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Joint Strike Fighter Integrated Subsystems Technology, A Demonstration for Industry, by Industry

Alan Burkhard*
U.S. Air Force Research Laboratory, Wright–Patterson Air Force Base, Ohio 45433-7531
and
Richard Deitrich†
Joint Strike Fighter Program Office, Arlington, Virginia 22202-4304

The Joint Strike Fighter (JSF) Integrated Subsystems Technology Demonstration Program was a highly successful industry-wide five-year program in which normally competitive JSF weapon system contractors and suppliers worked together with competitors to accomplish technology maturation and mitigate technological risks of a revolutionary subsystem concept for tactical aircraft that integrates the subsystems and utility functions thereby reducing the associated major equipment groups from 13 to 5. As a result of this integration, the volume, weight, and costs allocated to these subsystems are significantly reduced without sacrificing vehicle performance and safety. Major and minor management and execution methods used to focus, solidify, and maintain this industry team over the five-year program are outlined.

Introduction

IN January 1994, the Department of Defense (DOD) established a joint service organization, the Joint Advanced Strike Technology (JAST) Program, to define and develop aircraft, weapon system, and mission technologies for future tactical aircraft systems. The initial thrusts of this organization were to "catalogue work already underway, conduct analysis of joint service requirements and identify launch candidate technology efforts."[1] The program would establish technology building blocks for the development of the next tactical aircraft. Among the first tasks of this organization was to "focus and integrate" tactical aircraft technology programs and coordinate a "technology roadmap." To accomplish these objectives the JAST organization came to the aerospace industry and the U.S. Air Force and U.S. Navy science and technology (S&T) communities to identify what JAST Program called "low hanging fruit" (technologies already under development and that had creditable affordability and benefits analysis showing that the technologies were beneficial and that the maturing of these technologies could be accelerated with additional funding).

A series of joint industry and government meetings were held to discuss and identify which of the proposed technologies made the most sense to recommend for maturation in light of established JAST metrics. These first meetings focused on structuring a set of unrelated component efforts, each one of which would help solve a particular problem, but did not adequately address the JAST metrics.

The metrics of interest to JAST were vehicle-level benefits such as system acquisition cost, triservice applicability, sortie generation rate, and reduced logistic footprint, rather than the kind of payoffs articulated by a single component or technology program. Therefore, the idea was born to pull together all of these technologies or portions of these technologies, whichever made sense, and enhanced the system-level benefit in so doing.

Four of the many technologies that were proposed by the S&T community for JAST consideration seemed ripe for evaluation as an integrated set. These technologies were more electric aircraft (MEA),[2–9] subsystem integration technology, (SUIT),[10–16] advanced vehicle management system (AVMS),[17] and advanced fixed area nozzle (AFAN).[18,19] In general, these four technology areas had been developed independently, and their respective visions of integration requirements had slightly different focus. It was conceivable, however, that revolutionary vehicle-level performance and affordability benefits might be achievable in the JAST time frame of interest via an integrated approach that would blend the best features of the MEA, SUIT, AFAN, and AVMS technology thrusts. This was the premise of the technology integration study, which became known as the vehicle integration technology planning study (VITPS). To this end, in conjunction with JAST, four Wright Laboratory divisions and the U.S. Navy came together to jointly manage this JAST and U.S. Air Force funded study.

VITPS

The VITPS statement of work was written to have integrated product teams (IPTs) seriously look at all of the technologies rather than just favorites and, most important, look at ways to integrate the best of all of the advanced concepts and technologies. The push was to identify and quantify as much as possible the benefits of technology integration. Three independent contractor study teams were formed. Two study contracts were awarded and a third JSF weapon system contractor (WSC) decided to do this using independent research and development (IRAD) funds. These study teams had exceptionally broad industry participation and significant depth, going down one or two levels of suppliers. This extensive supplier participation was stimulated by the request for proposal (RFP) requiring that approximately 50% of the study resources go to the suppliers. The government management team selected this approach because too often the primary study contractor reserves the majority of the study resources for itself and provides very little to its suppliers. In the case of these product areas, major WSCs procure this equipment from suppliers, who often take responsibility for some integration work, and it was essential to have the supplier involvement. For the VITPS study, a large supplier base was paid to participate, and therefore, a more complete understanding of what happens when technologies are integrated could be assessed from the air vehicle down to individual components.

These independent industry study teams evaluated a broad range of completed and ongoing S&T and IRAD programs to identify which technologies, when integrated, had potential to yield large

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*Senior Aerospace Engineer, Air Vehicle Directorate, Room 112, Building 45, 2130 Eight Street.

†Subsystems Lead, Vehicle Systems Integrated Product Team.

benefits in life cycle-cost (LCC) and war fighting capability. Additionally, an assessment was made as to which integrated technologies could be matured by calendar year (CY) 2000, CY2005, and CY2010 with some reasonable level of resource investment. Although the analysis from each study team indicated differences in the exact level of benefits, they were surprisingly consistent as to which technologies and integration concepts enabled those benefits.[18–20]

It was apparent to the government management team that even though the VITPS studies were being conducted independently, all three studies were converging on a similar end state configuration. Unfortunately, each study team thought they had identified an integration configuration that was unique and desired to keep it from their competitors even though two study teams developed their concepts using government funds. To break this mind set, the government team pointed out that if there was to be a funded technology maturation effort based on the VITPS study results, it would have to be of benefit to all three JAST WSCs. There were only enough funds available to fund one maturation program, and in fact, the JAST model required that technical maturation activities serve all WSCs. Therefore, the WSCs were encouraged to hold discussions to identify common ground in their independently developed configurations.

Out of these discussions, it became clear there was enough common ground that a single technology maturation program could serve all three JAST prime contractors. Additionally, for the JAST window of opportunity and JAST customers (U.S. Air Force, Navy, and Marines) a common set of technologies could be integrated and matured that would result in vehicle-level LCC and war fighting benefits that met and or exceeded JAST metrics. As a result of their extensive participation in the VITPS studies, the airframe, engine, and subsystem contractors determined that this suite could be readily transitioned. The three VITPS contractor study teams and the government management team prepared an integrated advocacy briefing for the JAST Program Office. Each VITPS contractor presented the results of (their) study showing how this technology, when matured, could help accomplish the JAST goals. The VITPS management team presented its approach for structuring and managing a single program that would provide the technology maturation desired by all three WSCs. Fund approval was then given by the JAST Program Office to prepare the necessary documentation for a formal procurement solicitation.

Program Formulation

The JAST Program Office established a joint U.S. Air Force/Navy (USAF/USN) effort, the JAST Integration Subsystem Technology (J/IST) demonstration program out of what was the VITPS government management team. This program was to execute the necessary technical maturation activities and promote transition of the industry-identified integrated subsystem suite. The objective of the J/IST demonstration program was to convince industry and government decision makers that the integrated subsystem suite provides promised LCC reductions and increased war fighting capability. Additionally, the program was to demonstrate that the technology on which this suite is based would be sufficiently mature to enter engineering and manufacturing development (E&MD) by the year 2000.

A major consideration in structuring the management approach to the J/IST demonstration program was its relationship to the overall JAST program, which in time transitioned to a major DOD acquisition (ACAT 1D), the Joint Strike Fighter (JSF) Program.[21] The JAST program was a new way of doing business, bringing together war fighters, maintainers, technologists, and developers on a single joint service team with a shared purpose. The team's mission was to identify, mature, demonstrate, and transition technologies and concepts that meet war fighters needs while reducing the cost of these future joint strike warfare aircraft weapon systems. To accomplish this objective, the JAST/JSF program has three distinct phases, concept exploration, concept development, and concept demonstration and flying demonstrators. The WSCs, who were developing their preferred weapon system concepts (PWSC) under this part of the JSF program, were viewed as the customer of the technology maturation efforts. These technical maturation activities were to run in parallel with PWSC development and refinement, as shown in Fig. 1. The J/IST demonstration program was one of these technology maturation programs.

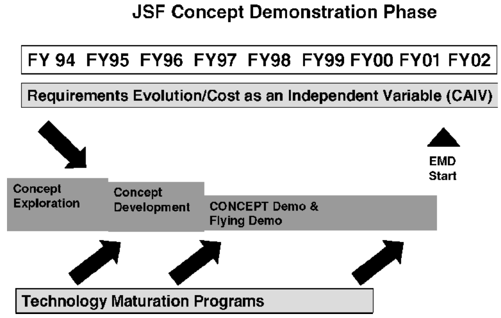

Fig. 1 JSF overall program schedule.

J/IST Demonstration Program

In January 1995, a management team composed of USAF/USN personnel was established at the U.S. Air Force Research Laboratory, Wright Patterson Air Force Base to plan and execute the J/IST demonstration Program. This team was responsible for planning, program control, financial management, and program execution of the J/IST demonstration program, subject to oversight and approval of the JAST program office. Even though the J/IST demonstration program involves many technologies and must deal with multiservice application issues, the J/IST project team was intentionally made a small management team following the JAST model to foster technology integration. The team was made up of individuals with diverse service and technical backgrounds, who are focused on the comprehensive goal of transitioning integrated subsystems rather than nurturing technology niches.

One of the first orders of business for this team was to develop a concept of operations for how this small management team would interface and work with industry. The primary customers were the JSF WSCs, who would "buy" the product of the J/IST demonstration program through incorporation in their JSF weapon system designs. Traditionally, the customer for a technology maturation effort is the government project office that funds and executes the effort. This government project office would set the requirements, represent the interests of the JAST program office, and act as an "honest broker" among the executing WSCs who were in fierce competition to win the JSF development contract. From the start, the J/IST management team realized that their role would to be to act more like program shepherds than requirement givers. This realization emerged from the following facts.

First, the VITPS study identified a subsystem integration concept to be matured, but did not identify any requirements as to size, performance metrics, etc. Second, the JSF WSCs, who were developing their highly proprietary aircraft design, needed the J/IST demonstration program to provide value to them without giving away their proprietary concepts. Additionally, the PWSC concepts would be evolving throughout the duration of the J/IST demonstration program so that the requirements that defined the J/IST program had to be robust enough to permit the J/IST program to be relevant even after several design iterations.

To ensure a high probability of transition of J/IST technologies, the J/IST program established an industry/customer user team (ICUT) and invited the five air framers, three jet engine manufactures, and government representatives to participate. In establishing the ICUT, the contractors were told that J/IST demonstration program would be competitively awarded to accomplish demonstrations that address the transition risk issues identified by the ICUT. All members of the ICUT not awarded specific demonstrations had the opportunity to take part in the technical review and assessment team that would closely track the progress and results from this program.

To start the discussions, the J/IST management team critically evaluated the results of the three VITPS study teams and then condensed the result to six essential technology sets or integrations. A document was prepared that captured a "consensus architecture" that encompassed the six essential technology sets or integrations. The initial draft of this document, the consensus technology package (CTP), had the J/IST management team's perspective as to the transition risk issues that needed to be addressed in the J/IST demonstration program to reduce the transition risk to low for E&MD.

The ICUT and selected government technical experts reviewed this document, and after several iterations, a final version emerged. This iterative process was facilitated in that the initial draft of the CTP plainly stated that the forthcoming RFPs for the J/IST demonstration program would be a competition on methodology: the methodology to cost effectively demonstrate the consensus architecture and reduce to low the identified transition risks outlined in the CTP. Novel ways of integrating, although interesting, were not to be used as source selection criteria. The resultant CTP was included as part of the Joint Advanced Strike Fighter Technology Broad Agency Announcement (BAA) 95-3, issued by the program office on 7 April 1995. This announcement provided data to assist the bidder in proposal preparation. The consensus architecture that was part of the BAA is shown in Fig. 2.

This approach enabled the J/IST customers to make sure that their issues and concerns that they chose to share would be addressed in the forthcoming procurement. The focus was on capturing technical issues and concerns rather than the generation of detailed design requirements for the demonstration hardware. This would allow a bidder to be creative in using existing facilities and/or equipment that could work the issues and not be viewed by other contractors as working their prototype hardware configurations for their proprietary aircraft design. Any such perception would have destroyed willingness to work together and share information.

The J/IST demonstration program was planned to be a single program that reduces to low the transition risk for E&MD of integrated subsystems technology for all JSF WSCs. The consensus technology package captured the issues and concerns that needed to be addressed in the J/IST demonstration program; however, every airframe contractor could not be selected to accomplish every demonstration due to funding limitations. Therefore, the evaluation criteria for BAA 95-3 clearly stated a major evaluation factor was the extent to which the bidder and the proposed demonstration plan would provide meaningful sharing of progress, results, and lessons learned with the other JSF WSCs. Additionally, all bidders were required to propose demonstrations that addressed all elements of the J/IST consensus architecture. This was done so that for each major technology set there would be several different demonstration approaches to choose from. This would allow the source selection team to weave together the best mix of contractors and demonstrations. To facilitate this approach, cost and technical effort had to be proposed in easily identifiable and severable tasks.

In the structuring of BAA 95-3, it was recognized also that the J/IST demonstration program had to address two categories of issues, technical and those related to affordability. Two general types of tasks were called out in the BAA. One task was to reduce to low the transition risk of this technology. The other task was to accomplish a more refined affordability assessment using the results of the various J/IST technical activities.

To further the likelihood that JSF WSC contractor issues and concerns were worked, the BAA required the proposed program to be divided into three phases: phase 1, program definition and planning; phase 2, detail demonstration hardware design; and phase 3, hardware fabrication and demonstration execution. The beginning and ending of these three phases were key milestones at which go/no-go decisions could be made.

From the proposals received, contractors were selected to accomplish major tasks and demonstrations. The contracts from the BAA solicitation contained contract language that designated the contractor doing a particular task or demonstration as a responsible agent contractor for the other JSF WSC contractors. As a responsible agent contractor, it was understood that the executing contractor was doing the work for the other two JSF WSC contractors and the government, as well as for their own company. To facilitate this, associate contractor agreement clauses and data sharing tasks were written into these contracts. This would allow direct sharing of technical information among the contractors and eliminate the government team being a choke point for this sharing.

Technical Program Planning

Program planning was envisioned as phase 1, a four-month effort, for the J/IST demonstration program. It turned out that program planning occurred throughout the entire program. During phase 1, the J/IST suite concept and the innovative demonstration approaches, methodologies, and techniques selected in source selection were converted into comprehensive plans for implementation of the concept and demonstration of the critical, enabling technologies so that technically sound and affordable low-risk transition into

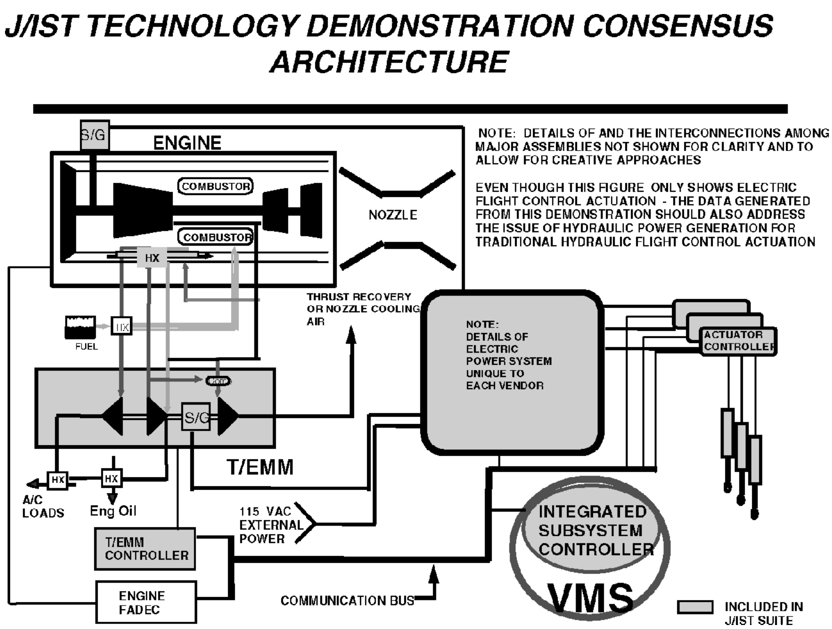

Fig. 2 J/IST BAA 95-3, consensus architecture.

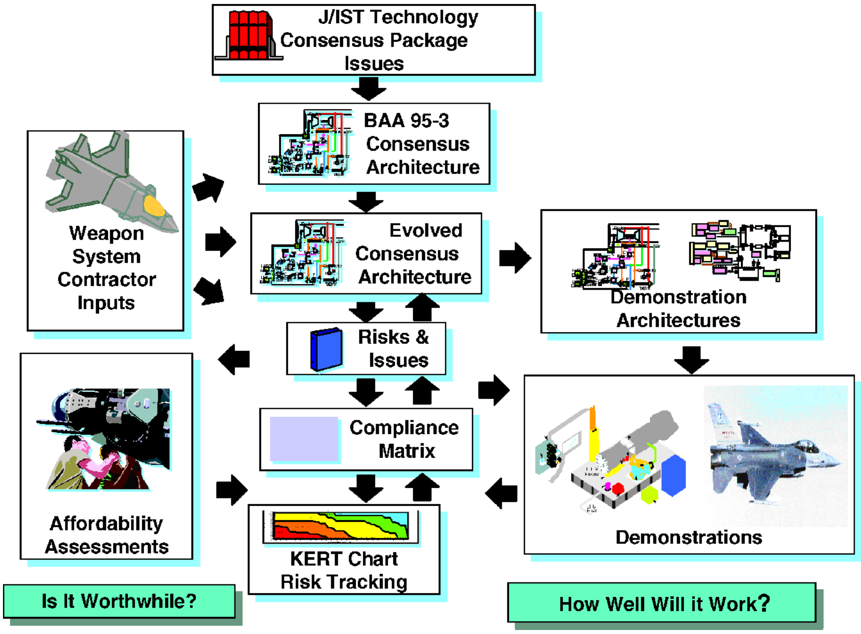

Fig. 3 Requirements generation and technology maturation process flow.

E&MD could be assured. This phase would allow contractors who were not selected to be the responsible agent contractor for a particular series of demonstrations to make sure their issues and concerns were adequately addressed.

At the initial J/IST phase 1 planning meeting, the J/IST management team made it very clear that IPTs, including the J/IST responsible agent contractors and JSF WSC design engineers, would be the forums to dovetail planning, review demonstration plans, and track/assess technical progress. Members of the J/IST management team would sit in on the IPT deliberations as facilitator/observers and make sure that contractual scope was not being violated. Three IPTs were formed to execute the J/IST demonstration program. These IPTs were power and actuation (P&A), thermal energy management module (T/EMM), and integration and analysis (I&A). The responsible agent contractor who was primarily responsible for the bulk of the demonstrations or technical activities that fell within each IPT technology domain was selected to lead and document the IPT deliberations and summarize the recommendations. The I&A IPT was led by the J/IST management team because the I&A IPT was not responsible for executing demonstrations but rather ensuring that everything was integrated to produce the desired results. At first it was difficult for the two demonstration IPTs, T/EMM and P&A, to solidify. The apparent reason for this was the significantly different experience base of the engineers from the three JSF WSCs. For example, although they all wanted to work many of the same issues, the level of understanding or knowledge about the existing state of the art around those issues varied greatly. An engineer with limited experience with the issue wanted to use J/IST resources to work technology maturation concerns that have been already resolved by other technical programs. This was overcome by a contractor initiative to share with the IPT the technical content of their own proposal submitted for the BAA 95-3 competition. This provided a framework for everyone on the demonstration IPTs to come to a common level of understanding concerning the various perspectives on a given issue and the state of the art for a particular technology. It had the additional benefit of establishing a level of trust among the program participants.

Detailed Requirements Definition and Risk Tracking

The product from phase 1 of the J/IST demonstration program was a robust set of integrated design and demonstration requirements, along with a risk-reduction tracking scheme for the rest of the program. The process to develop requirements began before the release of BAA 95-3. The activity to develop and establish a consensus technology package that was part of the BAA was the initial step. During phase 1, the top-level notional consensus architecture shown in Fig. 2 was evolved into a more detailed engineering functional configuration for demonstration purposes using the process outlined in Fig. 3.

From an overview perspective, all participants, who proposed to the J/IST BAA proposed two major technology maturation paths. One path was a series of comprehensive ground demonstrations, whereas the other path involved ground demonstrations followed by flight testing. These were judged to be acceptable and cost effective ways to mature the integrated J/IST technology suite. To accomplish this, the consensus demonstration architecture shown in Fig. 2 evolved into two major demonstration architectures, one for those technology that could be matured doing only ground-based demonstrations and another for those technologies that required both ground demonstrations and flight testing. Where practical and cost effective, the same component elements were used for both technology maturation paths. This involved some adjustments to a few of the elements originally proposed by the bidders.

Each WSC came to the demonstration IPTs with independently developed inputs including lists of key parameters and performance ranges they wanted demonstrated or measured. On the whole, these independently developed inputs were compatible, but there were areas of conflicting requirements and desires. To arrive at a set of robust design requirements for a given demonstration, hardware minitrade studies and analyses were accomplished. These analyses had to take into account both the desires of the WSCs and the hard constraints imposed by the already purchased demonstrations. For example, items to be flown had to fit and be compatible with the F-16, whereas items that had to interface with an F-119 engine had to be compatible with it. Extensive modifications to either the F-16 or the F-119 engine were out of the question due to financial constraints.

The mintrades and analyses involved an iterative process to balance WSC desires, J/IST hard demonstration constraints, laws of physics, and available resources. The responsible agent contractor and team accomplished engineering analysis to identify a set of design parameters that would result in demonstration hardware that could provide data for as many of the WSC identified issues as possible while still being compatible with all of the other constraints. This involved detailed engineering analysis followed by an across the board review of all of the issues and concerns to see how many were not addressed appropriately. This iterative process eventually converged to a final set of demonstration hardware requirements that the IPT felt would allow the planned demonstration to appropriately address all of the identified issues and concerns. This iterative process had an additional benefit because the JSF WSCs gained insight into what were the key metrics or parameters that drive the design. This knowledge often resulted in WSCs restating their concerns or issues in ways that still provided them the key knowledge and data they wanted but enabled one demonstration hardware design to work all of the issues and concerns.

The actual demonstrations were conducted using a mixture of flight-designed and laboratory-type of hardware. Flight-designed hardware was fabricated for those components where risk issues involved size and weight in relation to performance level. Commonly, laboratory or industrial equipment was used for features such as lubrication systems or power supplies. This kept the focus on the primary purpose of the demonstration, which was to gather data on the key risk elements of the architecture.

To facilitate this technology maturation process, a tracking methodology was used to ensure all issues and concerns were addressed. Figure 4 shows the three charts used to capture this tracking methodology. A compliance matrix called the maturation matrix (MoM) was constructed that lists, for each milestone, the WSC issue or issues that would be addressed by data and the results produced by completion of that milestone. A milestone could be the completion of a detailed analysis, passing preliminary review (PDR) and critical design review (CDR), or completion of a demonstration or test. Before any technical work, the anticipated amount of risk reduction available from each milestone for each WSC issue was assessed by the appropriate IPT. Based on this assessment, a second tracking chart, the key element risk tracking (KERT) chart, was

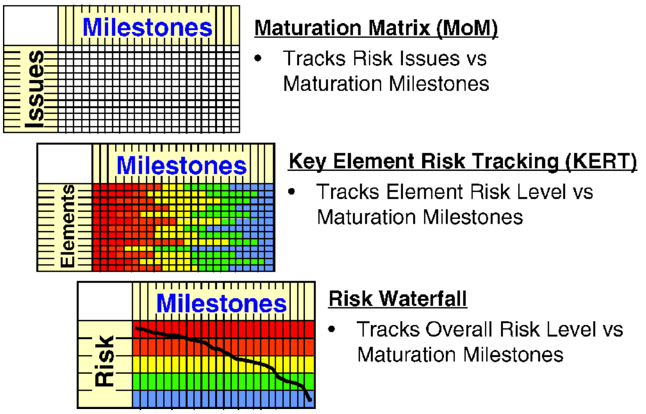

Fig. 4 Technology maturation and risk-tracking charts.

structured to track the amount of risk reduction anticipated by the IPT from each demonstration milestone. From the KERT chart, a risk waterfall chart was constructed that tracks the highest risk level for any element of the J/IST Program. The waterfall chart shows the anticipated overall risk reduction progression as a function of demonstration milestone.

Figure 5 outlines the extensive participation of the IPTs in the planning and execution of the demonstrations. It also highlights IPT involvement in the assessment and tracking of the risk reduction achieved from each demonstration. The three crosshatched blocks represent the activities accomplished primarily during phase 1 of the J/IST demonstration program. The rest of the blocks represent the activities before and after accomplishment of each milestone. After a milestone event was completed, the responsible agent contractor who conducted it prepared a coordination memo documenting the results of the milestone event. The appropriate J/IST IPT would evaluate this document, technical data, and results of the witnessed demonstration to determine if the desired level of risk reduction was achieved, or to identify any shortfalls.

If the milestone event produced risk reduction that met or exceeded the anticipated values, the JSF WSCs design team representatives signed the coordination memo. If the accomplished level of risk reduction was more than expected, the KERT and waterfall charts were adjusted to accurately reflect the actual achieved level of risk reduction. Conversely, if the level of risk reduction was less than anticipated, an evaluation to assess the impact of this shortfall was performed. This assessment examined the impact on the J/IST critical path leading to the overshadowing demonstrations.

The overshadowing demonstrations were those functions that the J/IST customers indicated had to be demonstrated to transition this technology to their JSF aircraft designs. The J/IST customers identified two overshadowing demonstrations: 1) multimode operation of the integrated subsystems suite with a F-119 engine during an integrated ground demonstration and 2) flying the F-16 with all primary flight control surfaces powered electrically.

If the shortfall was not on the critical path, then it was just noted and the program continued as planned. If the critical path was impacted, the responsible agent contractor for that demonstration milestone proposed how the risk reduction shortfall could be eliminated. This proposal could include additional testing, analysis, or modifying future demonstrations. The executing IPT evaluated the technical merits of the proposal, whereas the government management team and executing contractor evaluated the financial implications of the proposal.

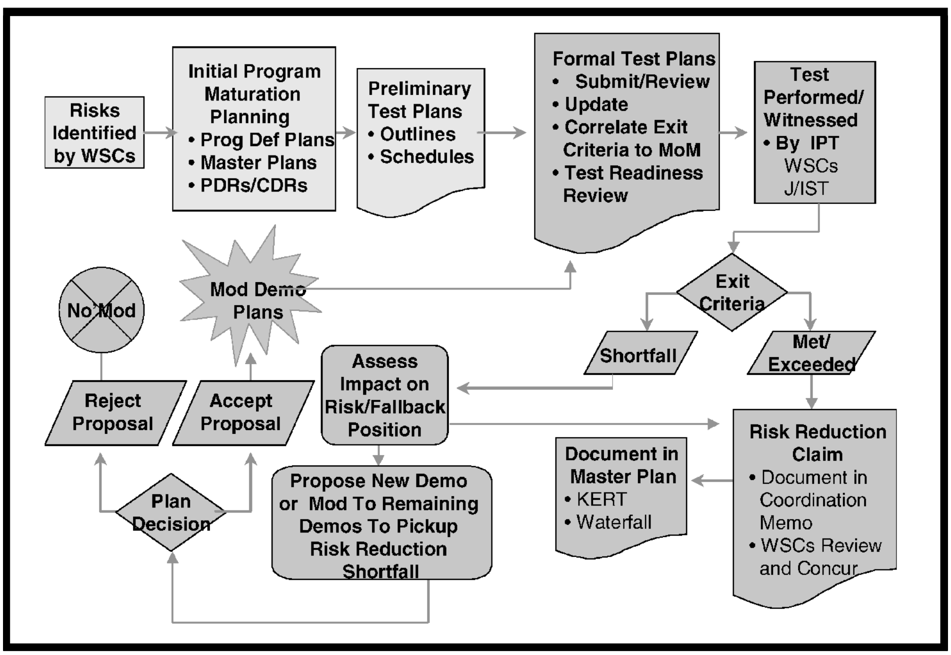

Fig. 5 IPT risk reduction planning and verification process.

If the proposed modified work plan had no net cost impact and would solve the risk reduction shortfall, the plan would be implemented. If, however, the only way of filling in the shortfall required technical and/or programmatic decisions with cost or schedule impacts to major program milestones or involved significant deviations from the demonstration consensus architecture, the ICUT became involved.

The ICUT transitioned into what became the J/IST executive council. The name change from ICUT to J/IST executive council reflects the changing role of this group, a shifting membership, and the providing of additional prestige so that the appropriate decision makers needed at these meetings would participate. This council was made up of the JSF program office flight systems IPT lead, JSF WSC subsystem design teams, J/IST management team, and the program managers from each of the J/IST contracts. If a particular demonstration had a shortfall in achieving risk reduction, this council reviewed the associated technical issues and the recommended solution(s) proposed by the responsible agent contractor. A particular corrective action was not implemented unless this council agreed that the approach still provided value to the JSF WSCs, and the potential level of risk reduction from this approach was acceptable.

In all cases, the financial details of any technical approach were never presented to or discussed by the J/IST executive council. All financial discussions were private between the J/IST management team and the effected responsible agent contractor. All that the executive council knew was the viability of the proposed approach within the current J/IST budget, and whether it was within the contract scope of the effected contractor. If the risk reduction shortfall could not be corrected within the available budget, the J/IST executive council identified lower priority tasks that could be sources of funding.

Affordability Assessment Planning

The affordability assessment task within the J/IST demonstration program was a major activity that in its final form required close coordination and cooperation among the three JSF WSCs. Initially, all three JSF WSCs were contracted to work independently, essentially rerunning the just completed VITPS type of benefits assessments. All JSF WSCs would be using their own VITPS generic study aircraft and methodology just like in the VITPS studies. This was viewed to be a low-cost effort because the WSCs had just completed the VITPS studies, and for the most part, all that had to be done was to rerun these studies using a more refined set of component data produced during the various J/IST technical activities. The perceived value of this activity was validation of whether the projected benefits from the VITPS studies were maintained or enhanced as the technology maturation activities produced data.

During the program definition and planning phase, phase 1, of the J/IST demonstration program, the JSF WSCs voiced concern that, from their perspective, there was not much value in reaccomplishing the VITPS studies. The benefit assessments of great value to them were those being made on their proprietary JSF competition aircraft as the J/IST technology was folded into these designs. The resultant studies obviously would be proprietary, but they saw the J/IST demonstration program providing needed refined data that they could use in these proprietary studies. Refined data of interest would be the emerging results of the various J/IST technology maturation efforts. Therefore, a VITPS-like study as part of the J/IST demonstration program seemed of little value.

During the phase 1 discussions, another perspective emerged. The JSF program office was developing the joint logistic modeling environment (JLME) that would eventually be used to help evaluate the proprietary aircraft designs for JSF E&MD selection. It seemed that if J/IST, utilizing JLME, did an open-to-all WSCs benefits assessment within the J/IST demonstration program, it would provide an opportunity to exercise this new environment where problems could be identified and worked out before use in the proprietary arena. This activity would only need one assessment study using resources initially allocated to accomplish the original three studies.

Drawings of the candidate (non-proprietary) study aircraft were exchanged and reviewed by the I&A IPT and JSF WSCs to identify which aircraft design should be used for the study. The consensus was that the The Boeing Company Seattle study aircraft would be appropriate because it has sufficient technical detail available. Boeing Seattle was selected to crunch the numbers, with McDonnell Douglas (now Boeing St. Louis) and Lockheed Martin Corporation providing the detailed parameters from their J/IST component suppliers. The list of components was divided, and the suppliers designed, through to least a PDR level of detail, components for both a traditional federated subsystem and a J/IST integrated subsystem configuration. The same supplier designed both the federated and J/IST components for the same/similar function to reduce unavoidable bias. The consensus architecture and requirements were used to size and configure the J/IST study components. The consensus requirements and an F-22-like subsystem architecture were used to size and configure the traditional federated components.

A benefit assessment involves more information than just component engineering parameters. Additional studies were accomplished to get a handle on some of these other factors. Virtual installation and supportability studies developed typical maintenance parameters and ground support equipment requirements for the J/IST subsystem.[21] A quick-look study was also conducted that looked at the impact of J/IST integrated subsystem on ground and carrier support requirements.[22] The results from these supporting studies flowed into the overall benefits assessment study.[23]

Communication and Team Building

Good, open, and frequent communication is critical to team building and the success of any large project involving many different players. This was especially important to the success of the J/IST demonstration program. Whereas the supplier base was in competition to be the suppliers of choice for the JSF WSCs, the JSF WSCs were engaged in a fierce competition to win the JSF program contract. The J/IST demonstration program had to resolve the issues and concerns of all involved. To consolidate these voices into one, the J/IST management team used several mechanisms and techniques outlined as follows.

1) The J/IST contracts were written with clear delineation of technical task responsibilities so that competition for doing J/IST tasks ended with the source selection decision. If the scope of a technical task had to change during the execution of the J/IST program, these changes were made through the contractor responsible for that task.

2) Team administrative tasks were distributed among J/IST contracts. The Lockheed Martin team was responsible for making finalized viewgraphs and charts for joint presentations. The Boeing St. Louis team was responsible for constructing the J/IST master plan and risk-tracking documentation.

3) The Boeing Seattle and Lockheed Martin contracts contained tasks to provide inputs to the development of the master plan being assembled by the Boeing St. Louis team.

4) The responsible agent contractor concept was written into each contract. A responsible agent contractor was the contractor under contract to accomplish a given task for the entire J/IST team.

5) Each J/IST contract had the requirement to establish associate contractor agreement clauses to enable direct information flow between all participating J/IST contractors. This avoided the problem of needing to funnel data through the government J/IST demonstration team.

6) The J/IST demonstration team and the executing contractors jointly briefed technical plans and progress to the JSF program office. These were unified briefs, not contractor centric. It was common that one contractor would brief technical work being accomplished by another contractor because they were both working on different aspects of the same issues and the work logically fit together for presentation continuity.

7) Weekly "meet-me" calls were held for each J/IST IPT. These weekly calls were standing meetings with written minutes. To facilitate discussions, copies of drawings, viewgraph charts, or test plans were e-mailed ahead of time to the team members so that everyone had copies in front of them during these discussions. If the files were large, sensitive, or contained proprietary information, they were uploaded onto a secure FTP site operated by the JSF program

office or e-mailed in an encrypted form. Often additional telephone conference calls were set up to hold in-depth discussions or reviews of specific technical issues. This approach saved the J/IST program travel costs and loss of productive work hours during travel.

8) All J/IST contractors participated in the demonstration hardware PDRs and CDRs. The tendency by some contractors to stamp almost everything as proprietary was strongly challenged by the government team. If necessary, short, closed-door limited audience discussions were held. However, for the most part, PDRs and CDRs were open meetings because eventually all of this hardware had to work together in the various demonstrations.

9) The role of government technical experts is best summed up by the phrase, "insight, not oversight," providing wise council from their expertise and experience, but not direction and/or establishment of requirements. Although most government experts understood and performed this role, there was a natural tendency on the part of some of the contractors to look to the government IPT members for more.

10) Major programmatic decisions that emerged from program milestone shortfalls were elevated to the J/IST executive council for resolution. This council membership was made up of the JSF program office flight systems lead, JSF WSC subsystem design teams, J/IST management team, and the program managers from each of the J/IST contracts.

The entire team got together about every six months, initially for program planning, PDRs, and CDRs. However, when the program moved into phase 3, technical interchange meetings (TIMs) were scheduled. TIMs were contracted meetings for the last three years of the program as forums where the executing contractor team, the responsible agent contractor, presented the technical progress for the past six months to the rest of the JSF WSC and J/IST contractor community. Additionally, the executing contractor presented planned technical activity for the next nine months. These meetings were technical workshops with open exchanges among the technical experts, which resulted in extensive technical interchange. The presentation of the planned technical activities for the next nine months was to inform and invite JSF WSCs and J/IST contractor involvement in upcoming efforts if they so chose. Generally, participation involved special analyses, reviewing, and providing comments on test plans.

Early on in the program, the suppliers were hesitant about briefing their technical work with competitors in the room. Often, a supplier or two had to leave so that a proprietary brief could be made. However, as technical results became available, the level of sensitivity decreased until a proprietary briefing was the exception rather than the rule. One got the impression that they wanted to broadcast their technical accomplishments.

In the initial phase of the program, face-to-face meetings were commonplace and encouraged. It helps to foster good working relationships if individuals have met and developed a relationship. This helped to build a team spirit because you got to meet and know your technical counterparts in the industry. To nurture this J/IST team spirit, after business hours social events were commonly scheduled in conjunction with IPT meeting and major program reviews. These events ranged from cookouts to dinners together at a local restaurant with local character. These were always arranged and paid for by the individual, never at contract expense. As the program progressed, the approach of choice for IPT meetings, technical planning, and the executive council were electronic meetings via meet-me telephone calls with pre-distributed documentation. At the end of the program, face-to-face meetings were generally only to witness a J/IST major milestone or to attend a TIM. The technical details and results of the various J/IST maturation activities are documented in the technical reports (Refs. 21, 23, 24–31).

Summary

The J/IST demonstration program was a highly successful technology maturation program that made available to all three JSF aircraft design teams the technical data, risk reduction, and demonstrations that allowed them to assess and, as appropriate, use this integrated technology. The information and demonstration results were made available to all JSF WSCs to implement into their competitive JSF aircraft design, as applicable. In fact, the integrated technology matured in this program has transitioned to the F-35 aircraft. The approach used in the J/IST demonstration program enabled one effort to serve all.

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