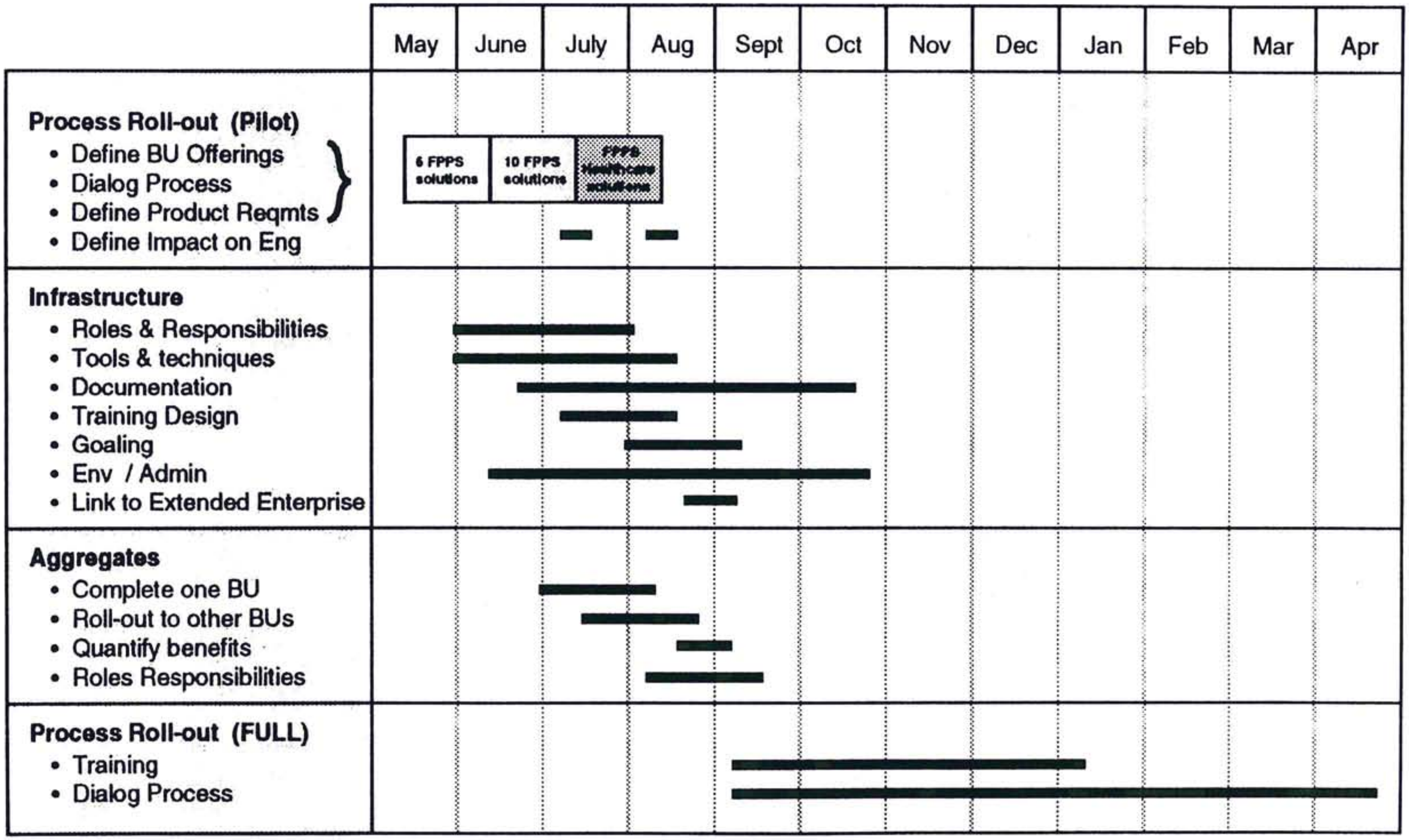
AEE PLANNING PROCESS MODULES

- Pilot
- Infrastructure
- Aggregates
- Full roll-out

Next Steps...

THE PLANNING PROCESS CAN BE READY FOR FULL ROLL-OUT BY FALL

AEE PHASE II WORKPLAN — PLANNING PROCESS IMPLEMENTATION



Next Steps...

AEE PLANNING PROCESS — PILOT WORK MODULE

Description

Complete Planning process for >80% of FPPS requirements*. Execution of several stages (beginning with only 6 customer solutions and escalating) to learn from the new process. Testing and refining the process through hands-on planning experience. (see also infrastructure and aggregates modules)

Objectives

- Fully characterize BU offerings
- Test & refine process thru actual situations
- Provide early / visible successes
- Provide real-time input into product strategies

Proposed Completion

Target: 8/30/93 — to employ for FY95, lead time is req'd for the rest of BU's to be trained in the new process and to undergo process w/Eng.

Resource Requirements

	Initial FTE Per Cust Soln*
• AEE Leader / facilitator	0.5
• Business Units	1.0
• Product Marketing	0.2
• Systems Engineer	0.1
• Documentation / analysis	0.5
• Engineering Content resources	2.0

Key Phase I Participants

- Anker Berg-Sonne, Health
- Paul Kyzivat, CIM
- Alan Briggs, Retail MS
- Pat Prince, Chemicals
- John Giudice, TOEM
- Don Harbert, VMS
- John Adams, NOS
- Howard Mayberry, NOS

Benefits

- Momentum / good-will in adoption of AEE planning process
- Initial, market driven feedback to technology and product strategies
- Training of a cadre of professionals in the application of the planning process
- Completion of the definition and doc- umentation of the planning process

Value

Value of AEE Planning Process

- $90 million
- 2 - 3 months elapsed time

Impact

- ⊘ Cost
- ⊘ Quality
- ○ Cycle-time

LEGEND

- ● High
- ⊘ Medium
- ○ Low

Workplan

- Engage one BU (FPPS) to work with engineering to define all BU offerings and drive to product reqmts
- Stage 1: begin with approx. 6 customer platforms
- Stage 2: 10 add'l cust platforms using aggregates
- Stage 3: complete FPPS and expand to Healthcare
- Capture / integrate learning into each successive stage
- Quantify benefits of aggregates: BU needs rationaliza- tion; reduced cost to deliver; faster / better planning, etc

Completed in Phase I

- High-level process definition
- Developed dialog / POR templates
- Tested / proved role and value of dialog process
  - Chemicals MSDS Pilot
  - Healthview Pilot
  - TOEM Pilot

Immediate Next Steps

- Finalize / assign resources
- Review market justifications of stage 1 solutions
- Initiate dialog process for stage 1
- Initiate stage 2 research as required

* approx. 25 customer solution platforms account for 80% of FPPS's business

AEE PLANNING PROCESS — INFRASTRUCTURE WORK MODULE

Description

Define and charter the Engineering support infrastructure as it applies to the Planning Process. Define / assign planning roles. Develop tools & techniques, training / communications , metrics; env. / admin. reqmts. Continue to explicitly link the AEE Planning Process to the extended enterprise.

Objectives

- Define owners / decision makers and assign roles
- Define objectives / metrics for these roles
- Document process and application (training)
- Execute complementary changes in env / admin
- Develop tools & techniques

Proposed Completion

Target: 9/30/93 — needs to be 80% in place before full roll-out to remaining BUs can occur

Resource Requirements

	Total FTE
• AEE Leader / facilitator	1.0
• Documentation specialists	10
• Training Specialists	10
• HR Specialists	2.0
• Engineering Content resources	5.0
• Other Functional members	5.0

Key Phase I Participants

- Ralph Christiensen, HR
- Bill Koteff, Opns

Benefits

- Operationalize / facilitate use of Planning Process
- Capture Lessons Learned
- Maximize effectiveness of Planning Process across
- extended enterprise
- Assure smooth roll-out
- Define / direct / embed cultural change

Value

Value of AEE Planning Process

- $90 million
- 2 - 3 months elapsed time

Impact

- O Cost
- ⦸ Quality
- ⦸ Cycle-time

LEGEND

- ● High
- ⦸ Medium
- O Low

Workplan

- Define / assign planning roles & skill requirements
- Identify and address environmental / cultural issues
- Identify / develop tools & techniques
- Document process and most effective utilization
- Design targeted training programs
- Develop goals / metrics to measure success
- Link to extended enterprise thru Supply Chain Identify and document required infrastructure and administration

Completed in Phase I

- Capabilities gaps
- Organizational Implications
- Information systems reqmts

Immediate Next Steps

- Identify and assign resources

Next Steps...

AEE PLANNING PROCESS — AGGREGATES WORK MODULE

Description

An "Aggregate" is a specification of how the things DEC builds combine modularly into solutions to meet customer needs. What is required is a "structure" that segments customer needs in terms that allow Digital to define its product space in this manner

Objectives

- Fully characterize / operationalize aggregates
- Define aggregates based on current offerings
- Define role in planning process
- Define / charter / enroll management structure

Proposed Completion

Target: 9/30/93 — to employ for FY95, lead time is req'd for the BU's to realign their business and to define their requirements with Engineering

Resource Requirements

	FTE Per Aggregate
• AEE Leader / facilitator	0.2
• Business Units	1.0
• Product Marketing	0.2
• Systems Engineer	1.0
• AEE Process Expert	0.2
• Engineering Content resources	1.0

Key Phase I Participants

- Paul Kyzivat, BU-CIM
- Alan Briggs, BU-Retail
- MSJackie Kahle, Prod Mktg
- Gene Hodges, Prod Mktg
- Jack Bowie, Prod Mktg
- Ladin / Langdon, CSE
- Dick Loveland, CSE
- Les Kramer, CSE

Benefits

- Rationalization across BU reqmts
- Achieve system-ness for both solutions and systems Businesses
- Reduction in operational complexity
- Reduction of risk of customer sales

Value

Value of AEE Planning Process
- $90 million
- 2 - 3 months elapsed time

Impact

- ● Cost
- ⊘ Quality
- ● Cycle-time

LEGEND

- ● High
- ⊘ Medium
- ○ Low

Workplan

- Engage one BU (FPPS) to work with engineering to map all BU offerings and relate to aggregates
- With these aggregates, work with other business units to define / align their offerings
- Quantify benefits of aggregates: BU needs rationalization; reduce cost to deliver; faster / better planning, etc
- Design & deploy management and architectural roles and responsibilities (define capabilities & gaps)

Completed in Phase I

- How to define
- Existence proven w/ examples
- Proposed ten
- Reconciled with "Domains"

Immediate Next Steps

- Define constituents of examples
- Define owners
- Engage with other BUs
- Reconcile with "Product Sets"

AEE PLANNING PROCESS — FULL ROLL-OUT WORK MODULE

Description

Fully engage all the business units in the application of the AEE Planning Process. Roll-out will require the utilization of all the participants trained throughout the Pilot(s); and will require significant training of large portions of engineering and BU professionals

Objectives

- Engage all BUs
- Training of affected professionals
- Rationalization of needs across BUs
- Direct input for technology & product strategies

Proposed Timing

Roll-out Target: 8/30/93 — to employ for FY95, lead time is req'd for the BU's to be trained in the new process and to undergo process w/Eng.

Resource Requirements

	Initial FTE Per Cust Soln
• AEE Leader / facilitator	0.1
• Business Units - Marketing	1.0
• Systems Engineer	0.1
• Documentation / analysis	0.1
• Aggregate agents	0.2
• Product agents	0.5
• Other functional agents	0.2

Key Phase I Participants

- Anker Berg-Sonne, Health
- Paul Kyzivat, CIM
- Alan Briggs, Retail MS
- Pat Prince, Chemicals
- John Giudice, TOEM
- Don Harbert, VMS
- John Adams, NOS
- Howard Mayberry, NOS

Benefits

- Market driven feedback to technology and product strategies
- Greater requirements stability
- Partnership with BUs
- Responsive, while stable, planning process
- Decentralization of decision making

Value

Value of AEE Planning Process
- $90 million
- 2 - 3 months elapsed time

Impact

- ● Cost
- ● Quality
- ● Cycle-time

LEGEND

- ● High
- ⊘ Medium
- ○ Low

Workplan

- Engage all BUs to work with engineering to define all BU offerings and drive to product reqmts
- Launch training program
- Define / Identify / Charter management roles & resp.
- Refine & implement product strategy process
- Quantify benefits of new AEE Planning Process and aggregates: BU needs rationalization; reduced cost to deliver; faster / better planning, etc

Completed in Phase I

- High-level process definition
- Developed dialog / POR templates
- Tested / proved role and value of dialog process
  - Chemicals MSDS Pilot
  - Healthview Pilot
  - TOEM Pilot

Immediate Next Steps

Initiate communication and buy-in program targeted at BUs and all of engineering

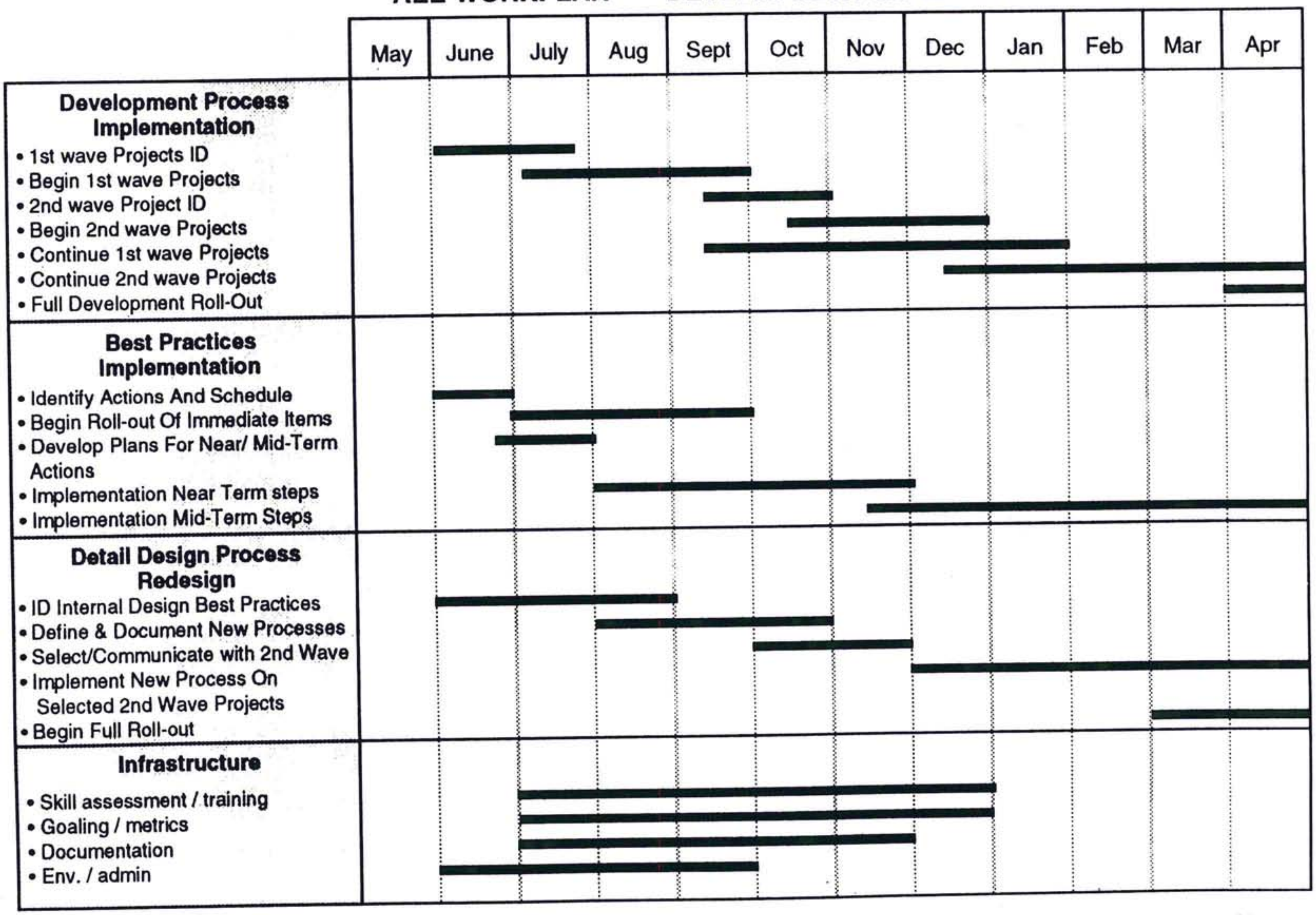
AEE DEVELOPMENT PROCESS MODULES

- Process Implementation
- Best Practice Implementation
- Detail Design Process Redesign
- Infrastructure

Next Steps...

THE FOUR KEY DEVELOPMENT EFFORTS CAN BE DONE IN PARALLEL

AEE WORKPLAN — DEVELOPMENT IMPLEMENTATION SCHEDULE



AEE DEVELOPMENT PROCESS — AEE PROCESS IMPLEMENTATION MODULE

Description

Rolling out the new AEE development process across Digital. Executing a series of 1st and 2nd wave pilot implementations concurrently to learn from and progressively scale-up the new process. Testing and revising the Checkpoints and risk-based flex options through hands-on development experience.

Objectives

- Test the process in actual development situations
- Modify process as needed before full roll-out
- Progressively scale-up to build experienced cadre
- Provide initial focus to ensure success

Proposed Timing

- Target 9/30/93 for transition from 1st wave test
- Target 3/31/94 for transition from 2nd wave test
- Target 4/1/94 for beginning full roll-out

Resource Requirements

	FTE's Per 1st Wave Project
• Product Leader	1.0
• Systems Engineer	1.0
• Team Facilitator/Trainer	0.5
• AEE Process Expert	0.5
• Documentation Specialist	0.5
• Product Mgmt/Mktg	1.0
• Other Functional Members	?

Key Phase I Participants

- Tom Harris, SWG
- Bill Wright, SWG
- Neil Davies, CSG
- Anders Overgaard, CSG
- Masood Heydari, CSG
- Andrew Gent, IDC
- Tony Hutchings, SWG
- Frank Melanson, CSG

Benefits

- Shorter time and lower cost for development
- Greater discipline in execution of development
- Oversight based on inherent risk
- Required work based on inherent risk
- Less upfront churn/downstream rework
- Decentralized decision making, greater accountability
- Common process to allow easier roll-up of progress
- Built-in systems perspective upfront in process

Value

Quantifiable Value

Applied-Time: 25%-30%

Cycle-Time: 35%-40%

Risk Reduction Value

Shakes down process, building understanding

Impact

Rating	Impact
●	Cost
⊘	Quality
●	Cycle-time

Legend

Symbol	Meaning
●	High
⊘	Medium
○	Low

Workplan

- Select 3 1st wave projects to begin the prototype testing of the AEE development process for 3 months
- Select 30 2nd wave projects to scale-up the testing of the process. Initiate some based on FPPS pilot results
- Cross-pollinate 2nd wave projects with experience from 1st wave projects through-out process
- Initiate full roll-out to all projects after 8 months of 2nd wave experience. Continue ongoing lessons transfer

Completed in Phase I

- Defined process architecture
- Built in systems/CE view
- Defined planning/development link
- Identified major step deliverables
- Defined Checkpoint operation
- Identified key process responsibilities
- Defined risk criteria & decision rules
- Defined process flex options
- Defined team structure across process

Immediate Next Steps

- Identify stand-out leaders for 1st wave
- Define the 1st wave projects
  - Which BU will serve as sponsor?
  - Which organizations?
  - What size/complexity of project?
- Start screening to select 2nd wave
- Establish infrastructure for 1st wave
- Define CM process for AEE process

Next Steps...

AEE DEVELOPMENT PROCESS — BEST PRACTICE IMPLEMENTATION MODULE

Description

Drive the adoption of development best practice across the organization in the areas of:

- Reuse & standardization
- Requirements management
- Qualification & test
- Team operation

Ensure rapid and consistent adoption of identified best practices.

Objectives

- Implement HW reuse, initiate SW reuse
- Adopt requirements management practices/tools
- Streamline qualification and test activities
- Adopt CE-based team structure & operation

Proposed Timing

- Target 6/30/93 for first set of immediate actions
- Target 7/30/93 to finalize near-mid term plans
- Target 8/1/93 to begin near-term implementation

Resource Requirements

	FTE Per Best Practice Area
• Best Practice Initiative Leader	1.0
• Documentation Specialist	1.0
• Training Expert	1.0
• Hardware Engineer	1.5
• Software Engineer	1.5
• AEE Process Expert	0.5
• Product Mgmt/Mktg	0.3
• Other Discipline/Function Reps	?

Key Phase I Participants

- Steve Noyes, CSG
- Paul Vilcans, Mfg.
- David Hartzband, SWG
- Tony Hutchings, SWG
- Ted Gent, CSG
- Tom Harris, SWG
- Bill Wright, SWG
- Anders Overgaard, CSG

Benefits

- Shorter design time and lower design cost
- Better requirements with less churn
- Lower materials costs through standard parts
- Better requirements traceability — better products
- Better control of requirements changes — less rework
- Shorter qualification time and lower cost
- Earlier surfacing of downstream issues — less rework
- Greater accountability & faster communication

Value

Quantifiable Value

Applied-Time: 20%-25%

Cycle-Time: 10%-15%

Impact

- ● Cost
- ⊘ Quality
- ⊘ Cycle-time

Legend

- ● High
- ⊘ Medium
- ○ Low

Workplan

- Identify initiative leaders and dedicated resources
- For each initiative identify immediate, near-term, mid-term & long-term actions — prioritize work accordingly
- Establish roll-out plan for immediate changes and begin implementation planning of near and mid-term
- Segment actions by those to be rolled into pilots (team) and those to be adopted across the board (HW reuse)

Completed in Phase I

- 1st & 2nd level reuse defined
- Tech File/Aspect link established
- Reuse metrics/templates created
- Requirements Mgmt. process defined
- Traceability processes sketched out
- Verification gaps identified
- Program/product teams defined
- Team operation best practices defined

Immediate Next Steps

- Establish Tech File/Aspect funding & implementation plan with Mfg.
- Identify BP initiative leaders & staff
- Establish short & mid-term reuse template implementation plan
- Identify needed traceability tools

AEE DEVELOPMENT PROCESS — DETAIL DESIGN PROCESS REDESIGN MODULE

Description

Building upon the top-level architecture of the AEE planning & development process, develop standard detail design processes for each major design discipline: software, digital, analog/microwave, mechanical, etc. The defined process will address both the steps, methods, and tools to be employed when following the standard design process for that discipline.

Objectives

- Define best practice process by design discipline
- Deploy standard design processes across groups
- Improve cost, quality, and time via standardization
- Enhance discipline and commonality with process

Proposed Timing

- Target 8/31/93 for completion of best practice ID
- Target 10/31/93 for documenting new processes
- Target 11/30/93 to start using on 2nd wave projects

Resource Requirements

	FTE's Per Target Discipline
• Team Leader	1.0
• AEE Process Expert	1.0
• Documentation Specialist	1.0
• Engineers From Discipline	6.0
• Training Expert	1.0
• Team Facilitator	0.5

Key Phase I Participants

Topic Not Specifically Addressed In Phase I

Benefits

- Shorter, lower cost, and higher quality detail design processes with greater repeatability
- Leverage the best approaches used in DEC and standardize on them raising all to DEC's best
- Easier load leveling and resource use through common process knowledge
- Lower tool acquisition and support costs through standardization of platforms and design tools

Value

Quantifiable Value

Applied-Time: 15%-20%

Cycle-Time: 10%-15%

Impact

- ● Cost
- ⊘ Quality
- ⊘ Cycle-time

Legend

- ● High
- ⊘ Medium
- ○ Low

Workplan

- Form cross-group teams for each target design discipline — led by experienced engineering manager
- Map major versions of design process, ID practices and tools used by groups across DEC
- Gather data on execution results by group to assess impact of different methods: time, cost, and quality
- Identify best elements of processes currently used
- Define new processes for each discipline

Completed in Phase I

- Top-level AEE process defined
- Some internal best practices surfaced
- Some best practice gaps identified
- Principles defined:
  - Use standard off-the-shelf tools
  - Adopt methodology first

Immediate Next Steps

- Select target design disciplines
- Select effort's leaders and form teams
- Initiate data gathering/mapping
  - Internal assessment
  - External benchmarking

AEE DEVELOPMENT PROCESS — INFRASTRUCTURE WORK MODULE

Description

Define and charter the Engineering support infrastructure as it applies to the development process. Will include documentation of the process and training & communication, goaling / metrics, and defining environmental / admin. requirements.

Objectives

- Define supporting goals / metrics
- Execute complementary changes in env./admin
- Identify and develop standard processes, tools, techniques, libraries, etc.
- Complete documentation, communication, and training

Proposed Timing

Target: 9/30/93 — needs to be implemented in conjunction with development process roll-out

Resource Requirements

	Total FTE
• AEE Leader / facilitator	1.0
• Documentation specialists	5.0
• Training Specialists	5.0
• HR Specialists	2.0
• Engineering Content resources	5.0
• Other Functional members	5.0

Key Phase I Participants

- Tom Harris
- Masood Heydari
- Tony Hutchings
- Steve Noyes

Benefits

- Communicate and facilitate the use of the new development process and best practices
- Assure smooth roll-out and implementation
- Provide standard processes, tools, and techniques
- Improved efficiency & effectiveness; provides a new base for continuous improvement

Value

Key to enabling the achievement of the AEE development process goals

Impact

- ● Cost
- ⊘ Quality
- ● Cycle-time

LEGEND

- ● High
- ⊘ Medium
- ○ Low

Workplan

- Identify & address env. / cultural issues
- Identify / develop tools & techniques
- Document process and best practices and most effective utilization
- Perform skill assessment / design training programs
- Develop goals / metrics to measure success
- Identify & document required infrastructure & admin

Completed in Phase I

- Capabilities gaps
- Organizational implications
- Information systems requirements

Immediate Next Steps

- Identify & assign resources

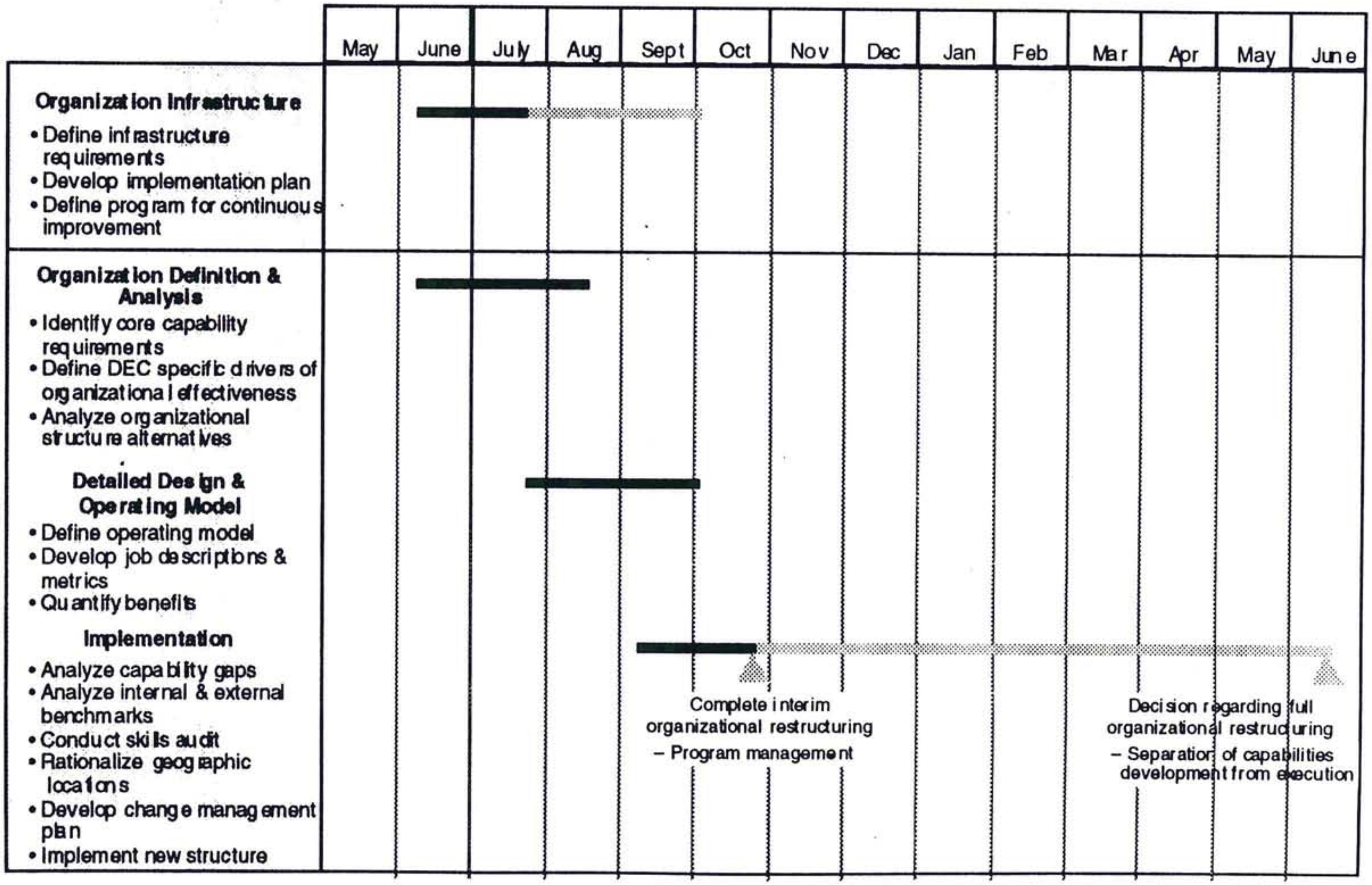
AEE ORGANIZATIONAL TRANSFORMATION

- Infrastructure
- Organizational Design

Next Steps...

THE WORK TO LAY THE FOUNDATION FOR ORGANIZATIONAL TRANSFORMATION CAN ALSO BE FINISHED BY THE FALL

AEE ORGANIZATIONAL TRANSFORMATION — WORKPLAN



AEE ORGANIZATION TRANSFORMATION — INFRASTRUCTURE WORK MODULE

Description

Define the engineering organization support infrastructure:
- Support organizations
- Support processes
- Information systems
- Tools & techniques

Link new organizational structure to AEE planning & development processes with appropriate supporting infrastructure.

Objectives

- Define roles & responsibilities of engineering support organizations (e.g. HR, Finance, etc.)
- Reengineer support processes
- Develop resource planning & allocation procedures

Proposed Completion

Target: 9/30/93 — significant changes need to be specified for organizational transformation steps

Resource Requirements

	Total FTE
• AEE Leader / facilitator	1.0
• HR Specialists	1.0
• Org. Design Specialists	2.0
• Engineering Content resources	10.0
• Other Functional members	10.0

Key Phase I Participants

- Ralph Christianson, HR
- Bill Koteff
- Tom Harris, Team C/D

Benefits

- Ensure congruency between AEE planning & development processes and organizational structure
- Assure smooth implementation
- Streamline interfaces and optimize informal processes
- Maximize efficiency & effectiveness of planning & development processes

Value

Key Enabler To Achieving The Savings / Value Outlined In AEE Planning And Development Modules

Impact

- Cost
- Quality
- Cycle-time

LEGEND

- High
- Medium
- Low

Workplan

- Define support infrastructure requirements for major areas of engineering organization activity:
  - Capability development & deployment
  - Decision making
  - Resource planning & allocation
  - Budgeting & control
  - Performance management
- Develop implementation plan
- Define program for ongoing continuous improvement

Completed in Phase I

- Capabilities gaps
- Organizational Implications
- Preliminary information systems requirements

Immediate Next Steps

- Define organization infrastructure requirements

AEE ORGANIZATIONAL TRANSFORMATION - DEFINITION, ANALYSIS, DESIGN & IMPLEMENTATION

Description

Engineering organization structure must be congruent with DEC's strategy to develop and deliver integrated customer solutions and be consistent with the new AEE planning & development processes. These significant changes drive a fundamental need to restructure the engineering organization.

Objectives

- Build on organizational concepts from Phase I
- Complete detailed organizational design
- Define organization operating model
- Develop detailed implementation plan

Proposed Completion

- Driven by 9/30 adoption of AEE processes
  – Target : 9/30/93 - program management
  – Target: 5/31/94 - complete transformation

Resource Requirements

	FTEs
• Team Leader	1.0
• Team Facilitator	0.2
• Senior Engineering Mgmt.	0.1
• Human Resources	0.5
• Engineering Content	2.0
• Supply Chain Functions	1.0

Phase I Participants

- Bill Strecker
- Ralph Christensen

Benefits

- Improved program/product development & delivery effectiveness
- Streamlined organization for reduced cycle and applied time
- Improved capability building - establish and maintain critical mass
- Improved responsiveness to changing market requirements
- Reduced cost for scale sensitive activities

Value

Key Enabler To Achieving The Savings / Value Outlined In AEE Planning And Development Modules

Impact

- ● Cost
- ⊘ Quality
- ● Cycle-time

LEGEND

- ● High
- ⊘ Medium
- ○ Low

Workplan

- Identify core engineering capability requirements/gaps
- Identify drivers of organizational effectiveness
- Analyze organizational alternatives
- Define organizational operating model (e.g. decision flow, job descriptions, funding, metrics, etc.)
- Rationalize geographic locations
- Quantify benefits of new organizational model
- Conduct skills audit
- Develop change management plan

Completed in Phase I

- Engineering organization concept
- Development team structure and operations
- Preliminary implementation planning

Immediate Next Steps

- Begin detailed organization analysis and design
- Near-term implementation of program organization

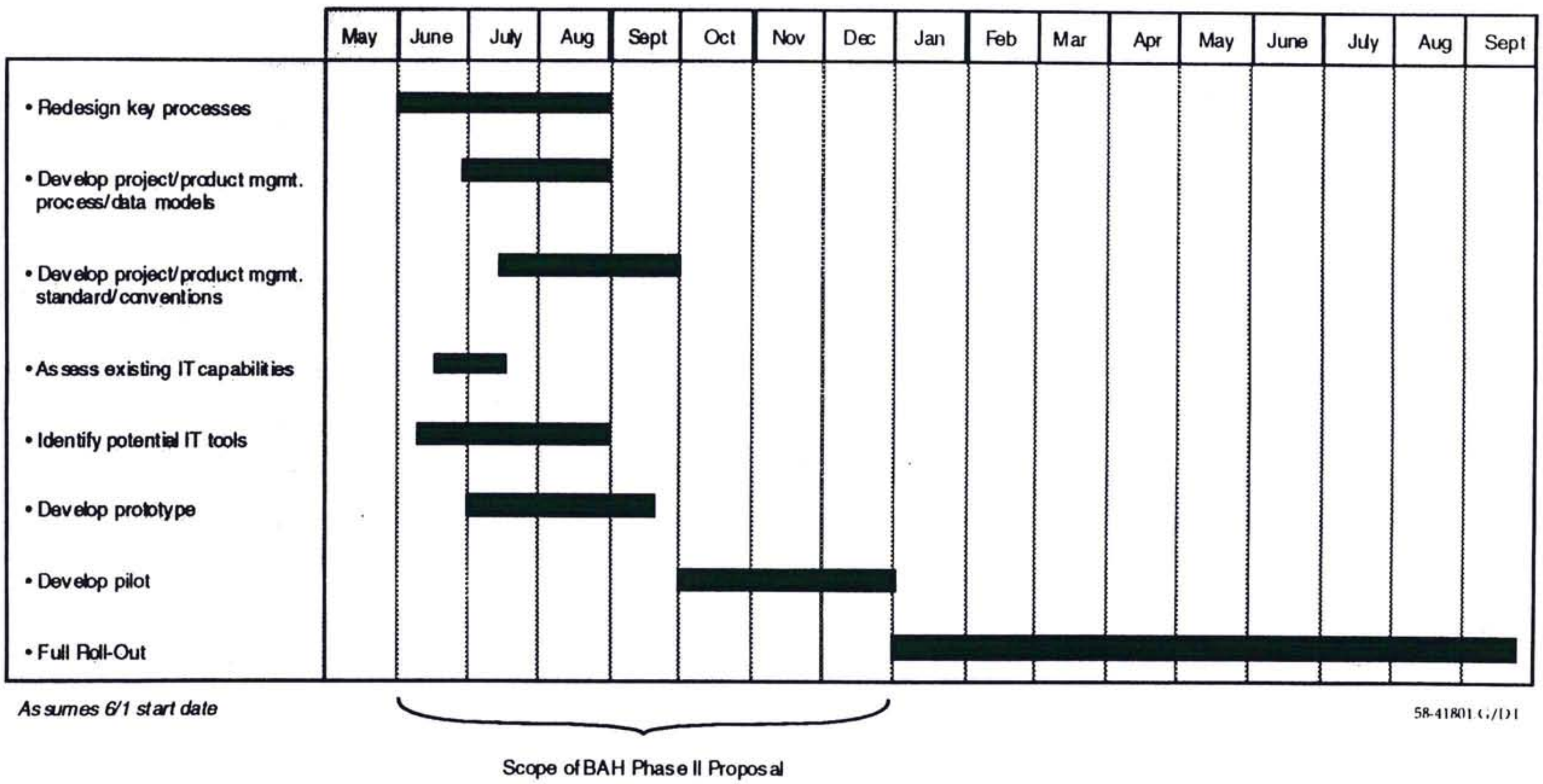
AEE ENGINEERING INFORMATION INFRASTRUCTURE

- **Project and Program / Product Management System**

Next Steps...

THE NEW PROJECT/PRODUCT MANAGEMENT SYSTEM COULD BE READY BY THE BEGINNING OF 1994

AEE WORKPLAN — PROJECT/PRODUCT MANAGEMENT SYSTEM



AEE IS INFRASTRUCTURE — PROJECT/PRODUCT MANAGEMENT SYSTEM

Description

An integrated set of IT enabled product and project management capabilities, including product and project databases, management and financial reporting, tracking, and performance measures. Leverage commercial off the shelf (COTS) software where possible.

Objectives

- Standardize project and product management data and processes, consistent with AEE
- Enable integration to other/future systems
- Ensure capture and use of key management, financial, and performance data

Proposed Completion

- Pilot deployed for one or more design entities targeted for 11/93

Resource Requirements

- Project team leaders (2)
- Models/reqm't.s team (5)
- Templates, stds., conventions (3)
- Tools and technology (prototyping) (3)
- Add'l QA/QC, steering committee, industry expert resources

Key Phase I Participants

- IM&T
  - Lou Cintron
  - Priscilla Monroe
- Bill James
- Nigel Turner
- Jim Despathy

Benefits

- Resource / capability loading and planning
- IT infrastructure to support AGE processes
- Consistent definition of data and processes
- Integrated tools and methodologies for product and project management
- Overall reduced systems costs – reduced number of systems and streamlined processes

Value

- Integration of systems and data
- Standardization of processes & information for sharing and delivery
- Tracking of metrics for processes

Impact

⊘	Cost
●	Quality
●	Cycle-time

LEGEND

●	High
⊘	Medium
○	Low

Workplan

- Refine business needs/information reqm'ts.
- Develop project/product management process and data models
- Develop project/product management standards and conventions
- Assess existing IT capabilities
- Identify potential IT tools
- Develop prototype
- Develop pilot
- Refine implementation plan

Phase II Deliverables

- Prototype/pilot of new product/ project mgmt. system, piloted to one eng. entity – leveraging COTS
- Project/product management:
  - Standards and conventions
  - Project templates
  - Planning metrics
  - Perf. measures and rept'g. reqm'ts
  - Work breakdown structure
- IT capabilities requirements

Immediate Next Steps

- Collect and document info needs and reqm'ts.
- Develop templates/strawhorses for facilitated sessions
- Identify facilitated session participants

II. Aggregates

Outline

A. Introduction...

Core to achieving excellence in engineering at digital is the convergence of Digital's market and technology strategies in driving engineering planning and development activities

...Market-based, interoperable and integrated are common themes

Realizing Digital's new strategies will require reaching a common ground between solutions demanded by the market and the engineered components which constitute those solutions

Clearly, Digital's historical approach of managing its complex product offerings at the component level is inefficient and ineffective

Importantly, whether digital builds systems or not, Digital's products will eventually comprise systems in the market and therefore must be engineered with an eye toward eventual interoperability requirements

Given the need for Digital's offerings to be interoperable with other Digital and third party products / solutions, it is critical to define the right level at which to drive a systems focus

...Defining the decision dynamics and implementing a strong management structure to support this architecture are mandatory for successfully exploiting aggregates, and discussed elsewhere

Aggregates are central to the AEE planning and development processes — a key foundation for driving efficiency and effectiveness across all the AEE recommendations

The central principle underlying the development of aggregates must be to reduce the risk of customer engagements

Aggregation into systems can be accomplished at a number of levels / dimensions...

...however, the right place is that which holds the highest value-added levers for customers and which allows Digital to capture the greatest amount of that value added

An Aggregate is a combination of products and/or capabilities that are engineered as an integrated entity to satisfy a defined need

"Aggregates" exist at every level in this chart — the cross-Industry platform level is key to supporting the CBU / SI initiatives...

Based on the analysis to-date, we believe that upwards of 10 - 20 aggregates exist in this space

... or at the IT platform level, which represents discrete technology sets

Therefore the goals of aggregate development were as follows

B. Background... II–12

Digital has done a lot of thinking around the issue of how to aggregate

Strecker / Supnik have employed a technology driven model for defining system-level platforms...

Though not market driven, as a transition model it serves an important role in communicating to the company that digital will no longer operate at the components level

SWG has developed a similar paradigm to segment and recast their work more in line with their view of market requirements

Tthe CIM Group has proposed a paradigm which is intuitive and Customer / solution driven

The CIM framework has evolved into the current structure employed for the work of the aggregate examples team

II. Aggregates

...wherein the overlap between the stalagmite and stalactite Represents The Point Around Which market driven Aggregates Should Emerge

Specific Definitions Of These Layers Follow

C. **Examples... II–18**

Objective — To Test The Concept Of Market-Driven and technology-driven "Aggregates" Through The Development Of A "Full Set" Of Real Life Examples

A team of product marketing, business units, SE/si taskforce and Booz•Allen has been tasked with developing examples of market driven aggregates

To fully complete this charter, additional resources are needed

Specifically, the method we employed to develop the market-driven examples was as follows

<u>Step 1</u> **Analyzed industry specific requirements using:**

SI Pipeline analysis

Existing BU solutions already defined

Specific customer examples

What technology is being used; what functionality / value does it provide

<u>Step 2</u> **Looked for "patterns" of technology use across industries**

Common business process paradigms

Commonalities / patterns at all levels

<u>Step 3</u> **Further defined / exploded each aggregate** (see Appendix S)

Description

Target Customer

Industry Specific Examples

Technology Requirements

Development Environment Required

Operational Issues

In looking for "patterns" of technology use, first we identified common business process paradigms...

...then we looked for commonalities / patterns at all levels

II. Aggregates

Though still preliminary, we have described eight Cross-Industry Platforms in some detail…

Distributed Branch System - a cross-enterprise platform that supports a loosely connected set of fully or partially autonomous business entities, in which the communication enables coordination (e.g., of ordering and delivery of information) and/or control (e.g., of the operations of branch entities). (e.g.,)

Professional Data Analysis System - provides support to knowledge-workers who routinely gather and analyze large amounts of data to make critical business decisions. (e.g.,)

Case Handling System - supports the start to finish management of episodes constituting an enterprise's exchanges of goods and/or services with individual customers, clients, or suppliers. (an episode is a sequence of activities and decisions and/or actions). (e.g.,)

Control System - supports the control and/or monitoring of a process in real-time. The control system is connected to the process being controlled. (e.g.,)

On-line Library System - supports the storage, indexing, search and retrieval of large document-oriented databases. (e.g.,)

Integrated Business Operations System - a library of standard models and reusable service interfaces for accessing business operation and management functions — wrappers which make applications into clients or providers of those servers. (e.g.,)

Numeric Intensive Computing System - supports the specific requirements of computationally intensive applications, such as modeling and simulation. (e.g.,)

Proposal and Design System - supports the creation and storage of complex sets of product design information or compound documents for proposals – information may be later accessed by the Library System aggregate. (e.g.,)

Further detail can be found in Appendix S

…As well as two aggregates which can both be sold independently and probably underlie all identified cross-industry platforms

- Application Development Environment
- Network and Systems Management

this work is preliminary and less well defined than the previous Eight

further work for the generation of the market driven aggregate examples

- We have identified three potential, additional Cross-Industry Platforms which require further evaluation…
- And are aware of the potential for several more
- In order to maximize the benefit to the ongoing Planning Process

We also identified eight IT Platforms / Subsystems which the cross-industry platform aggregates require — and for simplicity mapped them as follows

- Application Integration
- Data Integration
- Workflow
- Business Process Modeling
- Repository
- Transaction Processing
- Inter-/Intra-Enterpreise Communications
- Complex Data Modeling

we repeated a similar method Starting from the technology perspective to develop a complete set of it platform / Sub-system aggregates

as a going-in hypothesis, we employed the paradigm developed by the software group

However, there is a not a simple, direct mapping of the cross-industry aggregates or identified needs to the SWG product set groupings

- Many aggregates need pieces of different Product Sets – what seems to characterize much of Digital's potential customer advantage / competitive edge are solutions that blend elements of both Workgroup and Enterprise
- Although there is significant value in products within a defined Product Set working together, there is an equal or greater need to have specific products currently in different Product Sets work together

Our analysis clearly identifies the need for IT platform / sub-system aggregates, but with significantly more granularity than the product set paradigm currently offers

D. Operationalization... II–30

In the near-term, the focus of aggregates is delivery against current needs

however, in the future aggregates should be used to drive investment

driving engineering investment from market needs will be facilitated through the application of aggregates

Specification of aggregates will likely occur over several stages

Organizationally, an important first step will be to clarify roles & responsibilities for definition and delivery of aggregates

E. Next Steps... II–34

To complete development of examples, significant buy-in / guidance and additional resources will be needed

- Business Units need to internalize and align their business needs to assist in both refining and prioritizing current examples
- Engineering, also, needs to internalize and align the product strategies
- Further, significant activities are required to operationalize aggregates

The aggregate team will pursue two activities in parallel...

...the details of which are in Appendix S

The high-level workplan summary shows the heavy reliance upon the planning process pilot now underway with FPPS

Aggressive pursuit of aggregates and the planning process pilot will be required to drive success of the AEE planning and development processes

PLANNING PROCESS		DEVELOPMENT PROCESS	
Principles	**Recommendations**	**Principles**	**Recommendations**
Minimalistic	Dialog Process	Increasing Value-added	Re-use
Collaborative	Planning Templates	Concurrent Invlovement	Checkpoint Process
Responsive	Cross-engineering Dialog	SE Methodology	Risk-based Flex
Systems Focused \		Accountability	Empowered Teams
	> Aggregates		
Bilateral Contract /			
		Decision Making \	
		>	Requirements Management
		Efficiency /	

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

Outline

A. Integration... III-1

In order for Digital to achieve excellence as a corporation, an overall & integrated architecture for world-class planning and execution will be required

AEE's integrated approach to engineering planning and product development must be consistent with this overall architecture

Planning and development processes reflect each other

The integration of planning and development, through shared value and concurrency, yields an effective engineering process

The integrated process must add value — through balancing demand and supply via planning and thereby driving development

The endgame is an integrated process for driving and ensuring excellence in engineering planning and development

B. Diagnostic/Charter... III-7

Presently, engineering planning is broken – either there is no planning process or there are 7 unconnected planning processes, none of which satisfactorily drive market-based engineering

- 8 Quarter Volume Planning (8QVP)
- Corporate Phase Review Process
- LRP/"Bottom Up" Process
- Customer Program Reviews
  - Semi-annual proces involving selecting customers to discuss current products, customer needs & market trends
  - 80% of DEC technologies represented by partners programs (e.g.: UNIX, VMS, Networks, Graphics, Real Time)
- "Ad Hoc Cooperation"
- "Domain" Process

Although slightly different in each group, there is an existing development process at Digital

However, Digital's current overall process suffers from a lack of discipline that results in minimal control and predictability in engineering spending

this lack of process discipline also translates into cycle times which are too long given competitive pressures — and "advanced" development in excess of 8 months, on average

Charter... III-11

To tackle Digital's severe problems, aggressive goals were set for the 2-3 year horizon of the AEE program, establishing a clear charter for what the integrated planning and development process must deliver

The substantial challenges confronting Digital engineering indicate that achieving these goals is critical

Planning Gaps:

- No established link to the newly formed business units to drive engineering planning
- Technology driven, rather than market driven, engineering planning

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

- Absence of a construct to drive planning from a systems or components perspective
- Inadequate link to the "extended enterprise" to drive engineering planning

Development Gaps:

- Development cycle-times significantly longer than competitively permissible
- Substantial requirements churn post initial product specification
- Absence of best practice and tool standardization across development groups
- Minimal discipline in the execution of design processes
- Limited attention given to part standardization and design reuse
- Inconsistent employment of concurrent engineering principles

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

C. Principles... III-13

The AEE re-design of DEC's processes is driven from several basic principles which apply to both planning and development:

1. Minimalistic
- A simple and highly implementable process requiring minimal documentation

2. Collaborative & Concurrent Involvement
- A partnership based dialog between the BUs and Engineering
- All relevant functions are involved as early as possible in effort

3. Responsive & Flexible
- A continuous (i.e., not annual) process that is responsive to market changes and flexible

4. Systems Focused & SE Methodology
- A process that drives to a systems view of interoperability requirements
- Steps geared to addressing system considerations from the start

5. Bilateral Contract
- Schedule / cost / deliverable for committed business results

6. Increasing Value-Added
- The process will be gated by demonstrable increases in value

7. Accountability & Decision Making
- All requirements, deliverables, and tasks are explicitly owned
- Decisions are only made by people directly participating in the process

8. Efficiency
- Flexibility, scalability and standardization are balanced to optimize efficiency

It is these principles which are central to AEE. The specific recommended processes facilitate the implementation of these principles

Let's discuss each of the basic principles in turn

1. Minimalism... III-15

Providing market driven, needs based customer solutions requires effectively linking the various Digital organizations in the extended enterprise representing demand and supply – primarily the business units and engineering

The dialog process is guided by rules agreed upon by both business units and engineering

The AEE planning process promotes the most efficient & effective dialog between BU's and engineering based on a minimum amount of documentation

Fundamental to the minimalistic principle is the need for only the key information – derived from a finite set of inputs – to feed into the engineering planning process

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

More specifically, the information needed to support the business unit / engineering dialog must reflect actionable outputs for engineering

The development process is minimalist in that it provides structure, yet imposes the minimum administrative or overhead work for engineering

2. Collaborative & Concurrent Involvement... III-21

The dialog is not only minimalistic, but it also requires collaboration and enables rapid decision-making and action by both engineering and business units

The information templates, created by the business units, are the basis for initiating the BU/engineering dialog and documenting BU solutions

The overlap of the phases – from planning through development – makes their activities concurrent – involving all relevant functions as early as possible in the effort

This is accomplished by pulling phase steps forward as early as possible

strong coordination of released work output is necessary

In addition, the AEE process is linked to all relevant Digital planning activities

Key extended enterprise linkages have been categorized in eight areas to be further defined and implemented in Phase II

3. Responsive & Flexible... III-27

the engineering planning process is responsive yet stable through a repeatable series of steps

Inherent flex was designed into the AEE process to adjust for three variables: levels of risk, different propositions, and different use

these variables are explained on the following pages

A critical concept for Digital, given the broad range of activities undertaken, and the lessons learned from the phase review process, is that of risk-based process 'flex"

AEE has created a common procedure for flexing the AEE process – both planning & development

- Planning process/flex... III-30

  The planning process needs to "flex" to reflect varying degrees of risk – four types of risk have been identified to

  drive the level of planning effort

  - Financial exposure
  - Technology risk
  - Market risk
  - Execution risk

- Development process–flex... III-31

  Risk is calibrated by flexing of checkpoints for the process phases

  Checkpoints synchronize the product's definition & provide process visibility

  At the concept checkpoint, programs/products will be assessed for risk to determine the appropriate flex in the development process as well

  WE APPLY four pronged DECISION guidelines TO EVALUATE the merger of EACH RISK PARAMETER

  THESE CODES ALLOW FOR RISK LEVELS THAT ARE HISTORICALLY DISPROPORTIONATE WITH PROJECT SIZE

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

THE TYPE and degree OF RISK DETERMINE THE Types OF PROCESS FLEX APPLIED: resources applied, reviews, checkpoints and the planning contract's tasks

The AEE process provides appropriate combinations to scale projects

The range of risks leads to eight potential paths through the process, WITH AN ASSOCIATED NUMBER OF CHECKPOINTS

Though more simplicity would be preferred, Digital engineering managers feel that this is the least complex description of a complex issue

This four-pronged assessment of risk parameters results in a tailoring of the process to <u>one</u> path through the common backbone

This process may seem complex — but the problem is complex, this allows a one time decision on the best process for the project

These risk parameters capture inherent differences between development disciplines such as hardware vs. Software

Appropriate external inspection is declared at the concept checkpoint

Responsive / Situation... III-39

the dialog process needs to be responsive to various situational triggers – In a steady state environment, this is a "portfolio" management process – with review of limited new proposals

however, changes that impact product requirements will be regulated through formal change management

changes due to situational triggers may affect all aspects of a project including: requirements, project plan, resources applied and design

Requirements Management ... III-40

A requirements management process has been designed to track requirements and control changes over the entire the planning and development process

Formal requirements management reduces churn by screening for cost effectiveness and allocating the costs of changes appropriately

Responsive/Offering...42

The engineering planning process also needs to respond to different types of customer needs — skipping steps for certain offerings

4. Systems Focused & SE Methodolgy... III-43

Clearly, Digital's historical approach of managing its complex product offerings at the component level is inefficient and ineffective

Importantly, whether Digital builds systems or not, Digital's products will eventually comprise systems in the market and therefore must be engineered with an eye toward eventual interoperability requirements

Aggregates are central to the AEE planning and development processes — a key foundation for driving efficiency and effectiveness across all the AEE recommendations

SE Methodology...
System engineering methods organize the development process

- The SE role & responsibility is at the nexus of a communicating process
- SE's have skills to progressively drive needs into product definition
- Staging the system definition before design optimizes the overall system cost/performance
- The resulting SE contribution shifts over the product lifecycle

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

5. Bilateral Contract... III-47

At the end of concept exploration, a letter of intent is agreed upon which communicates expectations between business units and engineering and releases funds for further solution definition

at the end of the definition stage, the contract releases funds for the life cycle of the solution

Inherent in the contract are the solution / product specifications – articulated in a way to enable creativity and innovation rather than inhibit them

The solution / product space concept lays the foundation for progressively reducing risk by increasing the specificity of requirements

6. Increasing Value Added... III-49

value increases through the seamless transition from planning into development

EACH PHASE RELEASES VALUE TO OTHER PHASES by answering questions about the product and the process in formal plans and specs – "ratcheting up" in effect

an early release should be whole or partial value, not 'preliminary' work

7. Accountability / Decision Making... III-51

The planning and development processes concentrate decisions and the corresponding accountability in the hands of participants

8. Efficiency.... III-52

The planning and development processes are efficient

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

Principles / Process Recommendations... III-53

These principles led to several major recommendations on the AEE processes and tools required to drive excellence in engineering:

1. **Dialog Process** - Institute the dialog based planning process for Engineering and the BUs in a joint forum to determine the product development priorities of central engineering

2. **Planning Templates** - Employ the planning templates across all BUs to consistently capture / communicate the results of the dialog process in the form of detailed customer requirements

3. **Cross-engineering Dialog** - Utilize the Dialog Forum to address cross-functional issues across Design Entities — whether component or solution level, and/or driven internally or externally

4. **Aggregates** - Adopt the intellectual construct of 10-15 aggregations of customer desired system capabilities to drive planning for engineering as well as the management of interoperability

5. **Reuse** - Adopt Tech Files/Aspect as the required parts selection medium and institute an assessment of design reuse opportunities through standard reuse templates and metrics

6. **Checkpoint Process** - Adopt a disciplined milestone based development process that integrates planning & development, but clearly distinguishes between technical & business decisions

7. **Risk Based Flex** - Employ specific risk criteria to flex the amount of work and oversight required, and to identify explicit responses to internal or external driven "trigger" events

8. **Empowered Teams** - Form teams led by an empowered Product Team Leader with full multi-functional membership, funded to deliver across all functions for the total development effort

9. **Requirements Management** - Institute standardized and formal procedures to document, trace, and change product specifications, plans & dependencies developed and prioritized through the customer driven Planning Process

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

D. Process Definition... III-55

An overly simplistic process structure would not address the AEE principles

The AEE process provides a range from the simplest to the most robust process implementation — chiefly by institutionalizing flex

The AEE process is substantially different in three key initiative areas: process discipline, systems engineering, and concurrent engineering teams

- Process Discipline
  - Defines a disciplined process that has built in flexibility
  - Establishes a single point of accountability
- Systems Engineering
  - Creates an aggregate/systems driven approach to management
  - Drives an approach to product definition which emphasizes increasing "value-added"
  - Emphasizes management and risk assessment of dependencies
- Concurrent Engineering Teams
  - Embeds concurrent engineering into the process and team structure
  - Forces early cross-functional involvement; empowerment is commensurate with accountability
  - Creates a deliverable focus, not a functional focus

In the needs identification step, business units define, prioritize and rationalize customer needs for exploration III-56

In concept exploration the business units / engineering dialog gets refined eventually leading to a joint BU/engineering decision whether to further invest in a solution

Additional analysis needs to be undertaken in some cases to further define the concept – this step ends with a joint investment decision by BU and engineering to proceed into development (through a contract)

The 'analysis' phase analyzes connections between definition & design phases III-59

analysis checkpoint is a business decision to refine the product definition

The 'design' phase resolves what components the product will be built from

design checkpoint is a business decision to implement the product definition

The 'implementation' phase builds quality components for production

implementation checkpoint is a business decision to launch the physical product

The 'ramp up' phase deploys the product for general availability

ramp up checkpoint is a business decision to commit product to market

During the AEE planning process, phases are completed with checkpoints that map to other phases -- 3 such checkpoints exist in the AEE planning process III-63

after concept exploration, the two additional checkpoints (compared to the current phase review process) ensure that only market driven, proposed solutions are developed

During the AEE development process, complex projects (about 20% of total projects) will undergo the same number of checkpoints (4 after planning) as the current phase review process

However, because of flex in AEE development, nearly 80% of the projects will undergo fewer checkpoints than the current phase review process (see III-35)

Process Definition–Checkpoints...III-65

Key differences in the AEE checkpoints stem from a control of phase interaction

Checkpoints are a process and event that do not disrupt planning or development

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

THE PROCESS LEADING TO EACH CHECKPOINT is explicit and on-going

THIS PROCESS IS MANIFESTED IN OFFICIAL PLANS AND SPECS

THE focus of the CHECKPOINT MEETING IS DECISIONS, NOT escalation

The technical reviews propose specs of the offered products & services: they consummate best practices for work-in-process and administration

As with checkpoints, reviews are mainly for decisions, not escalation

Each checkpoint explicitly defines participants, responsibilities, and decisions–this clarity of roles is required to "operationalize" the AEE principles and processes

E. Process Operationalization... III-71

Each step of the engineering planning process is accompanied by a set of specific decisions – culminating in checkpoint decisions

To be operationalized, these decisions need to be associated with forums and meetings that take place periodically

BU and engineering planning activities take place asynchronuously as well as on periodic basis to ensure "more frequent than annual" execution of the planning process

We are recommending a BU planning forum to facilitate BU planning decision making and ensure the quality and timeliness of BU inputs into the engineering planning process

For the engineering planning activities, we are recommending an engineering planning forum to execute against all the planning activities...

...and a development portfolio forum for the execution of planning decisions

Process operationalization—EPF...
The engineering planning forum (EPF) reflects the necessary expertise/skills to successfully achieve translation of market needs into products

Process operalization—DPF...
The development portfolio forum ensures the continuity between planning and development as well as the execution of the planning activities

F. AEE Benefits... III-81

The AEE planning process produces quantifiable benefits in up front planning as well as later in the product life cycle

The new planning process will save $90MM over the current process

Most of the AEE benefits will be derived from implementing the development process architecture — process discipline, a systems engineering focus, and concurrent engineering principles

Process Architecture Benefits

- **ELAPSED TIME (CYCLE) = 35% - 40% REDUCTION**
  - **Process Discipline (10-15%)**
    - Single, shared definitions of product and process
    - Technical and business decisions linked by deliverables
    - Flex is structured, yet accommodating
    - Schedules are explicit and current
  - **Systems Engineering (10-15%)**
    - Partitioning designs makes work modular, reducing time between activities
    - Trade-offs are more effective
    - Smoother integration and test
  - **Concurrent Engineering Team (26%)**
    - Early multi-functional involvement
    - Overlapping development activities
    - Faster decision-making, single point accountability

- **APPLIED TIME (Cost) = 25% - 30% REDUCTION**
  - **Process Discipline (15-20%)**
    - Single, shared definitions of product and process
    - Single point of accountability throughout the process
    - Risk is staged and managed
    - Deliverables are understood
  - **Systems Engineering (3-7%)**
    - Maximum risk is reduced
    - Trade-offs are more efficient
    - Interfaces aggressively managed
    - Improved test planning
  - **Concurrent Engineering Team (7-11%)**
    - Improved communication and coordination from co-location
    - More efficient documentation process
    - Less time for meetings and cross-functional negotiation

- **PRODUCT/PROCESS QUALITY = 50% - 70% DEFECT REDUCTION**
  - **Process Discipline**
    - Single, shared definitions of product and process
    - Ongoing validation and verification throughout the process
    - Explicit accountability for deliverables
    - Defects/errors are identified earlier
  - **Systems Engineering**
    - Optimizes design iteration
    - provides basis for validation and verification

III. INTEGRATED PLANNING AND DEVELOPMENT PROCESS

  - Quality is made integral to the process not added to the product
- **Concurrent Engineering Team**
  - Multi-functional design reviews minimize downstream engineering changes and rework
  - More producable, serviceable design

Note: Estimated savings do not include design reuse and requirements management, Total percent reductions are multiplicative result of individual components
Source: Industry benchmarks & parametric relationships from C. Jones, USAF, B. Boehm, BAH studies, to estimate implementation impact

The benefits of the AEE process architecture are derived from focusing attention on what must be done, by whom, at the earliest possible point

The AEE process should consume one-sixth of the time which the current, ad-hoc process utilizes in meetings and wasted effort

When AEE is fully implemented, products / solutions will be planned and developed in half the time

IV. MANAGEMENT STRUCTURE / TEAM OPERATIONS

Outline

A. Introduction... **IV–1**

Although the AEE initiative explicitly placed organizational issues secondary to process re-design in Phase I – organization must assume a prominent role in Phase II in order to fully realize AEE objectives

the organization must be congruent with the process

Aligned with the concept that process & structure are explicitly linked, the AEE recommendations have major implications for engineering's organizational structure

- Organizational structure is a key element in a dynamic framework that defines a company's success
- To maintain or improve the level of efficiency/effectiveness, a change in one element must be followed by a change in one or more of the remaining elements
  - Significant changes in the market have re-focused Digital's strategy on the customer and to delivering integrated solutions
  - Management must place increasing emphasis on building and deploying competitive capabilities in this environment
  - To date, AEE has focused primarily on a complete re-engineering of the existing planning and development processes
- Given the significant changes in strategy, capabilities, and processes concurrent with AEE, there will be an increasing need to change the organizational structure as well

The current organizational structure is not consistent with a number of the driving principles and recommendations from AEE's Phase I

- Significant capability gaps exist which bound Engineering's ability to achieve market and AEE objectives
- Product development teams were re-defined to address the principles of AEE development process
- Several principles which have driven the AEE initiative are not supported by the current organizational structure
  - Concurrent Involvement - relevant functions are involved as early as appropriate
  - Accountability - all requirements, deliverables, and tasks are explicitly owned
  - Decision making - decisions made only by people directly participating in the process
  - Efficiency - flexibility, scalability, and standardization are balanced to optimize efficiency and effectiveness

the overall objectives of this chapter are threefold:

1. Characterize the current organizational structure and perceived gaps in light of AEE's objectives and recommendations
2. Identify optimal organizational alternatives given the expected changes in strategy, process, and capabilities from AEE Phase I recommendations
3. Identify interim/migration options and highlight the implementation implications of the proposed change

Detailed organizational design was not within the scope of AEE Phase I – however, it will become a critical part of successful implementation

B. Issues/Principles... **IV–5**

AEE objectives and recommendations drive a clear set of organizational implications and principles

IV. MANAGEMENT STRUCTURE / TEAM OPERATIONS

These organizational principles are consistent with AEE's objectives and recommendations – their implications will be discussed in turn

1. Strategy/Structure/Process consistency
2. Aggregate management
3. Decentralized decision making
4. Clear authority, accountability, measurability – explicit responsibility for deliverables
5. Facilitates concurrent engineering and multi-functional involvement

1. Strategy/Structure Congruency
   - the leanest organizations are structured in a vertically congruent fashion so that response time, applied time, and informal processes are minimized
   - At this point in its evolution, Digital should structure itself to manage the formal processes that AEE recommends
2. Aggregate Management...
   - Given Digital's strategy to deliver integrated solutions, a higher order segmentation framework and management structure is required to resolve interoperability and interdependency issues
   - We recognize that integrated solutions currently account for a small portion of Digital's business – however, the market and Digital's strategy are moving increasingly in that direction
3. Decision Making
   - to achieve faster / better decision making, decisions must be streamlined and driven to the lowest appropriate level
   - palmer has stated that faster/better decision making is the most significant challenge for engineering
4. Authority/Accountability

   to support, improve, and speed lower level decisions, Responsibility for deliverables must be clear – with authority commensurate with accountability
5. Concurrent Engineering...

   further, concurrency and multi-functional involvement in both planning & development are key AEE recommendations which the current organizational structure does not support

C. **Capabilities Requirements/Gaps IV–12**

Changes in market/business requirements are driving Digital to focus on building and deploying highly competitive capabilities

- Capabilities are a company's unique combinations of know-how *and* business processes that it uses to innovate and deliver customer value
- Capabilities are a critical source of competitive advantage
- The leverage from capabilities is maximized when capabilities are used to *change the basis of customer choice*
- Externally, future customer relationships will be structured on the basis of capabilities performance instead of positional assets
- Internally, capabilities will interface with positional assets to determine economies of scale, focus, and critical mass
- Capabilities performance underpins continuous improvement in cost, quality, and time

We have identified several added capabilities required to implement the AEE planning and development process...

Systems engineering — development of system / technical architectural specs, at all levels

Program/ management — integration / resolution between business and technology issues; manage for inter-operability requirements and dependency implications

IV. MANAGEMENT STRUCTURE / TEAM OPERATIONS

Product management — resolution of business requirements and technology issues; coordination of development and delivery of product against requirements

Project management — management of projects against difficult constraints of product and system requirements, as well as complex inter-dependencies

Engineering functional expertise — Focus on building, maintaining, and ensuring the usage of highly productive and competitive capabilities

Systems engineering... IV–14

Systems engineers are critical to the development of complex products across extended organizations

Program/product management... IV–15

- Program & product teams will execute the planning & development process with single point accountability for deliverables
- the focus of program management is somewhat more "definitional" while product management is focused on "execution"
- cross-industry and information technology platforms can be most effectively managed through program management...
- ...while product management is emphasized for subsystems and components
- a small empowered program office for each cross-industry and information technology platform could optimize across the multiple constituents of the "aggregate"
- the skill and activities above would be part of the program management office

Gaps... IV–19

- looking across the organization, Systems Engineering, and Program & Product management skills are scarce
- Compared to the resource mix of peers, DEC has a very limited systems engineering resource base

Implications... IV–21

Organizational design could have a major impact on the effectiveness and efficiency of engineering by following several key principles

- The role of functional organizations would be to select and build capabilities
- The role of a program/product organization would be to deploy and apply these capabilities
- Digital engineering falls short in execution of some of these principles
- An important first step would be to clarify roles and responsibilities within the engineering organizations

D. **Team Operations... IV–22**

1. Team Structure & Operations...
   a. A key module of AEE Phase I was defining a team structure for execution of development activities...
      - Focus was product management and team structure
      - Product development team definition was connected to the organizational principles
      - In order to fully develop product management and the role of the product team leader, it was necessary to understand – at a crude level – the interfaces

      ...this work has clear impact on the overall organizational design

   b. requirements and deliverables map directly to team structure to focus efforts and boost accountability
   c. The product team should be multi-functional and co-located to the greatest extent practical
      - Product team is composed of the product team leader PTL and appropriate multi-functional representation (i.e. Functional Product Leaders - engineering, manufacturing, etc.)
      - The product team should be co-located to the greatest extent practical; for example, a rule of thumb that any team member >50% on team for at least six months should be co-located

IV. MANAGEMENT STRUCTURE / TEAM OPERATIONS

- The product team executes cross-functional planning and development activities
- Measured on meeting team goals and objectives in addition to individual performance and contribution

d. early multi-functional involvement is a critical success factor for reducing applied time and cycle time by decreasing requirements churn

e. Co-location also has a positive impact on reducing requirements churn through better communications – thus, improving program performance

f. this approach provides single-point accountability by function for a product, and empowers the multi-functional team to focus on its collective goals

g. the full program/product team will evolve at discrete points in the development process of a system or product

h. this model implies a shift in decision making from functional management to program/product management

2. Roles & Responsibilities... IV–30

Roles and responsibilities would need to be significantly different with this new approach to team structure – many of which currently do not exist

- Matrix of responsibility driving both cross-functional program/product execution and functional expertise & capability development
- Cross-functional program/product execution roles:
  a. VP of Programs
  b. Program Manager
  c. Product Leader
  d. Functional Product Leader (e.g. Engineering Product Leader, EPL)
- Engineering functional expertise roles:
  e. Project Manager
  f. Functional Manager (e.g. Design Entity Manager)

a. VP of Programs...

The VP of Programs is accountable for optimizing the execution of all program development activities

b. Program Management...

Program Management provides accountability and coordination at the aggregate level

c. Product Leader...

Product Management is required to rationalize needs of various internal and external customers and is embodied in the product team leader

d. Functional Product Leader...

A Functional Product Leader, which reports to the ptl, is responsible for coordinating and delivering all respective functional project work

e. Project Leader...

Project Leaders are responsible for delivering specified functionality to a product

f. Functional Manager...

Further, this structure identifies the explicit need for Functional Managers who are responsible for building and maintaining competitive capabilities

E. **Organizational Implications... IV–37**

Matrix Organizations...

Matrix organizations should only be employed when pure product-oriented or pure function-oriented models are sub-optimal

the most significant challenge to successfully implementing a matrix organization is to ensure explicit leadership/authority decision conflicts can be minimized in a matrix structure by clearly delineating explicit and mutually exclusive roles & responsibilities between entities

- Engineering functional organization focuses on building highly productive capabilities
- Program organizations lead application of capabilities through multi-functional teams

The principle advantage of a matrix structure for Digital is the dual focus on both effectiveness and efficiency

- Explicit links to the market (for market-driven) and engineering skills (for scale & critical mass)
- Separates and balances capabilities development and capabilities deployment consistent with overall company strategy
- Ensures interoperability and interdependency issues are addressed by establishing clear accountability for program/product management across engineering disciplines
- Provides clear responsibility for deliverables within the program/product organization
- Program/function matrix supports concurrent planning & development process

Organizational Alternatives... IV–40

There are at least four matrix organizational alternatives to consider for Digital engineering – each will be discussed in turn

Alternative A – Product/Functional Mix
Alternative B – Weak Program Management
Alternative C – Strong Program Management
Alternative D – Dual Product Focus

Alternative A... IV–41

the current organization is a mixture of product and discipline focus

product development is embedded in the functional organization and reports through engineering line management

A similar structure could be used to incorporate some aspects of the AEE planning & development process; however, program management effectiveness would be limited

Alternative "A" does not clearly delineate between capabilities building and deployment

Alternative "A" is similar to the current organizational structure

Alternative B... IV–46

Alternative "B" provides clear accountability for aggregate management, but maintains the mixed product/discipline focus in functional engineering

Responsibility for base product delivery remains in the functional engineering organization

Alternative "B" could provide a logical transition to a pure product/functional matrix, but does not represent the optimal long-term solution

the new program organization could be established right away; without significant central engineering disruption near-term

Alternative C... IV–50

Alternative "C" clearly separates program/product execution & delivery from functional capabilities development via a product/function matrix

Responsibility and control for planning & development activities would shift to the program organization...

...while engineering functional disciplines would be clearly focused on building and maintaining functional engineering capabilities

a pure product/functional matrix, with clearly defined responsibilities, is the recommended structure for product planning & development at DEC

Alternative "C" would require significant organizational change across the entire engineering organization

IV. MANAGEMENT STRUCTURE / TEAM OPERATIONS

Alternative D... IV–55

Alternative "D" overlays the proposed program/product management structure on the existing engineering organization

this mixes product delivery on both dimensions of the matrix

Alternative "D" is suboptimal and should not be viewed as a viable organizational structure

Alternative "D" would create a dual product focus in both the program and functional organizations – accountability could be blurred

Implications... IV-59

comparing the options against the organizational principles clearly demonstrates the need to adopt a new organizational design

We believe alternative "C" is clearly superior...

...however, because of the magnitude of change, a logical, sequenced implementation has the best chance of success

this approach would establish a program organization in the near-term, while providing a transition to a strong product/function matrix in the medium-term

The transition to "weak-form" program management could begin almost immediately

Moving to "strong-form" program management would require a number of additional actions

A detailed study is required to determine the best way of implementing "strong-form" program management at Digital

the organizational design effort would include three major activities

F. Selected Operationalization Issues... IV–66

Operationalization of the principles, frameworks, and concepts discussed in the preceding sections will be a central challenge of Phase II

- Exploration of existing, successful implementation of these concepts in other companies (for lessons learned)
- Development of a working model to pilot
- Migration and transition issues

We have explored selected implementation issues – summaries follow:

Decision decentralization

Multiple masters = f(matrix organization, market & product complexity, decision decentralization)

Funding, for instance, should support decision decentralization and multiple master fixes

Decision Making... IV–68

Although product & market complexity may require centralization of strategy and planning decisions,...

...operational decision making should be decentralized and distributed throughout the program/product management structure

Decentralized decision making requires clearly defined roles and responsibilities for each layer / level of management leading to faster, better decisions...

...as well as clear objectives from above

Clear authority & accountability for decision making is critical to the proposed organizational structure and consistent with the AEE planning & development process

Multiple Masters... IV–71

Given the complexity of Digital's product strategy, it is difficult to completely eliminate the "multiple master" problem

The multiple master problem this creates for management can be minimized, through organizational design

Funding... IV–73

Funding is a good operationalization example, as it should support decision decentralization and multiple master fixes – there are three key issues

IV. MANAGEMENT STRUCTURE / TEAM OPERATIONS

1. Development activities should be funded "directly"
2. Base" vs "variant" product development
3. Paying for indirect activities
   - Unallocatable investment
   - Architectural, Centers of Excellence, Functional Disciplines
   - Overhead

The biggest challenge for Digital regarding funding is solving the "public goods" issue — allocating costs among the BUs for baseline development

We identified three options for the funding process between the business units and central engineering:

- **Option 1**: BUs fund engineering "line" functions (SW, HW, Networks), Corporate funds the remaining near and long term engineering "product strategy" activities inclusive of Strecker and staff ("product strategy" activities include: SE, product mktg, HR, finance, bus ops and long term technology strategy)
- **Option 2**: BUs fund Design Entities (i.e.; Windows NT, Open VMS...), Corporate funds near and long term engineering product strategy activities inclusive of Strecker and staff and senior line managers
- **Option 3**: BUs fund either Aggregate/Program managers or Product Team Leaders depending on the type of solution (point product or SI solution), Corporate funds near and long term engineering product strategy activities inclusive of Strecker and staff and senior line managers

There is a detailed discussion of each alternative in the planning appendix

AEE principles mandate that funding should be direct – this is consistent with option 3

For direct activities, the solution to resolving conflicts to drive baseline development from the primary market for each product and justify variants individually

However, it is unclear how to fund "indirect" activities

There are at least two approaches for funding indirect activities:

1. Tax" levied on project
   - Costs for indirect activities applied directly to appropriate projects
   - For example:

     TOTAL COST(PROJECT) = DIRECT COST + INDIRECT COST
2. Lump sum "tax" on the BUs
   - Costs for all engineering indirect activities are totaled
   - BUs would collectively be charged a lump sum for all activities
   - Indirect funding would be distributed to appropriate engineering functions

There are clear choices for each type of indirect funding

G. **Next Steps...** **IV–81**

The organizational transformation should begin near-term in order to build on the momentum of AEE

Implement the program management organization

Kick-off detailed organization design initiative

Define requirements for organizational infrastructure to support the AEE processes

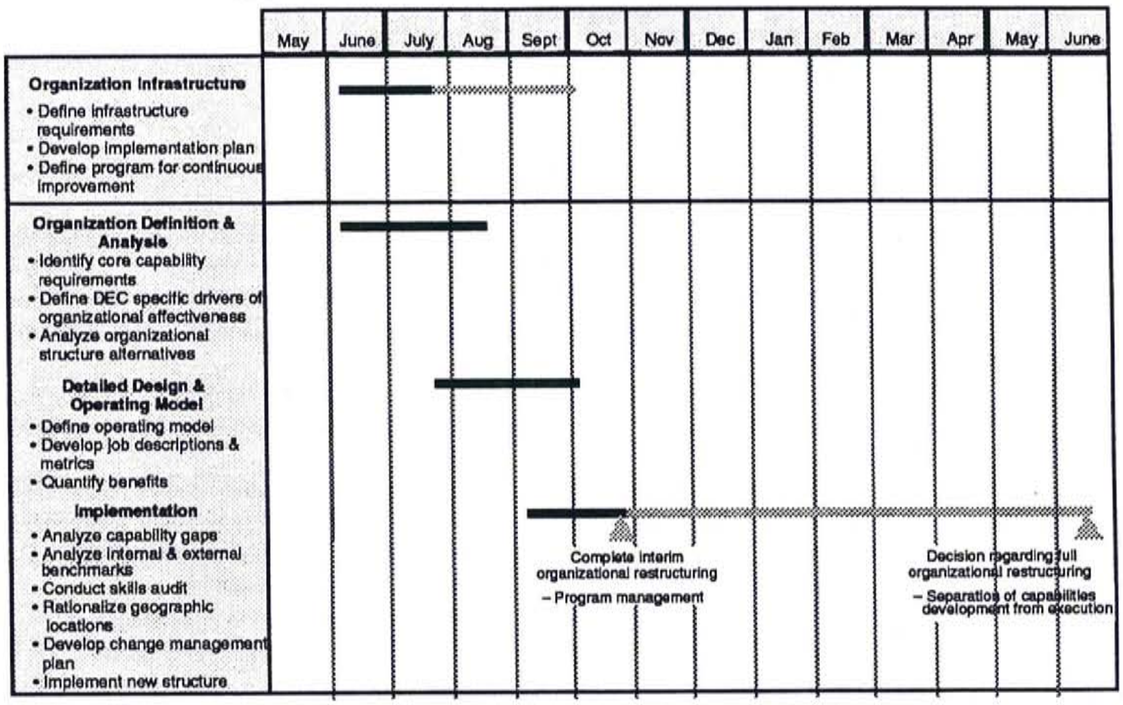
the key first module is organizational design

it would be supported by the creation of the appropriate infrastructure

the key initial steps could be taken by this fall

IV. MANAGEMENT STRUCTURE / TEAM OPERATIONS

AEE ORGANIZATIONAL TRANSFORMATION — WORKPLAN



V. BEST PRACTICES INTRODUCTION

Recommended Target Areas

- **Requirements Management**
- **Re-use and Standardization**
- **Verification & Test**

The AEE process diagnostic identified a variety of areas of engineering where Digital could significantly improve it effectiveness

This diagnostic analysis, coupled with input from Digital management, drove the selection of three target areas for best practice definition

- **Requirements Management:**
  - Employs the tools of systems engineering to structure and decompose requirements
  - Imposes a disciplined requirements "freeze" point to avoid "whip sawing" development effort
  - Employs stringent cost benefit analyses to limit unneeded requirements' churn
  - Uses traceability methods and tools to ensure that requirements are met
- **Reuse & Standardization:**
  - Opportunistically reuses existing hardware & software design elements
  - Proactively designs for reuse to cut the design cost and time of succeeding generations
  - Modularizes products to simplify design process
  - Increases end product quality as design elements are better "scrubbed" of errors
  - Employs standard parts to minimize cost and part number complexity
- **Verification & Test:**
  - Standardizes on a common set of value-added tests
  - Eliminates redundant testing steps
  - Centralizes common testing across multiple organizations
  - Balances value of tests performed against cost and cycle-time required

These practice areas address the beginning, middle, and end of the process

Teams were establsihed to address practices in each major phase

Each of the these categories of development best practice operates within the overall structure of the AEE process

The following three sub-sections lay-out the phase i findings and recommendations of teams A, B, and C in development best practices

- **Va - Requirements Management:** Team B
  - Definition
  - Control
  - Traceability
- **Vb - Reuse & Standardization:** Team A
  - Standard parts system
  - Reuse metrics
  - Templates
- **Vc - Verification & Test:** Team E
  - Redundant testing
  - Standardization

V.a. BEST PRACTICES — REQUIREMENTS MANAGEMENT

Outline

A. Background... Va-1

The AEE diagnostic surveys identified requirements management as a high leverage improvement opportunity for engineering and resulted in the formation of the requirements management team

The team's objective was to develop a rigorous requirements management process to reverse typical "back-end" heavy Digital development process

the team identified requirements churn as one of the biggest problems with an average of 40% of product requirements redefined from the end of phase zero through product release

this requirements churn is positively correlated to budget overruns

churn drives up costs since A CHANGE TO the Requirements impacts all aspects of the project – Requirements, project plan, resources applied and design

The process manages the evolution of the product contract within the constraints of product strategy, product performance, existing technology, and economics

B. Overview... Va–6

the REQUIREMENTS MANAGEMENT process IS A SET OF best practices within both the planning and development processes which help define the linkages between the two

specifically, the process focuses on the creation of needs, requirements, and concept and the management of changes to these deliverables

The objectives of the new requirements management process are to ensure development of the right products on schedule and within budget

- Requirements definition activities ensure development of the right products
  - Gathering needs from the customer
  - Incorporating input via product team representation from all relevant Digital organizations – bus, service, manufacturing, etc...
  - Deriving requirements and specifications directly from these needs
  - Evaluating changes to requirements through cost / benefit analysis
- Requirements control activities enable development teams to meet budget and schedule commitments
  - Reducing requirements churn by:
    - Setting control/freeze points

    - Recognizing full impact of change through dependency tracking
    - Rigorously assessing the costs/benefits of changes
  - Managing the scope of work through traceability
    - Explicitly addressing all needs
    - Limiting development work to functionality specified by requirements

C. **Benefits... Va-10**

The benefits of designing and implementing a new formal requirements management process are significant

- Ensures that development engineering delivers products and designs that meet expectations
  - That customers want
  - That fit into the corporate strategy defined in the planning process
- Contributes to interoperability of products
  - Increases visibility of dependencies through formal contracting process
  - Involves representatives from other dependent engineering projects in requirements definition
- Increases engineering productivity – potentially 10% - 20%
  - Reduction in requirements volatility in software development from "very high" to "high" results in a reduction in applied time of 15% (COCOMO Study)
  - Consistent with a reduction in cumulative post phase-0 churn from 40% to approximately 20%
- Reduces time to market by about 5%
  - Based on COCOMO development schedule equations for "semidetached" software product
  - Assumes similar development schedule relationship for the average hardware project

THE PROCESS incorporates many elements of recognized best practices to achieve these benefits

- Defining and negotiating requirements
  - Considers long term vision of product and addresses full customer solution
  - Cross functional kickoff teams (DEC includes customers where possible)
  - Single designated point of contact from each group
  - Greater up-front effort to get requirements right – reducing back-end churn
- Requirements content
  - Complete, unambiguous, non-conflicting, verifiable and testable
  - Includes both business and technical requirements
  - Identifies mandatory requirements and prioritizes others
- Requirements change control
  - Methods well defined for agreeing on requirements and approving changes
  - Requirements are "frozen" early on – after which changes are difficult
  - Post freeze changes are analyzed for cost and schedule impact before approval
  - All dependent groups alerted in advance of possible changes
- Requirements tracking
  - Configuration management used for requirements documents
  - Each requirement tagged uniquely

V.a. BEST PRACTICES — REQUIREMENTS MANAGEMENT

D. **Process... Va-12**

The requirements management process consists of four steps that fit within the planning and development process framework:

- Gather Needs
- Develop Requirements & Concept
- Define Dependencies
- Manage Change

these steps are repeated at each level of the product hierarchy as specifications are allocated downstream AND COMMITMENTS MADE UPSTREAM

each of the four steps contains activities that both refine the requirements definition and control the process

Benefits — Each step of the process overcomes weaknesses in current practices identified by the team through interviews with engineering managers

All members of the cross functional product / program team are involved in the requirements management process...

...but the product leader / program manager and the engineering leader retain direct responsibility and accountability

the process covers all engineering requirements, but does not address requirements on other functions unless they impact engineering

E. **Gather Needs... Va–19**

in the first step the product team gathers and prioritizes specific needs from customers, business units and upstream projects

needs must be uniquely tagged, prioritized, and associated with the source of the need or its beneficiary to enable traceability and Upstream dependency mapping

F. **Develop Requirements and Concept... Va–21**

in the second step, needs are translated into requirements which are used to develop the product concept

Requirements are derived directly from needs using QFD

the correlation matrix from the qfd also serves as a critical link for traceability between needs and requirements

the requirements are used as input to a pugh matrix analysis to evaluate and compare alternative concepts for key features

the selected concept is then compared to competitive offerings to evaluate the product's marketability

G. **Define Dependencies... Va–26**

as specifications are developed in the definition phase, downstream dependencies are defined and the requirements are frozen

THE SPECIFICATION DERIVED FROM THE CONCEPT ARE MAPPED AGAINST THE REQUIREMENTS FOR TRACEABILITY

dependencies are THEN linked directly to specifications indicating the downstream commitments needed to deliver against the requirements

H. **Manage Change... Va–29**

after the requirements are frozen, changes are managed according to a configuration management model the change management process reduces requirements churn by screening for cost effectiveness and allocating the costs of changes appropriately

the IMPACTS OF A CHANGE on dependent organizations are made apparent by the requirements management process

similarly, the matrices linking different stages of the product definition provide traceability in both directions over the entire cycle

I. **Tools Va–34**

there are three categories of tools available to assist in the definition and control of requirements

Requirements Definition

Requirements Traceability

Configuration Management

requirements traceability tools provide the greatest leverage for implementing the requirements management process

J. **Process Verification... Va–35**

to verify the process, the team has already solicited feedback from a number of development teams and is planning a simulation to be followed by a pilot

K. **Simulation... Va–36**

the quality and quantity of artifacts from the sable project make it an ideal candidate for the simulation

L. **Next Steps... Va–37**

We have laid out an implementation workplan for the next 12 months. Over the next several weeks, the team will refine the process and prepare for the pilot and roll-out

M. **Issues... Va–38**

A few issues regarding verification and implementation of the process need to be addressed as work progresses:

- Recommendations for incorporating process "flex" based on feedback from simulation
- Appropriate timing for selection and implementation of requirements traceability tools
- Degree to which pilot and roll-out is incorporated with pilot and roll-out of overall AEE process
- Whether to apply new process only to new projects or to existing projects as well
  - Roll out to new projects only is easier but delays benefits
  - Applying process to existing projects adds overhead in the short term
- Role of requirements management team post-simulation

Vb. BEST PRACTICES — REUSE AND STANDARDIZATION

Reuse and standardization, team A, was formed based on AN EARLIER AEE diagnostic of DEC against best practices

- Surveys of design entities and projects indicated limited design reuse
  - Ad hoc reuse programs
  - Lack of focus on reuse in the development process
  - NIH syndrome
- The AEE surveys of design entity leaders identified the area of reuse as being critical for DEC's engineering success
- Best practice benchmarking also indicated that product family structure and standard parts programs were having limited effect in both software and hardware
  - Little commonality between software programs or hardware families
  - Hardware components proliferation, with large numbers of dated or redundant parts≈
    - 120,000 with only 30% active and less than 10% preferred for present products.
    - Spending $100mm per year on new part qualification, 10,500 new parts last year
  - Catastrophic software program failures using "from scratch" code generation
  - Approximately 200 million lines of code – implying 100k LOC for each SW engineer in maintenance duties

The reuse team has set aggressive goals:

Integrate Reuse metrics and review points into new phase process

<u>HARDWARE</u>

- Preferred parts reduced by 90% of current active list within 3 months, for IC and electrical components
- Eliminate Spoc System (~$3 mm year DEC savings vs. Aspect) in one and one-half years

<u>SOFTWARE</u>

- Develop business plan case for reuse — initial results indicate potential savings of $10-$30 mm per year through lower development and maintenance costs
- Draft initial implementation plan against current projects

Specific analysis and recommendations of the team;

- Initial implementation road maps, and a schedule to arrive at a full implementation plan
- Segmentation of reuse issues – levels of reuse, SW, HW, to support in implementation stages
- Associated metrics and the hooks for reuse into the new development process

Vb. BEST PRACTICES — REUSE AND STANDARDIZATION

Recommendations

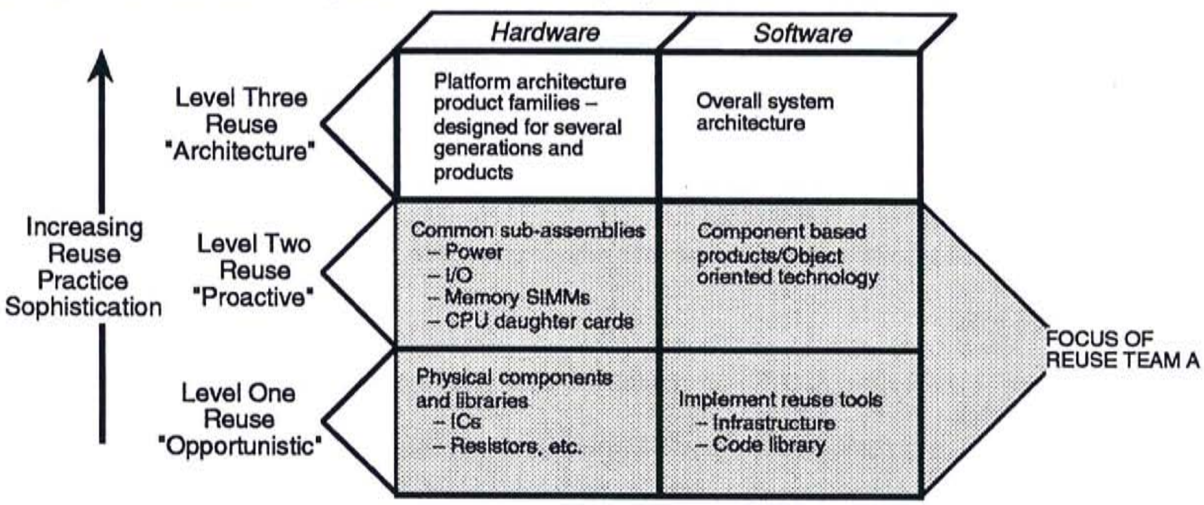
HARDWARE

- Implementation of Tech Files/Aspect system
- Begin metrics/justification for non-reuse with new phase development process using templates

SOFTWARE

• Large gains may be achieved through software reuse, however, implementation requires project level analysis (coming out of the current LRP process) and the involvement of line engineering managers to understand payback, as ye

Scope: reuse can be structured along three levels of increasing sophistication



the team focused on levels one and two

level one reuse is the first step, minimizing the sheer numbers of component parts or modules in software and hardware

level two reuse extends the impact into subsystems and methodologies – Specific templates have been developed for hardware subassembly reuse (see the devlopment section appendix)

analysis of several projects reveals a wide divergence in the degree of level 2 hardware reuse currently employed

Level 3 requires that program/product management activities be modified

Reuse issues for hardware:

Reuse issues for software:

The reuse implementation "Hooks" into the process through the measurement system and checkpoint exit criteria

Enforcement will be achieved initially through rigorous review standards – different from today's practices

- Level I – Product teams sign off on non-preferred parts for hardware during reviews and checkpoint exits

Vb. BEST PRACTICES — REUSE AND STANDARDIZATION

- Level II – Product teams list and justify rationale for non-reuse for reviews and checkpoint exits
  - – ensure metrics for reuse are in place
- Today little attention is paid to reuse at any level in the current business or technical reviews
- Within 2 years specific goals or hurdles can be set based on experience gained

Implementation plan for HW

Expected benefits against AEE goals are 10%-15% decrease in elapsed time and 10-25% reduction in development cost for level II reuse

Expected benefits are driven from the differences from today's practices

- Reuse is explicitly identified in the product development process
- Tools and process force reuse across product teams instead of just within groups
- Engineers have easy access to existing design components

	Level I Reuse		Level II Reuse		Total Savings
	HW	SW	HW	SW	
Elapsed Time	Need to baseline reuse to accurately schedule gains, team estimate of ~ 5%	Increase reuse by 15% Δtime= -8% against applicable 40% of cycle = 3% total	Need to baseline reuse to accurately schedule gains, team estimate of 10%-15%	Need to baseline reuse to accurately schedule gains, team estimate of ~ 10%	~10%-15%
Cost (applied time)	• SPOC savings of $3mm • Parts verification savings TBD	Initial estimates of team indicate that total life cycle costs decrease by 5%-10%	Need to baseline reuse to accurately schedule gains, team estimate of 15%-25%	Initial estimates of team indicate that total life cycle costs decrease by 10%-20%	~10%-25%

Next steps in reuse implementation...

- SW team to define proposals for implementation, requires increased direction from engineering management and stability in budget process, and increased line-manager population on the team
- Implementation requires on-going effort - level II metric goals need to be established over the next year
- AEE implementation team for reuse to provide monitoring, metrics goals, training and other implementation steps

Vc. BEST PRACTICES - VERIFICATION & TEST

- Team E was initiated by Digital management to address practices to improve the cost effectiveness of the back-end of the development process
- The overall size of the verification process is heavily driven by the quality & stability of requirements — defined & managed in earlier Phases
- Qual time & cost is heavily a symptom of problems in the development process
- Though heavily driven by factors earlier in the process, there are aspects of the V&T process itself that warrant attention
  a. The current qualification process is too long — ranging from 4 to 18 months
  b. Qualifying products with the existing process is too costly — much higher than competitors
  c. The current process has grown up ad hoc
  d. The process is inconsistent across engineering groups for comparable activities
  e. It's difficult to determine the cost of qualification since the resources also perform other roles
- Team E was given an explicit charter by Digital management
- A variety of factors drive the perceived high cost of the qual process
  a. The large group of people executing the hardware qual process perform far more tasks than just DVT and qual — upon inspection, qual cost is probably only 50% of the conventional wisdom
  b. Lack of standardization of CAD tools exacerbates qual problems, there is a need to standardize on PC tool environment and move away from the current dual environments
  c. The biggest drivers of bugs in hardware are from layered products and firmware
  d. The RQT process does not apply to the semiconductor process employing Tech Files. As Tech Files are extended up to modules and systems, stress testing needs to replace RQT
  e. Design groups do not perform rigorous BOM analysis to understand problems with parts, like material compatibility, part limits, etc.
  f. Field test as currently performed is ineffective and very expensive
- An initial series of near, mid, and long-term recommendations have been developed by the team
  - **Near-Term Actions:**
    - Eliminate External Hardware Field Test
    - Eliminate Reliability Qualification Test string
  - **Mid-Term Actions:**
    - Consolidate and form a common hardware testing group
    - Design a common qualification process across all hardware platform groups
    - Review Digital standards against current and emerging industry standards

- **Long-Term Actions:**
  - Institute a feedback mechanism in the design process to create a closed loop process
- Preliminary estimates of the impact of the near-term actions indicate that they would save $10-$20 million/year and reduce cycle-time by about 6 weeks
- The team has several more work steps to reach its June 30th milestone
  1. Further explore opportunities to streamline process in layered products area
  2. Finalize emerging recommendations
  3. Quantify baseline and in detail assess the impact of process changes

     Time

     Cost

VI. INFORMATION INFRASTRUCTURE

A. Overview VI-1

Needs Identification... VI-1

Engineering needs a standard engineering information infrastructure (EII) to plan, communicate, track, and direct the engineering processes

Objectives... VI-2

To this end, our objectives were to specify the required information infrastructure and assist in analyzing existing systems

Once the system specification is completed, the plan is to work with im&t to plan implementation

Existing Systems... VI-3

Existing systems handle some of this functionality but fall short in several areas:

- Overall system is not addressing problems in information management and information sharing
- EPIC is not effective in supporting product and project management
- Financial system is not effectively linked with EPIC
- Key project management disciplines are not enabled or supported by current systems
- Other systems, such as problem tracking and product change, are not integrated into product and project management system

Benefits... VI-4

The AEE engineering information infrastructure (EII) is being designed to offer a number of advantages over existing systems including epic

Architecture... VI-5

The conceptual design of EII is driven by the principle of supporting high level business management processes while interfacing with tools supporting lower level processes

Under this architecture, high level process data will be shared across engineering – more detailed, group specific data will have limited distribution

Scope...7

The AEE team recommends that DEC focus on designing the common infrastructure and implementing the planning and project management modules first to derive the greatest near term benefit

B. Approach... VI-8

Development of EII is a major effort – the AEE phase 1 effort focused on needs identification and concept exploration

Work Flow... VI-8

The AEE team has successfully completed needs identification and concept exploration and has begun preparation for definition and analysis

Identify Needs... VI-10

The conceptual design of EII is derived from the information needs for six high level business processes

1. Product/Program Management & Planning
2. Project Management
3. Human Resource Management (Resource Management)
4. Asset Management (Resource Management)
5. Budgeting (Resource Management)
6. Technology Resource Management

VI. INFORMATION INFRASTRUCTURE

Categorize/Prioritize Needs... VI-11

The information needed to support these processes was categorized into six data entities (corresponding to the six business processes)

Define Business Processes VI-12

Integrating the detailed analyses of the six business processes results in a high level process model describing all engineering activity

Define Business Data VI-13

The detailed process analysis also leads to a high level graphical description of key data relationships

Existing Systems... VI-14

A parallel effort to understand the existing system infrastructure indicated that it does provide basic support for the engineering functions

However, information critical to engineering management is missing and/or inconsistent

Gap Analysis... VI-16

As a result, the engineering information infrastructure requires significant added capability beyond that of existing systems

There are many commercial-off-the-shelf (cots) products that can provide pieces of the missing functionality...

...commercial off-the-shelf products (continued)

Detailed analysis in the next phase will help determine the appropriate mix of cots products and internal development to provide an integrated solution

High Level Work Plan... VI-19

Team 3 involvement should continue as Planning, Analysis, And Design activities will be required throughout the development life cycle

The immediate next steps include the detailed definition and analysis for the engineering information infrastructure

The definition and analysis phase will detail the models, assess existing i/t capabilities, identify tools, and architect an integrated EII

Booz•Allen has proposed a workplan for implementing the two highest priority engineering processes as the first part of the longer term implementation plan

C. Conceptual Design... VI-23

Link to AEE... VI-23

The AEE engineering processes form the foundation of the data and process model of the engineering information infrastructure

- The process for Engineering planning and development provides the fundamental framework for the process model
  - The planning and development phases map the work flow
  - The process model determines the data flow for each phase
  - The process model is adaptable for process flex
- The data model is based on the information flow to support the Engineering processes
  - Major deliverables at each phase of planning and development
  - Metrics for each phase (encompassed in major deliverables)
- The data and process models link the extended enterprise to the AEE Engineering Information Infrastructure
  - Links to other corporate functions
  - Links to outside suppliers and alliances

Note: See Appendix Q for explanation of conceptual design

Processes... VI-24

A conceptual process model describes the primary activities within engineering

Lower Level Processes... VI-25

The conceptual process model decomposes each group of activities into lower level processes...

Data... VI-31

Linking these processes together at the highest level are seven data entities

1. Assets
2. Human Resources
3. Engineering Budget
4. Project
5. Technology Artifacts
6. Business Units
7. Solution / Product