F-22 PROGRAM INTEGRATED PRODUCT DEVELOPMENT TEAMS

How One Major Aircraft Program Developed Integrated vs. Independent Product Teams

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The Air Force Materiel Command (AFMC) is implementing a management philosophy called Integrated Product Development (IPD) to improve Air Force acquisition. The Air Force defines IPD as follows:

A team approach to systematically integrate and concurrently apply all necessary disciplines throughout the system life cycle to produce an effective and efficient product or process that satisfies customer needs.

Ideally, IPD will enable program managers to more effectively and efficiently manage program cost, schedule and performance risks. This article highlights how the Air Force's

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The U.S. Air Force F-22 Systems Program Office was the first Air Force program to implement the Integrated Product Development Team concept in development of systems for the F-22 aircraft. However, deployment of systems acquired using Integrated Product Development will

F-22 Program is implementing IPD. Our goal was to examine IPD implementation in one program to serve as an example to other managers from which to learn. Our research examined how IPD impacted both senior management and lower-level team personnel. We chose the F-22 Systems Program Office (SPO) because it was the first Air Force program to implement IPD, and it had been doing so for several years. We believed it was the best source of data in the Air Force for researching IPD.

We did not try to define the success of IPD within the F-22 Program, since success is relevant to each organization's goals, resources and constraints. Also, IPD was very new in the Air Force, and deployment of systems acquired using IPD will not occur for several years — in the case of the F-22 Program, into the next century. For the benefit of those who may be implementing IPD, we offer our experiences with the various characteristics of the F-22 Program, and how one major aircraft program is successfully implementing IPD.

The goals of IPD are improving quality, productivity, production flexibility, and reducing product development time.

Photo courtesy Lockheed Corporation

not occur for several years — in the case of the F-22 Program, into the next century. Pictured: Lockheed F-22 Advanced Tactical Fighter.

Background

First, some background is appropriate before we discuss how the F-22 Program implemented IPD. The term "IPD" is one the Air Force adopted from McDonnell Douglas for a concept called Concurrent Engineering (CE). An Institute of Defense Analysis (IDA) Report, R-338, defines Concurrent Engineering as follows:

A systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule and user requirements.

The definitions of IPD and CE both reflect the idea of blending disciplines early in product development.

The goals of IPD are improving quality, productivity, production flexibility, and reducing product development time. This philosophy advocates collocated teams that use simultaneous engineering, design for manufacturing and assembly, flexible operations, and open sharing of information. Specifically, IPD designates these integrated teams as either Integrated Product Teams (IPT) or Integrated Product Development Teams (IPDT). The IPTs are structured around major subsystems, such as aircraft avionics or engines, and are responsible for all aspects of their products, including technical, contractual, and financial issues. However, other types of groups, such as func-

tional staffs, still exist within the IPD environment. In 1991, the Advanced Tactical Fighter Program, the forerunner to today's F-22 Program, adopted CE under the name of IPD as its approach to acquisition. In 1992, AFMC, the command responsible for cradle-to-grave acquisition and support of Air Force weapon systems, established a working group to develop and oversee the implementation of IPD throughout the Air Force.

To understand how the F-22 Program implemented IPD, we needed to develop a set of investigative questions that addressed specific aspects of IPD. After reviewing the available literature, we decided the following questions were key to understanding the IPD implementation process:

1. How are the IPTs physically structured, and how are the reporting chains-of-command configured?

2. How do the IPTs communicate internally within the teams and externally with other teams and customers?

3. How often and what type of planning do individuals and IPTs conduct?

4. How did the F-22 Program train team members, and how did it accomplish the cultural change involved in transitioning to IPD?

5. What types of integrated management tools did the teams use?

6. What major hurdles did the IPD teams encounter while implementing IPD, and how were they overcome? What do the teams recommend other organizations do to transition to IPD?

We decided to conduct on-site personal interviews to obtain the greatest level of detail and first-hand knowledge. Personal interviews also allowed us to witness facial expressions and other body language to factor in our conclusions — information that we couldn't have obtained via surveys or in telephone conversations. Naturally, we couldn't interview all SPO personnel because of their diverse schedules and time constraints; therefore, we selected a representative sample from throughout the F-22 organization. Altogether, we interviewed 20 of the 22 selected subjects independently. Initially, we interviewed the program director and deputy program director together. Next, we interviewed major subsystem IPT leaders, functional chiefs, and other selected IPT members as shown.

The next sections discuss some of the more important highlights from our interviews. We organized them according to each of the six investigative areas discussed previously.

SPO REPRESENTATION

IPT Teams	*Functional Support*	*Front Office*
Air Vehicle - 7	Projects Div - 3	3
Support - 2	Engineering Div - 2	
Engine - 2	Contracting Div - 1	
Training - 0	Finance Mgmt Div - 1	
	Test Div - 1	

Organizational Structure

First, we needed to understand the F-22 SPO's organizational structure. The four primary IPTs were the Air Vehicle IPT, the Engine IPT, the Training IPT, and the Support Equipment IPT. Each IPT had two team leaders; normally, one was an engineer, while the other was a program manager. Interestingly, nearly all the interviewees did not perceive any conflicts arising from two team leaders giving conflicting guidance. Each IPT further divided into many sub-IPTs. For example, the Air Vehicle IPT included the armaments, propulsion system, airframe, avionics, cockpit, utilities and subsystems, and vehicle management system sub-IPTs. An Air Vehicle Analysis and Integration team was also included as part of the IPT.

Functionally matrixed support personnel, such as contracting and finance, were physically separated from the IPTs for three reasons. First, there was not enough manpower to allow dedication of a functional representative to each IPT sub-team, as would occur in ideal IPTs. Second, most of the functional members had activities that affected the entire weapon system and spanned across all IPTs, so they needed to communicate with other functional workers to obtain a program-wide perspective. Third, they used common reference and training materials that were not practical to place in each IPT's area. The disadvantage, however, was most functional personnel realized that being separated from the IPTs may cause them to miss notification of important issues and decisions. They realized that it was very important to work hard to remain in the communication loop with the IPTs.

Another hot issue within the SPO was the performance evaluation of functional personnel. Upper management thought that it was probably advantageous that functional personnel reported via their functional chains as opposed to team-oriented chains. The reason was that IPT team leaders could not observe many of the func-

tional activities, and would therefore encounter difficulty in writing evaluations and obtaining the ratings their functional personnel deserved. However, team leaders did provide inputs to their functional personnel performance evaluations.

Finally, one of the big advantages of the IPT structure was that the system user, Air Combat Command, had local representatives on the IPTs. These representatives were active team members and provided on-the-spot inputs for requirement issues. This kept the user in the loop and provided a quick way of obtaining guidance on requirements.

Communication is Vital

The F-22 Program considered communication a great advantage — if not requirement — for successfully implementing IPD. The IPD structure allowed for increased communication. However, it was still up to each individual to remain in the communication loop, since IPTs could not effectively function without frequent communication among team members. As a result, meetings were prevalent in the IPTs, and the time spent in meetings was directly proportionate to the management level. Inevitably, disadvantages surfaced in having this number of meetings. Contracting and finance personnel were unable to attend many meetings due to the large number of sub-IPTs they supported, and because they were not collocated. Our interviewees believed that the most important advantage of collocation was enhanced communication with team members. The two most valuable communication mediums in the F-22 Program, according to our interviewees, were electronic mail and "across-the-aisle" sub-IPT communication. These means of communication were in keeping with the SPO's initiative of moving toward an electronic, paperless operation. Other communication tools to inform team members were Weekly Activity Reports (WAR) and trip reports. Management consistently posted WARs in one common room, allowing any team member access to an update on the entire program.

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Intense Up-Front Planning

One of the keys of IPD implementation was starting at the beginning of a program. To achieve optimal benefit from implementing IPD, our interviewees stated that an organization should implement IPD from program onset. Planning should be extensive, and from the beginning should be product-focused. It was important to design the program structure early and to incorporate a suitable contract type with detailed requirements for the tools essential to the IPTs. Only then should management organize personnel into teams. Also of great importance is government and contractors' planning for use of successful management tools such as an Integrated Master Plan (IMP) and an Integrated Master Schedule (IMS). The IMP describes the program's major events, while the IMS depicts when they occurred. The contractor as well as the government assigned focal point team members responsible for signing approval for closure plans for each criterion of the IMP. This encouraged government team members and their contractor counterparts to plan jointly as a team.

Training

Another key to IPD is training and education. Regrettably, F-22 SPO members had to learn about IPD through trial and error, work experiences and informal training sessions. One reason was the F-22 Program was on the cutting edge of IPD in the Air Force, which forced it to learn through experience. However, the SPO did have some effective training techniques. One technique required functional personnel to brief their individual functional areas to all team members who lacked experience in those functions. This fostered a team approach and ensured team members stayed abreast of other members' activities. Other team-building exercises that included either government and/or contractor personnel were another way to help transition to IPD. The F-22 Program also established a newcomer's briefing to help orient new personnel to IPD. This was particularly important in bringing members into the midst of the F-22 Program, who were unfamiliar with operating under IPD. The briefing also helped to reduce the slope of the learning curve.

Integrated Management Tools

The last of our six areas essential to IPD implementation is Integrated Management Tools. Ideally, these tools allow workers to track program development and permit prompt corrective action before problems become large. From the onset of the program, SPO upper management tried to give workers a toolbox from which they could draw various integrated management tools to do their particular jobs. Previously, we discussed two of the most important tools — the IMP and IMS. All of the management tools primarily provided information on schedules, costs, variances, and tasks

to be accomplished. Workers correlated IMP accomplishments and the Work Breakdown Structure with cost and schedule variances. Technical Performance Measures provided indicators to track how the product developed. The design of many of the management tools allowed lower-level workers to channel information upward to senior management to keep them informed on program status.

Lessons Learned

We asked each of the interviewees what advice they would provide other program personnel attempting to implement IPD. They responded with many valuable tips. First, one major hurdle to implementing IPD was the development of *Independent* Product Teams instead of *Integrated* Product Teams. When IPTs received the people, funding and authority to develop individual products, each of the teams concentrated solely on its product and over-optimized it. Teams would produce components of outstanding design that were not easily integrated with other components. Therefore, the SPO established critical Analysis and Integration teams so that the product teams interacted to ensure the F-22 Program assembled together as an integrated weapon system. A Weapons Systems IPT made up of the four IPT chiefs, functional divisional chiefs and the front office also helped cross-team integration.

Next, organizations should understand that IPD is not a panacea for all acquisition problems. The F-22 Program concept of IPD is not guaranteed to work for all programs, and other programs should tailor IPTs to fit their needs. Also, influences such as budgetary funding play major roles because a stable funding profile is essential to long-range planning. Another lesson applicable to all DoD programs is both sides of weapon system acquisition — industry and the government — must work together as a team. They must overcome the traditional adversarial government-contractor relationship. Interviewees thought this was easiest under a cost-plus-award fee contract because both sides had the same objective of allocating resources as wisely as possible.

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Management believed the most difficult aspect to overcome for the contractors as well as the government was functional organizations that were too concerned about career progression. Organizations should not underestimate the amount of bureaucratic resistance to implementing IPD. Also, formation into teams does not ensure that the necessary integration and communication occurs. Integration and communication are still individual responsibilities, and not every individual is comfortable with the IPD philosophy. Introverts uncomfortable with interacting with other disciplines sometimes prefer isolating themselves within their functional divisions, thus hampering the effective communication essential to IPD.

Conclusion

In conclusion, we examined the six areas of organizational structure — communication, intense up-front planning, training, use of integrated management tools and lessons learned — because we believed these areas vital to understanding how the F-22 Program implemented IPD. Other areas pinpointed as vitally important to the success of implementing IPD follow:

- The SPO emphasized planning up-front to establish an organizational and contractual structure that empowered workers at the lowest levels to develop their products.
- Interviewees stressed constant communication with all other functions of the IPT and other IPTs.
- Management conducted training, primarily during transition to IPD, but was beginning to reemphasize it.
- Team members tailored their own management toolbox to the activities necessary to perform their duties.

All the actions listed above were important. However, the most important lesson learned was *avoid letting Integrated Product Teams evolve into Independent Product Teams!*

References

1. Bucher, Tom, "Integrated Product Development," Unpublished Briefing to IPD Working Group, 27 October 1992.
2. Winner, Robert I., James P. Pennell, Harold E. Bertrand, and Marko Slusarczuk. "The Role of Concurrent Engineering in Weapons System Acquisition" (Institute for Defense Analyses Report R-338, Virginia, December 1988).
3. Wagner, Gary F., and Randall L. White. "An Investigation of Integrated Product Development Teams of the F-22 Program" (Air Force Institute of Technology Thesis AFIT/GSM/LAS/93S-19, September 1993).