Lean Aircraft Initiative Plenary Workshop

SUPPLIER INTEGRATION INTO DESIGN AND DEVELOPMENT

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Outline

- **Focus on integrative research:** ***Supplier Integration into Design and Development***
  - Joint with Product Development and Supplier Relations Focus Teams
  - Part of longer-term research on technology supply chain management
- **Report on interim findings**
  - Research overview: Kirk Bozdogan
  - JDAM Case Study: John Deyst
  - F119 Engine Nozzle Case Study: Dave Hoult
  - Summary and next steps: Kirk Bozdogan

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Lessons from Auto Industry

Early supplier integration key to efficient product development (shorter cycle time, lower cost, higher quality, enhanced competitive advantage)

- **Early supplier involvement in design**
- **Supplier participation IPPTs**
- **High design content by suppliers**
- **Joint engineering problem-solving**

- **Reduction in design change traffic**
- **More efficient coordination; fosters innovation**
- **Up-front design/process integration; improved producibility**
- **Reduction in rework cycle**

Key Enablers

- **Pre-sourcing; long-term commitments**
- **Target costing**
- **Supplier-capability-enhancing investments**
- **Strong communications links**

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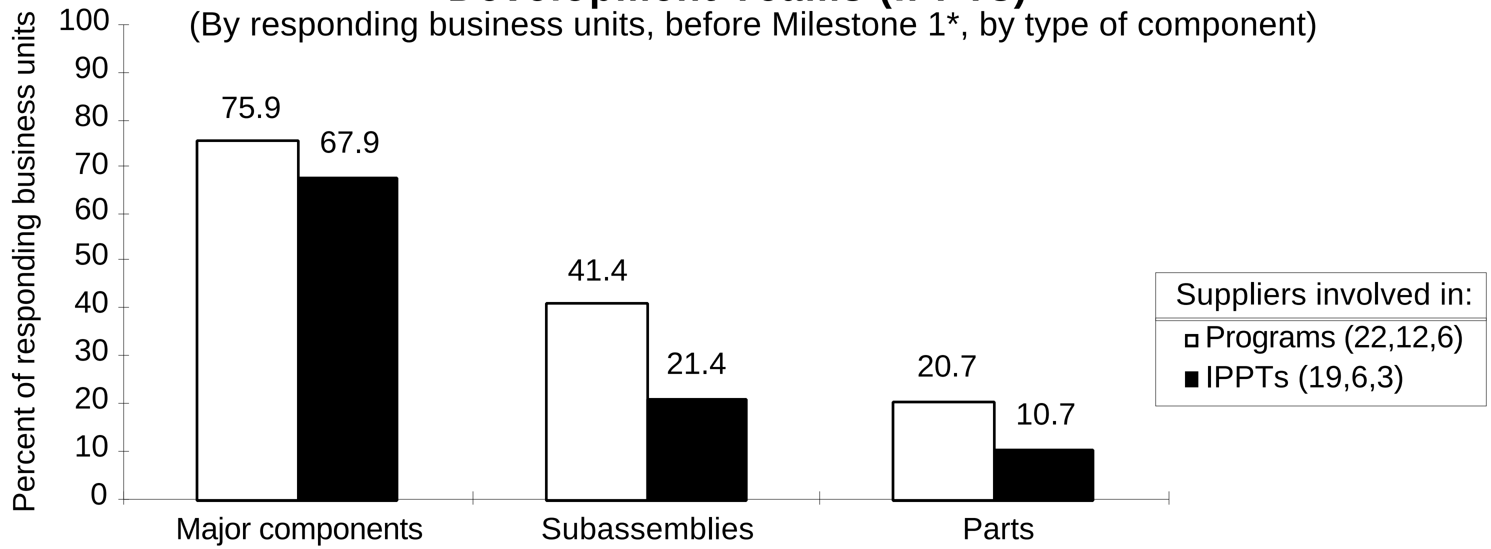
Defense Aircraft Industry Moving in Same Direction

Early Supplier Involvement in Military Product Development Programs and in Integrated Product & Process Development Teams (IPPTs)

(By responding business units, before Milestone 1*, by type of component)



(N1,N2 = 29,28: Total number of business units responding to questions on programs & IPPTs, respectively)

* During requirements definition and concept exploration & definition; before demonstration & validation

Source: MIT Product Development Survey (1993-94)

Early Supplier Involvement in IPPTs Impacts Producibility and Cost

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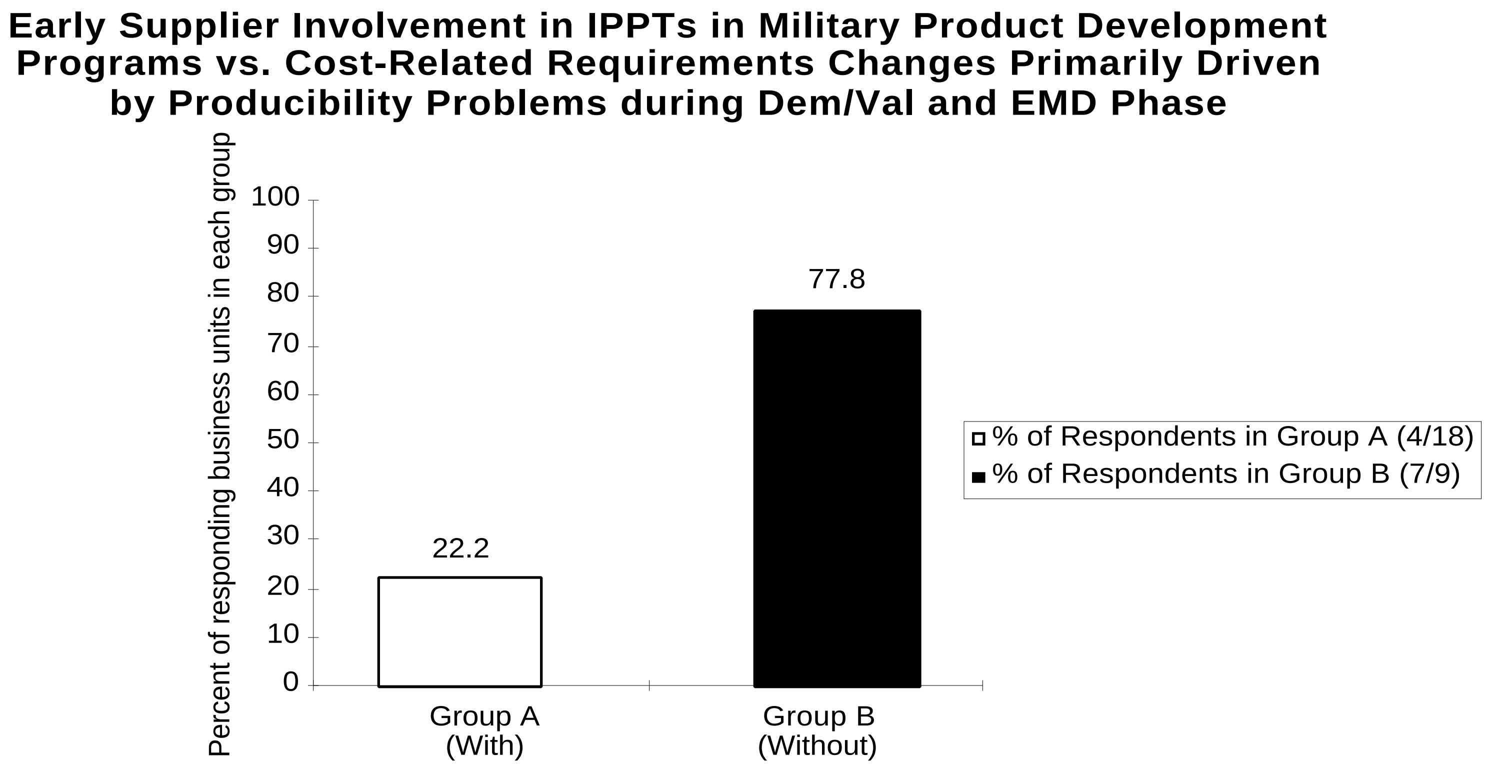

Group A: With early supplier involvement in IPPTs (N=18)

Group B: Without early supplier involvement in IPPTs (N=9)

Note: Early supplier involvement before Miliestone 1: during requirements definition and concept exploration & definition; before demonstration & validation

Source: MIT Product Development Survey (1993-94)

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Major Hypothesis

- **Early supplier integration into IPPTs is a critical enabler of "architectural innovation" in product development**
- **"Architectural innovation"*: Major modification of how components in a system are linked together, resulting in significant new benefits for entire value stream including changes in:**
  - Physical system form and structure
  - Functional interfaces
  - System configuration; relationships among components
  - Materials
  - Manufacturing processes
  - Tooling
  - Assembly methods

* Concept draws on Henderson and Clark (1990)

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*Innovation Framework**

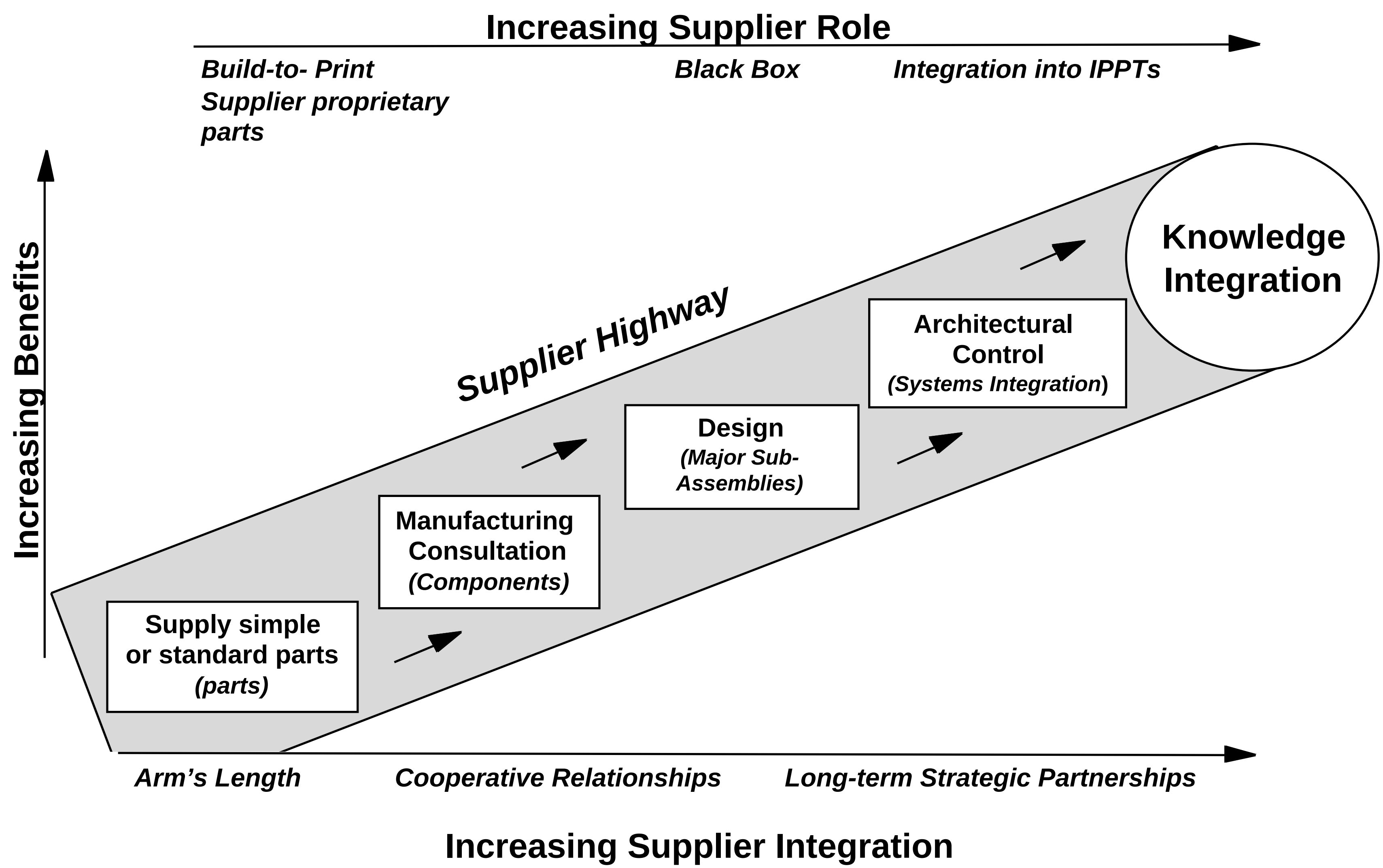
Impact of Innovation on:		Existing Technology	
Linkages Among Components		**Further Exploited**	**Replaced**
	Unchanged	Incremental (e.g., 286,386,486 processors)	Modular (e.g.,analog to digital telephone, electronic engine controls in diesel engines)
	Changed	Architectural (e.g., Front wheel drive cars; small copiers)	Radical (e.g., jet engine,microprocessor, radar)

*Framework draws on Henderson and Clark (1990)

Architectual Innovation Concept Extended

Intra-Organizational Perspective	Inter-Organizational Perspective
Concept originally developed in context of single product development organization	First-time application of concept here in inter-organizational context (over supplier web)
Emphasis on impact of architectural innovation upon firm's technological capability	Emphasis on value chain (prime-key suppliers-subtiers)
Narrow focus on new system configuration (how components are linked together)	Broader focus on enablers & incentive systems for integration of specialized knowledge bases over supplier web

Evolution of Supplier Role in Product Development*



*Extends general idea expressed in Virag and Stoller (SAE,1996)

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Focus on Two Case Studies

- JDAM case study -- John Deyst
- F119 Engine Nozzle Case Study - Dave Hoult

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JDAM Tail Kit

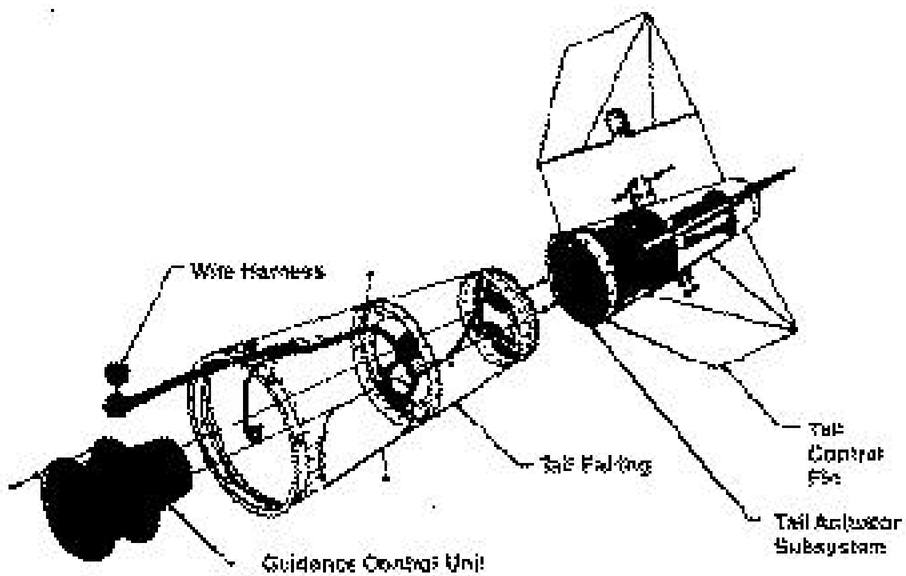

Figure 3-1: The JDAM Tail Kit

JDAM (Smart Munition)

- **Guidance kit that attaches to 1,000 or 2,000 lb. bombs**
  - Tail fairing/structure
  - Actuator subsystem and fins
  - IMU/GPS guidance control unit
  - Battery
  - Wire harness assembly
  - Strakes
  - Container

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Six "Live or Die" Requirements

1. Low unit cost (target of $40K)
2. Adverse weather capability
3. Multiple aircraft compatibility
4. Aircraft carrier suitability
5. In-flight re-targeting
6. Warhead compatibility

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Program Factors

- Long term program
- Strong price competition
- Contractor configuration control
- Long term warranty
- Joint government/prime-contractor/supplier teams

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Team Formation Factors

- Protection of trade secrets
- Allowance for commercial pricing strategy
- Preferred supplier program
- Supplier training
- Open communications with many informal links
- Shared win strategy

Architectual Innovation Through Supplier Involvement

- **Program created strong incentives for cost reduction**
- **Architectural innovation was key to cost reductions**
- **Supplier knowledge base necessary for**
  - Architectural innovation
  - Design for manufacturing and assembly
- **Shared goals allowed give and take on workshare**

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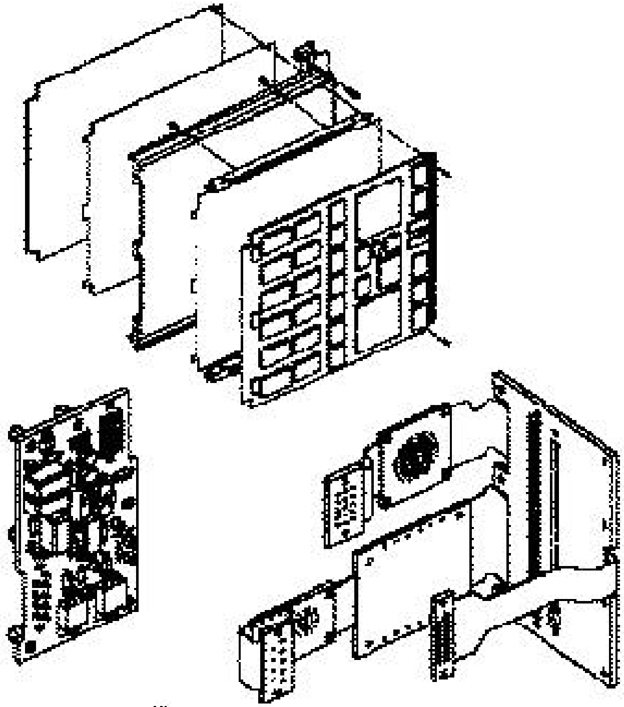
Architectual Innovation in the GCU

- **Single battery design to supply both 28v and 100v**
- **Change from SEM-E module configuration to a highly integrated mission computer design resulted in:**
  - Elimination of a circuit module
  - Reduced heat management requirements
  - Inherent EMI shielding
  - Reductions in wire harness assemblies and connectors
  - Better DFM/DFA
  - More economical/efficient workshare structure
  - Greater vibration tolerance
  - Reduced parts count/increased reliability

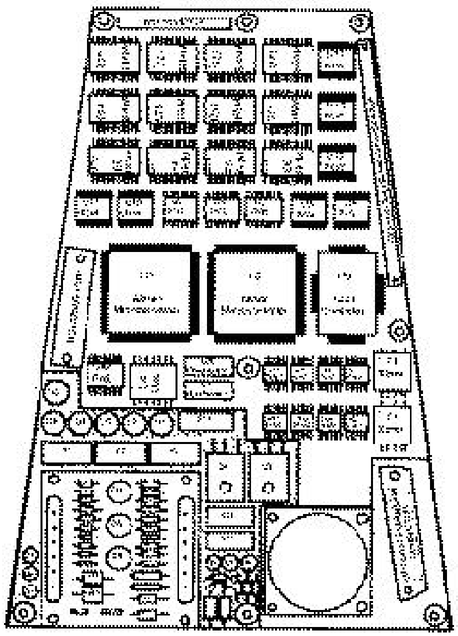
Architectural Innovation in the GCU (cont.)

- **Front end receiver functions moved to antenna module**
  - Reduced cost for antenna/receiver combination
- **Overall cost reduction of 40%-60% in GCU**
- **Cost reduction impact on other areas (e.g. heat, power, volume, etc.)**

Mission Computer Architecture Innovation



Original Mission Computer Design Concept



Mission Computer Design for the Low Cost GCU

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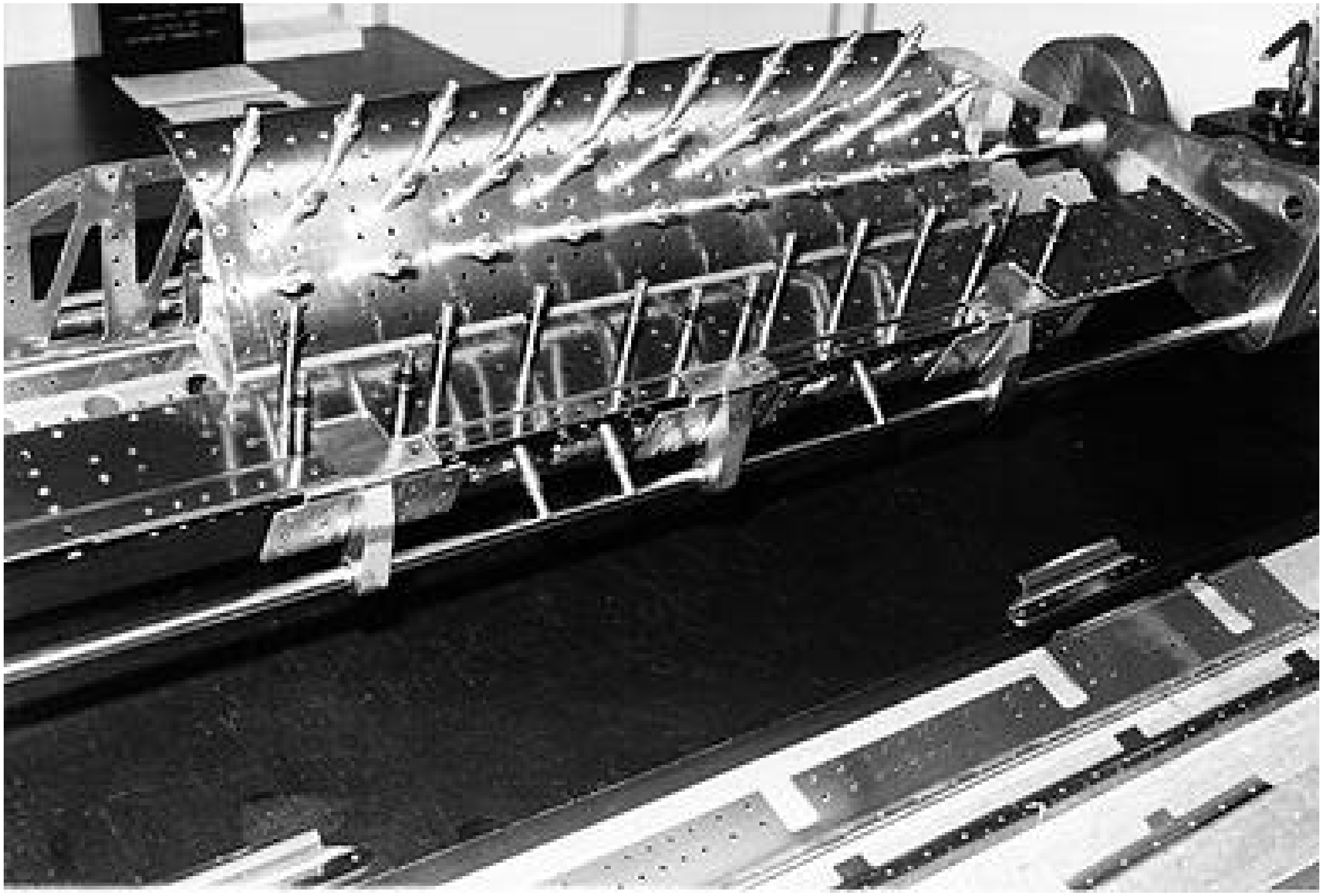
Benefits

Benefits To	Key Benefits
Government	· AUPP reduction ($68K → $15K) · Development time reduction (46 mo. → 30 mo.) · Procurement cycle length reduction (15 yrs → 10 yrs) · Warranty length increase (5 yrs → 20 yrs) · Program office staff decrease (70 people → 40 people) · No degradation on accuracy
Prime Contractor	· Increased design flexibility and configuration control · Reduced MIL-SPECS (87 → 0) · Reduced SOW (137 pgs → 2 pgs) · Reduced proposal length (1000+ pgs → 15 pgs) · Reduced government-mandated contract terms (243 reports → 15) · Long term stable program
Suppliers	· Protection of trade secrets · Relaxed requirements for pricing data · Elimination of MIL-SPECS · Training program · Long term business relationship (Preferred Suppliers Program)

F119 Engine Nozzle: Introduction



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Case Study Profile: Key Issue

- **The key issue of the F119 Nozzle**
  - High exhaust temperature (4300ºF)
  - Thermal cycling of nozzle (Fatigue)
  - High tolerance requirements (to prevent leaks)
- **Very tight coupling between:**
  - (A) Design
  - (B) Manufacturing process
  - (C) Materials
- **Each of the ABCs impact the others strongly**

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Case Study Profile: 1980s

- **Prime responsible for all design and engineering**
- **Role of suppliers: build-to-print**
- **Went through four generations of design; each one a separate invention (different materials, design, technology, processes)**
- **Traditional design/development process did not deliver optimal product**

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Case Study Profile: 1990s

- New material technology driving design and manufacturing/assembly process
- Co-located design teams (prime,key potential suppliers); supplier downselect
- Prime adopted new design approach based on make/buy
- Joint design/development with selected suppliers; design control by prime
- IPT approach; concurrent engineering
- Electronic integration with suppliers
- Not-to-compete agreement with suppliers (until Lot X)

Case Study Profile: Organization

F119 Nozzle Team

Prime:
- Pratt + Whitney - West Palm Beach (Prime for F119 Engine)

Tier 1:
- Key Supplier Convergent Sector
- (now P+W) Divergent Flap
- Ducts
- Side Walls

Tier 2:
- Tool Supplier Stamping Tools (under Key Supplier Convergent Sector)

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Case Study Profile: The Players

- **Pratt + Whitney, West Palm Beach - Prime for F119 Engine**
- **Key supplier of convergent-divergent component of nozzle**
- **Tool supplier next door to key supplier, makes stamping tooling**

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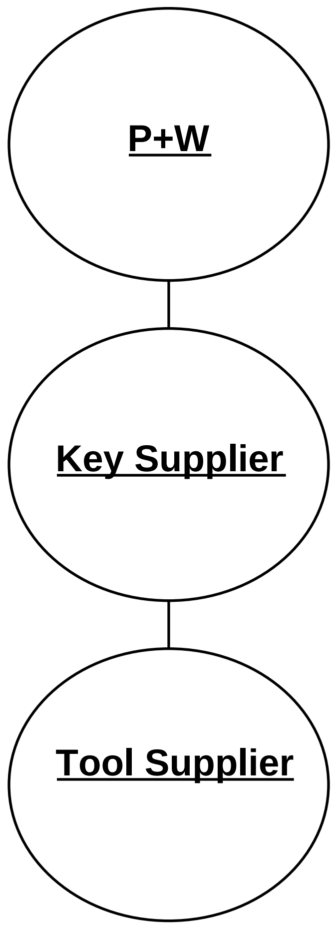
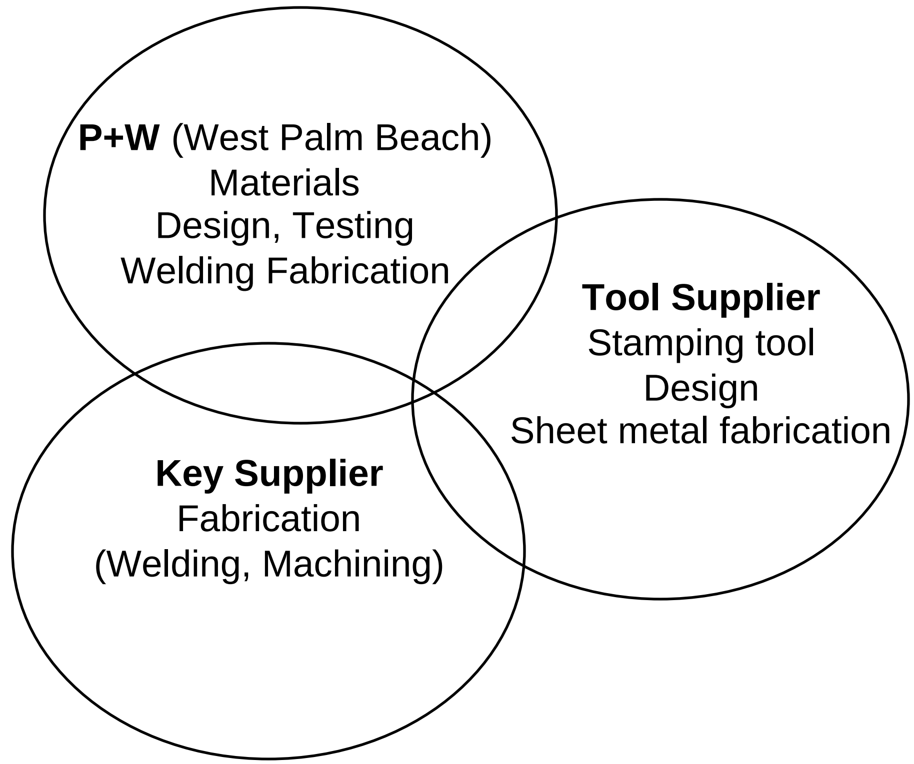
Case Study Profile: Information Flows &Knowledge Integration

OLD



Information flows:
- contractual requirements
- blueprints

NEW



Knowledge integration (pooling of specialized core competencies)

Case Study Profile: The Story

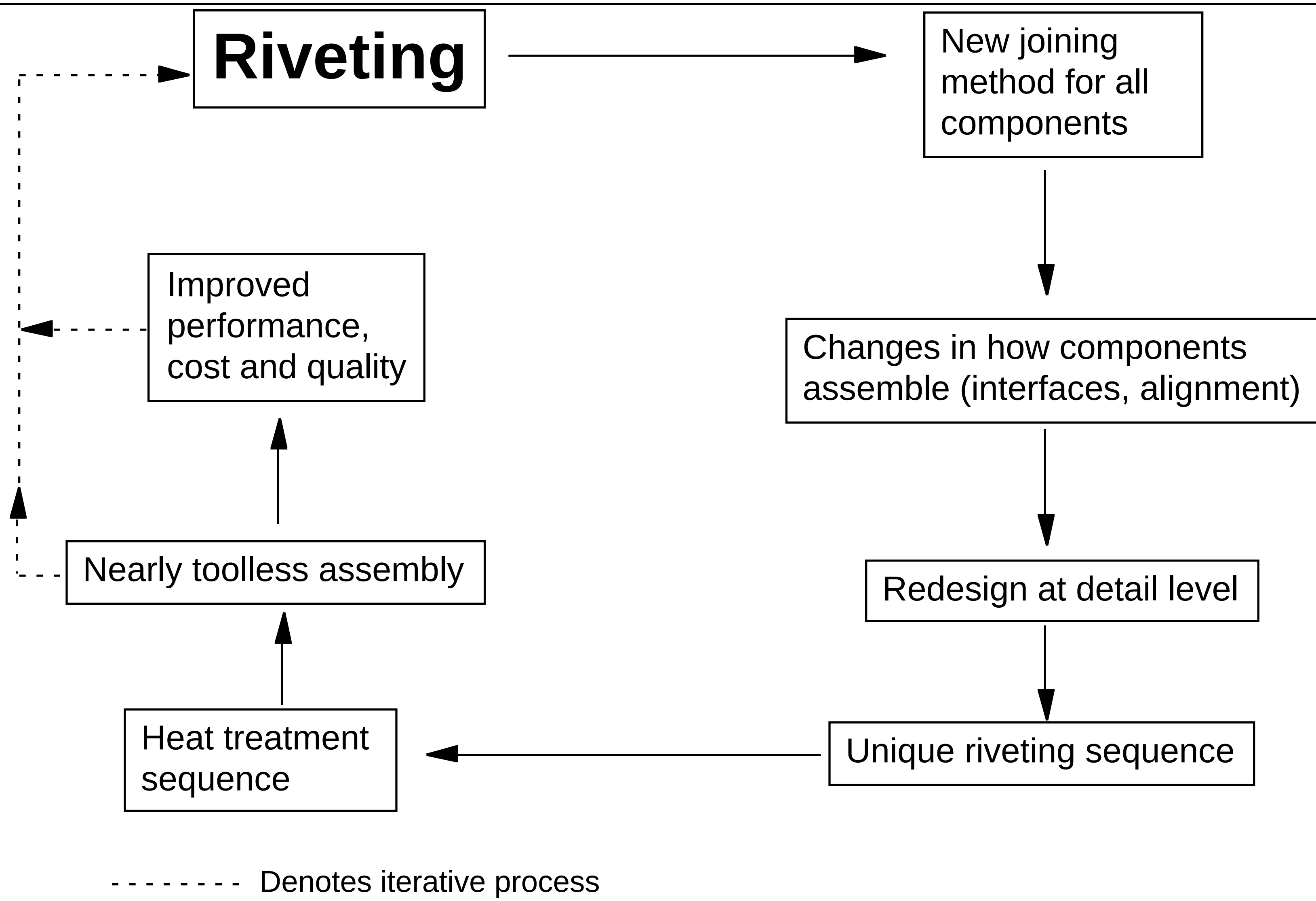
- **Pratt & Whitney make-buy decision**
  - not to invest in new capital equipment
- **Selection of Key Supplier because of its welding capability for convergent nozzle component**
- **Pratt & Whitney agrees not to compete with Key Supplier (until Lot X)**
- **Virtually no investment risk by suppliers**

Architectural Innovation

- **The IPT jointly agrees to rivet rather than weld the nozzle assembly, based on**
  - Tool supplier's stamping experience
  - Key supplier's riveting experience
  - Prior sharing of this information with P&W
- **Result: New way of linking components together; new manufacturing and assembly process; much improved product**

Riveting idea originated from key supplier and its tool supplier

Architectural Innovation: Impact Stream



Benefits

Benefits To:	Key Benefits
Program	◗ Substantial risk reduction ◗ Major cost reduction (more than 5-fold reduction in unit cost)
Prime	◗ Significant improvement in cost performance ◗ Significant savings of capital investment ◗ Control of new process by prime through proprietary technology
Key Supplier	◗ Repeat business in future; incentivized by not-to-compete agreement--nozzle is a wear part ◗ Enhanced capability for similar future programs
Tool Supplier	◗ Develops new technical capability ◗ Transfers technology to automotive practice, gaining new business (from .020” tolerance to .002” tolerance)

Link to LEM

Early supplier integration into design and development key enabler of major enterprise-wide overarching practices

- **Implement integrated product and process development**
- **Develop relationships based on mutual trust and commitment**
- **Assure seamless information flow**
- **Identify and optimize enterprise flow**
- **Optimize capability and utilization of people**
- **Make decisions at lowest possible level**
- **Nurture a learning environment**

Key Lessons

- Follow proactive "make-buy" strategy based on understanding of core competency over entire value chain
- Integrate specialized knowledge bases over supplier web (key suppliers, subtiers)
- Facilitate early integration of key suppliers in design and development
- Retain flexibility in defining system architecture
- Develop incentive mechanisms for mutual gain, both internally and externally

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Summary

- Early supplier integration into design and development can yield potentially significant benefits
- Major source of benefits: Enabling "architectural innovation" in product development
- Requires proactive integration of core competency of suppliers into design process
- Innovative government acquisition and oversight practices essential
- Current and future research aimed at helping industry in this journey (e.g., define best practices,metrics, enablers, benefits, formal analytical methods)

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Next Steps (Joint PD and SR)

- **Identify strategies and systematic methods for cycle time reduction and risk management**
  - Key characteristics
  - Design structure matrix
  - Software factories (continuing)
  - Dynamic modeling of design process
  - Reducing DOD product development time
- **Technology supply chain design and management**
  - Strategic make-buy decisions
  - Concurrent design of product development, technology supply chains and production supplier networks
  - Parts obsolescence and diminishing manufacturing resources
- **Information infrastructure requirements and approaches**
  - Vertical design/process integration information requirements
  - Structured methods (function/design/process decomposition; data flow management)

