Invited Paper
"The History of the Joint Directors of Laboratories (JDL): Data Fusion Group."
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ABSTRACT

This Presentation and paper will address the history of the Joint Directories of Laboratories (JDL), established in 1982; the history of the JDL Technology Panel for C3 (TPC3) and the origins and history of the JDL Data Fusion Subpanel, later redesignated the Data Fusion Group. The Objective of the presentation is twofold:

1. To document the creation of the JDL, the DFS and the development of a US National and ultimately International Fusion Community for contemporary audiences who have very little knowledge of the difficulties, ups and downs and setbacks experienced by the community founders and the community itself over 40 years of evolution.
2. To set the stage for the follow-on plenary session papers, presentations and provide context discussions concerning the introduction and evolution of the JDL Data Fusion Functional Model which has been the seed crystal around which the Fusion Community has been built and evolved.

Authors note: This paper is not a technical paper but rather a cross between an historical essay and a personal memoir. The nearly 40 years of Fusion Community process has generated a lot of documents (hard copy notes, presentations etc.) many are still around, but a lot has been lost. Specifically, floppy discs, JAZ discs and other older removable media no longer function, or the files are inaccessible. Even when saved and accessible, electronic documents from early word processors (Wang), Apple MAC, and Microsoft can't be opened with current software versions. I have relied heavily on my memory, my notes, and many unpublished reports and community interactions. Therefore, some of the dates of events and individuals involved are potentially uncertain. Any errors of omission or commission are mine and opinions expressed are also mine and do not represent any official position of MSS, Navy, DoD, or component organizations.

SECTION I – JOINT DIRECTORS OF LABORATORIES HISTORY

The Joint Directors of Laboratories (JDL) was created by the Navy, Army, and Air Force in response to a 1982 Defense Science Board (DSB) study, which validated an earlier (1979) DSB study, in which it was found that:

- The three services' research and technology bases were not coordinated at the headquarters level.
- The various service laboratory investigators had no direct path to each other without bureaucratic permission.

- There was no coherent and coordinated program of Command Control and Communications (C3) research anywhere in DOD.

These findings, it was asserted, caused waste and duplication of the DOD technology base in all areas, but was particularly acute with Command Control and Communications (C3) research because it was stated that the supporting technologies were essentially service independent (with a few exceptions, such as Navy interest in underwater acoustics.). Furthermore, a lack of communication between the service's principal C3 investigators allowed very little leveraging of promising results between the services.

Both the 1979 and 1982 studies were chaired by Dr Robert J. Hermann. During Dr Hermann's career at the National Security Agency and his time as the Deputy Assistant Secretary of Defense for Communications, Command, Control, and Intelligence (DASDC3I) from 1977-1979 he developed a strong interest in the DOD research and technology base including the in-house laboratory component of that base. His initial study with the DSB was conducted as he was leaving his DASDC3I position and was awaiting installation as Assistant Secretary of the Air Force and, concurrently, as Director of the National Reconnaissance Office. In 1982 Dr Hermann was leaving Government to join United Technologies and the recently appointed Assistant Secretary of Defense for Communications, Command, Control, and Intelligence (ASDC3I), Don Latham, asked him to revisit his 1979 study, again with the DSB, presumably looking for progress on the 1979 recommendations. The 1982 study showed little or no progress and, as noted, validated the earlier study report. ASDC3I Latham took these finding seriously and since the new Reagan administration was pushing for change, the study recommendations got traction across DOD. It was this DSB study's 1982 report, which has been widely referred to as "the Hermann Report".

The Hermann Report acknowledged that many of the service labs were doing good work and that much of their work was specific to the individual services needs and requirements. However, in the basic research domain (6.1,6.2 and 6.3 funding lines) the report cited duplication and research that potentially had broad application across all services, but due to the lack of coordinating mechanisms and communications channels this research wasn't being shared or made available to researchers from other services. The report was particularly critical of the Command Control and Communications (C3) domain and the service's C3 laboratories. Again, the Hermann report acknowledged that there was significant worthy research happening at all the C3 labs, but too often in isolation. The DSB, given the increasing emphasis on Joint Warfighting, surfaced the idea that having a single Joint C3 laboratory would address the isolation and duplication problems in basic C3 research and help identify and focus research which potentially had Joint applications. The implication was creating a new DOD Laboratory that would be funded by capturing the services 6-1-6.3 funding lines and administering them as a Joint research program. Since the ASDC3I was taking the report seriously and suggested an intent to act on the recommendations, the Services, alarmed at the prospect of losing their in-house C3 laboratories and substantial amounts of 6.1-6.3 funding, reacted, proposing an alternate solution to the Hermann reports findings.

The alternate proposal was to create a senior level organization to ensure communication, coordination and "jointness" across each of the services laboratories. This very senior organization was to be led by the Four-Star Acquisition Chiefs of the Army, Air Force and Navy. The organization stood up as the Joint Directors of Laboratories (JDL) in late 1982 with the then Chief of Naval Materiel, the Commander, Air Force Systems Command, and the Commanding General, Army Material Command designated the principals (Note: There was apparently a Joint Directors of Laboratories created in 1974 but the author did not pursue that instantiation since it has no bearing this history). The 1982 action constituted reactivation and a major rechartering of the JDL. Each service had two representatives, a Flag Officer, and a civil servant. The Navy designated the Director, Navy Laboratories to be the civilian representative to the JDL. In the early meetings, the JDL formed several Technology Panels (TP), including robotics, high performance computing, electronic warfare, and C3. Although the Hermann report didn't propose a new Laboratory structure for deficiencies in all technical areas, but highlighted C3, the JDL still chose to stand up TPs in all areas in which the Hermann Report findings might apply. This broad approach was done to prevent a DOD "takeover" of the services 6.1 through 6.3 funding lines (which was recommended for further study by the Hermann report).

THE JDL TECHNOLOGY PANEL FOR C3 (TPC3) - HISTORY

The JDL directed that the Technical Panel for Command Control and Communications (TPC3) would consist of the Technical Directors of the three service C3 laboratories: for Navy, the Naval Ocean Systems Center (NOSC); for the Air Force, the Rome Air Development Center (RADC): and for the Army, the Communications-Electronics Command (CECOM). To be complete in the history, all these Laboratories still exist in some form and are still C3 laboratories. Navy's lab is now the Naval Information Warfare Center, Pacific (NIWCPAC), the Air Force lab is Air Force Rome Laboratories (AFRL Rome) and Army is still CECOM, although they have relocated to Aberdeen, MD from Ft Monmouth, New Jersey. The driving rationale for this membership, rather than the Service's Washington based sponsors, was that the C3 Laboratory Technical Directors had day to day visibility into the technology work performed by their laboratory/centers, which in every case, included considerably more basic research work than was funded by the various service headquarters agencies. For example, the Office of Naval Research (ONR) controlled 6.1 and 6.2 funds and the Office of Naval Technology (ONT) controlled 6.3 funds for Navy. However, NOSC while executing programs and projects for ONR, also received significant research funding from the Defense Advanced Research Projects Agency (DARPA), Defense Communications Agency/Defense Information Systems Agency (DCA/DISA), other DOD agencies, and importantly Intelligence Community sources. This was an important decision by the JDL considering the Hermann report findings for a lack coordination and sharing of C3 research across the whole spectrum of work being performed at all three laboratories. The JDL apparently reasoned that the collaboration process needed to get out of Washington and the laboratory directors could, with less effort and by side-stepping the bureaucratic hurdles inherent in the National Capitol Region (NCR), accomplish significant coordination and leveraging of technology at the working level.

The TPC3 hit the ground running. The Lab Directors, Bob Hillyer (NOSC), Fred Diamond of Rome and Ted Pfeiffer (CECOM) enjoyed each other's company and relished their charter. They elected to meet quarterly whenever possible and at a meeting in early 1983, decided to rotate the "Chair" between each of the Technical Directors every two years. Later that year, the TPC3 decided to create a program of technology leveraging and demonstration, as well as a program of basic research in C3. A full-time program manager, Mr. Victor Monteleon, was selected from NOSC, largely because NOSC's administrative structure facilitated moving money between the services and among various contractors as required.

In early 1984, the TPC3 briefed their program proposal and asked the services' research and technology agencies for funding, receiving commitments from each. Then, as required, the TPC3 briefed ASD C3I presenting their program and the funding agreements from the Services. Don Latham himself took the briefing and having been skeptical that the TPC3 (and perhaps the JDL) could ever accomplish anything, was impressed with the progress and the idea of a collaborative program with funding commitments from the services. He was pleased and since stories differ, either offered, or when asked, agreed to provide matching funds to broadly leverage the C3 research and technology work going on at the laboratories/centers as well as that funded through the centers to universities and contractors. He went further and had his staff set up a regular funding line in the budget to continue ASDC3I support.

Consequently, the TPC3 was unique among all the JDL Technology Panels because it had an approximate $5.0 million annual budget, and an ASDC3I charter to perform work to advance the cause of Joint C3. Sponsored by both ASD C3I and the service research and technology agencies, the TPC3 was able to put in place a structure and program that was exactly in the spirit of the recommendations of the Hermann report.

With approvals and funding lined up and importantly the backing of the ASDC3I, the TPC3 authorized its Program Manager to implement the program and establish:

- The Basic Research Group (BRG)
- The Technology Applications and Demonstration Group (TAD)
- Four subpanels focusing on what were perceived as driving issues in Joint C3. They were:
    a) ELINT Correlation Subpanel- which became the Data Fusion Subpanel and later the Data Fusion Group
    b) Networks and Distributed Processing Subpanel
    c) Decision Aids Subpanel
    d) Dynamic Spectrum Management Subpanel (later dropped)

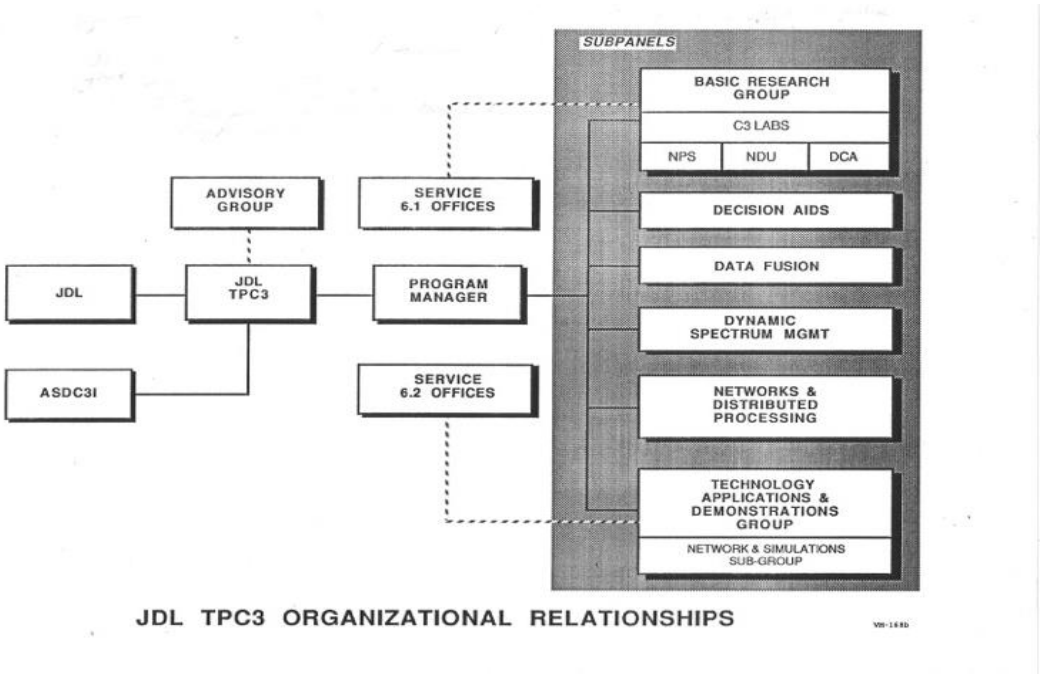


Figure 1

Figure 1shows the organization of the TPC3 program with two action groups. The Groups and Subpanels were to plan, and with the Program Manager oversight, execute the program. The TPC3 was to conduct quarterly reviews and report out to the JDL biannually. The ASD C3I was invited to all reviews.

IMPACT OF ORGANIZATIONAL AND PERSONNEL CHANGES

As happens in government and commerce, personnel and organizational changes occur frequently and can have both positive and negative effects. In case of the JDL, the JDL structure itself didn't last long. Established in 1982 the four-star heads of acquisition had put in place some effective organizations perhaps the most effective was the TPC3 which was up and running in 1984 and continued with good effect into 1988. However, the JDL itself lapsed when in May 1985, with the retirement of ADM Steve White, Navy Secretary Lehman disestablished the Navy Materiel Command, and eliminated the four-star billet of the Chief of Navy Material. Material acquisition responsibilities were distributed across the lower-level Systems Commands who then reported directly to the Chief of Naval Operations (DCNO Logistics) rather than to a senior umbrella acquisition command.

The impact on the JDL was immediate with the senior Navy Flag Officer gone. The Senior Navy Civilian member of the JDL, the Director of Navy Laboratories who had been responsible for much of the execution for the JDL, was moved briefly into the Office of the Secretary of the Navy and then under the Chief of Naval Research, a two-star Rear Admiral. At this point the JDL structure was essentially abandoned as both the Navy flag and civilian representative were no longer

senior. Nevertheless, The TPC3 continued to meet and pursue its charter, primarily because of the strong support from the ASDC3I and staff, in particular, Tom Quinn (who would be acting ASDC3I on two occasions) and Al Lubarsky who provided ASDC3I oversight of the JDL and in particular the TPC3. ASDC3I realized that none of the Joint Service C3 coordination and cooperation had existed prior to the creation of the TPC3 and it would not have transpired had the TPC3 not aggressively pursued its charter to correct the deficiencies identified in the Hermann report.

With the demise of the JDL as originally constituted, the objective of having the Technical Directors of the C3 Laboratories provide coordination and lead at the working level was eroding. While the TPC3 continued to function, a sequence of organizational and personnel events ensued which ultimately had the effect of undermining the TPC3 program.

> Ted Pfeiffer, the TD of CECOM retired, and although his replacement as TD, Tony Campi, became ARMY TPC3 member, it was soon passed to the next lower echelon of CECOM.
>
> Bob Hillyer, TD of NOSC retired and was replaced as the TPC3 Navy member by Sherman Gee, Office of the Chief of Naval Research (OCNR). This move meant the Navy laboratory now had no direct voting member of the TPC3, although Dr Bob Kolb, NOSC (code 40) was designated as Dr Gee's alternate.
>
> Dr Fred Diamond retired as Chief Scientist of Rome Labs and was replaced by Ray Urtz at a lower level of management.

The Subpanel structure also evolved over the years. Fairly early, the Dynamic Spectrum Management Subpanel was dropped, a Radios and Links Subpanel was added, and Networks and Distributed Processing was split into two subpanels...Wide Area Networks Subpanel, and Distributed Processing Subpanel and the ELINT Correlation became the Data Fusion Subpanel (later became a Group).

As the JDL TPC3 continued to function, the subpanel structure evolved as follows:

- The Basic Research Group (BRG)
- The Technology Applications and Demonstration Group (TAD)
- Subpanels evolved focusing on what were currently thought to be driving issues in Joint C3. They were:
  a) ELINT Correlation Subpanel- which became the Data Fusion Subpanel and later the Data Fusion Group
  b) Networks and Distributed Processing Subpanel was split into 2
     - Wide Area Networks Subpanel
     - Distributed Processing subpanel
  c) Decision Aids Subpanel
  d) Dynamic Spectrum Management Subpanel was dropped.
  e) Radios and Links Subpanel (added)

Resulting in the following structure, circa 1988, with still two action groups, now five subpanels:

- The Basic Research Group (BRG)
- The Technology Applications and Demonstration Group (TAD)
- 5 Subpanels:
  f) Data Fusion Group
  g) Wide Area Networks Subpanel
  h) Distributed Processing subpanel
  i) Decision Aids Subpanel
  j) Radios and Links Subpanel

In the JDL's original concept for the TPC3, the hope had been to keep the Washington acquisition bureaucracy out of the working level cooperative program, which would be run by the Lab directors themselves. With the Laboratory/Center Tech directors retiring and responsibilities shifting to subordinate levels the concept was weakened. Further, the Navy's structure was evolving and though ONR itself was never planned to be part of the JDL structure (since it was a research and technology sponsor and, thus, an advocate for specific work), it became the Navy JDL TPC3 representative when the Director of Navy Laboratories was moved to Chief of Naval Research upon disestablishment of Chief of Navy Material in 1985 and then in February of 1986 moved again from OCNR to Commander, Space and Naval Warfare Systems Command (COMSPAWAR). Even with Bob Kolb (NOSC department head and later Executive Director) as alternate, the JDL TPC3 management model was broken. The TPC3 of the Joint Directors of Laboratories no longer had Laboratory Directors as principal members.

While the above discussion illuminates Navy's Acquisition and RDT&E evolution, similar structural changes were happening at the laboratories all the services. The turmoil that swept up the JDL and JDL TPC3 was due to renewed concern and scrutiny by Congress and the Secretary of Defense about duplication of effort and multiple layers of management in the Defense R&D organization. These concerns included many of those of the Hermann reports of 1979 and 1982, but new investigations, studies and assessments were initiated. Still, amid the tumult, the TPC3 program, with ASDC3I support (and funding) continued to execute and had remarkable success considering the erosion of the management structure above and within the TPC3. Between 1984 and 1988, here are some of the highlights of TPC3 program activity:

- Initiated and conducted an annual C2 Research Symposium
- Initiated and conducted an annual Decision Aids Symposium
- Created a national Data Fusion community, and conducted an annual Data Fusion Symposium
- Developed the JDL NET, a multi-lab network of computers and battle simulators to drive and conduct joint exercises and technology demonstrations.
- Conducted the Joint, Distributed C3 Experiment in which various technologies for distributed C3 were evaluated.

- Developed a prototype Joint Air Strike Planning tool (Project Juniper), which was a forerunner of collaborative strike planning software.
- Developed and conducted a Joint program of basic research in C3 theory and methodology. This program was executed by the Service labs, the Naval Postgraduate School, National Defense University, George Mason University, and MIT.

The Defense Science Boards of 1987 and 1988 and the Congressional Office of Technology Assessment (OTA) in 1989, were all dedicated to scrutiny of Defense RDT&E and all reported problems with defense technology base management with recommendations for action. During the DSBs and OTA investigations, in late 1987, the Director of Defense Research and Engineering (DDR&E) declared that there was still too much duplication of effort between the services technology bases, and directed the services to report progress jointly, rather than on an individual service review basis.

The services responded to the DDRE directive by reconstituting the Joint Directors of Laboratories model, albeit at a lower level, with a "JDL" made up of the Deputy Chief of Staff : Science and Technology, USAF Material Command; the Commander of the U.S. Army Research Laboratory (Major General-2 stars) and the Chief of Naval Research (RADM – 2 Stars), This JDL reported to the Joint Logistics Commanders which were the former JDL members, but with the CNO office of Logistics, in place of the defunct Chief of Navy Material. This "new" JDL also worked from the earlier JDL model, setting up panels, this time however identified as "management" panels for technology areas and reporting out to DDR&E. This structure was titled "Project Reliance" "and the plan submitted to the Service Assistant Secretaries of Research Development and Acquisition in March 1991. After study, Project Reliance was implemented in November 1991 requiring the Reliance panels to meet, publish the Joint Services Program Plan (JSPP) and conduct annual reviews. The annual reviews were to be topical, and it was left to the services to choose their topical structure. In C3, Project Reliance chose to copy the TPC3 subpanel structure, and named, as its principals, the existing principal members of the TPC3, except for the Navy.

The Navy was initially directed by ASNRDA not to participate in Project Reliance, perhaps since Navy's own RDT&E restructuring was going on in late 1991. In January 1992, the various Navy R&D centers were joined to become Navy Warfare Mega Centers with each "Center" attached to the appropriate Systems Command (NAVAIR, NAVSEA, SPAWAR). By the same action, the Director of Naval Laboratories office was disestablished. Thus, the new Navy "mega centers" no longer had a single advocate, each "Center" reported to a separate Systems Command, and the senior civilian member of the JDL was gone, further breaking down the TPC3 concept of programs executed by independent laboratories. However, the Navy, despite ASNRDA direction not to participate in Reliance, through NOSC's history with the TPC3 structure, was able to participate "unofficially" on the C3 and related technology panel. I believe the ASNRDA withdrew their objection and in early 1992 Project Reliance became "Tri-Service Reliance" with Navy participating for the duration of Reliance.

The TPC3 began publishing their Joint Services Technology Program Plan (JSPP), in which each of the services work was related to the Reliance (and TPC3) structure. The outcome of the Reliance

management focus was to change the direction of the TPC3 subpanels from technology leveraging and demonstration projects to designating lead service/supporting service roles for technology areas, the creation/identification of joint technology initiatives, bookkeeping, and reporting. Technology sharing became less important than redundancy elimination. Although still called the TPC3, the panel was forced to abandon its shared technology, project-oriented approach that had brought them success. Although the Army and Air Force representatives to the TPC3 were still from their principal C3 Labs, the Navy's principal member was from the OCNR, and the alternate from the Navy Lab.

Under continued pressure to eliminate redundancy and with technology leveraging no longer the primary goal, Project Reliance/ Tri-Service Reliance and the JSSP approach where the service panels of Laboratory reps would produce a Joint plan didn't last long. The ASDC3I and DDR&E then created a series of oversight panels reporting directly to DDR&E. The panels roughly corresponded to the JDL Tech Panels, but the principal representatives now were ONR, ARL and AFOSR managers. At this point, the JDL idea of having the Laboratory Technical Directors manage resources and ideas in new, innovative, and collaborative ways was completely lost. Contrary to the ASDC3I and JDL vision of 1982, even though service laboratory/center personnel participated on the new panels, the decision power was again in the hands of the Washington bureaucracy. The JSPP was replaced by the DDRE Technology Area Plan (TAP). Although the TAP nominally served the purpose of the JSPP, the TAP was a DOD document. The JSPP was produced/published by the TPC3 (however constituted) and embodied the service's blueprints for cooperation. Conversely, the TAP, even though Service Labs/Centers participated, provided DOD, specifically DDR&E direction, a profound change. The JDL concept having been eroded; the JDL name generally faded away as well.

NOT ALL WAS LOST!

In the turmoil and restructuring of the JDL, the independent funding line item set up in ASDC3I for TPC3 initiatives was repeatedly threatened. Fortunately, ASD3I retained and protected this funding line and in 1994, ASDC3I created the Command Control Research Program (CCRP). The CCRP was run out ASDC3I by Dr. David Alberts, Director of Research in the OASDC3I, working closely with the National Defense University (NDU). This program continued the TPC3's Basic Research Group functions, addressing a key finding from the Hermann report, i.e., the paucity of basic research in Joint Command, Control and Communications. However, management of the program moved away from the service laboratories, but they continued to participate on many levels. The CCRP continued to perform advanced C3 basic research and expanded the initial JDL BRG's conference into the very successful annual Command and Control Research and Technology Symposia (CCRTS), even going international (ICCRTS). The CCRP continues successfully funding and documenting broad areas of C3 research, producing many useful books, pamphlets, and other material.

On the downside, since all the former JDL ASDC3I funds were necessarily rolled into the CCRP, the remaining JDL TPC3 initiatives were lost or forced to find other funding. With that alternative funding some TPC3 initiatives continued under the restructured DDR&E program and achieved

success. Specifically, the joint SPEAKEASY RADIO development and the Tri-service Distributed Computing Environment. JDL TPC3 coordination through the Decision Aids Subpanel led to several joint collaborative planning and decision support tools, which have been funded (primarily by DARPA).

The loss of JDL TPC3 funding did not impact the DFG, since we had never received much in the first place. However, the changes to the JDL structure and leadership, particularly the shift to DDR&E oversight cost the DFG high level backing. Initially the DFG Chair and other members participated in developing the JSPP but the increasing search for redundancy elimination interfered with the Groups community goals and the DFG participated less and less and by the mid 90s faded away. However, DDRE Charles Holland helped point The Fusion group to like some like-minded groups which benefitted the DFG's future. The evolution of the Data Fusion Sub-panel under the JDL TPC3 will be addressed in Section II.

SECTION II – THE HISTORY OF THE JDL DATA FUSION SUBPANEL

The above summarizes the history of the Joint Directors of Laboratories and the origins of what became the JDL Data Fusion Group and the National Symposium of Sensor and Data Fusion, now the National Security, Sensor, and Data Fusion conference. Interestingly, the Joint Directors of Laboratories (JDL) name survives in active use, but almost exclusively, in conjunction with Data and Information Fusion and specifically, the JDL Data Fusion Model. There have been requests over the years for an explanation of the Joint Directors of Laboratories and the association with Data and Information Fusion. Section I provided a history of the JDL, its initiatives and evolution including reference to the Data Fusion Subpanel when appropriate, this section will address the history of the Data Fusion Subpanel and its evolution to present, un detail. As noted in Section I, Data Fusion was a topic of sufficient interest that it was one of the original Subpanels and the only one that has survived, in a recognizable form, from 1984 to the present.

The DFS was born as the ELINT Correlation Sub-panel in the original program plan created by the JDL TPC3 in 1984. The ELINT Correlation Subpanel held its first meeting in late 1984 in conjunction with a TPC3 meeting at Rome Labs in Rome, New York. The original Subpanel members were Jim Tremlett of Rome Labs, Marty Wolff of CECOM and Frank White of NOSC. At the time, automation of the signal detection, de-interleaving, classification, and reporting from intercepts of Radar signals (ELINT) was undergoing exponential growth, with thousands of intercepts daily in an area of interest. Operators trying to use this firehose of data were being overwhelmed. I was managing two programs trying to automate the process for some Radars of interest and Jim and Marty both were working in this domain. Once identified, we all communicated in preparation for the meeting, and over the first days of the meeting, laid out a strategy for cooperatively addressing ways to improve the manual process of correlating ELINT intercepts and developing tools and mechanisms for automating at least some of the identifiable steps. The Sub-panel prepared a plan to leverage ELINT research and development from across the Services and Intelligence Community and proposed a way forward. When we

briefed the JDL TPC3, Ted Pfeiffer, Tech Director at CECOM, Dr Fred Diamond TD at Rome and Bob Hillyer of NOSC, the plan was accepted with a caveat, Fred Diamond asserted that ELINT Correlation was a small subset of a much larger problem, specifically, the Fusion of data from all kinds of sensors and sources into information that could be actionable for decision makers at all echelons. Our title and our focus were much too narrow and henceforth, by direction of the JDL TPC3, we would be known as the "Data Fusion Subpanel" or the DFS. The members of the subpanel were stunned, having devoted time over some months and finally two intense days preparing our plan, but Dr Diamond and the entire TPC3, complemented the plan we had developed, but were unanimous that our focus was too limited. The Subpanel needed to build on the current plan but expand the scope going forward to reflect the true nature of the problem.

This change and the implications of the broadened scope to somehow address all of Data Fusion was intimidating to the Sub-panel. But personally, it was an eye opener. Because of my Navy background in underwater acoustics and Naval Intelligence, I had been a Fusion practitioner including using some of the earliest available algorithms and tools for automating Fusion for over 15 years. Still, I had totally missed the broad spectrum of the domain and Fred Diamond's ideas resonated with me. Jim Tremlett was primarily interested in correlation of COMINT externals and to some level ELINT but was less interested in the broader scope. Marty Wolfe was interested principally in artificial intelligence research and while he could see that AI would play a role in the Fusion, he was concerned that the broadened scope would divert him from his primary focus. Over the next few meetings, it became clear that being on the DFS would be a time-consuming, potentially diverting collateral duty that would involve traveling for quarterly meetings at least and probably a lot more. As a result, Jim and Marty elected to be replaced on the panel and fortunately Len Converse from Rome labs and an Army representative (perhaps Larry Cook) and later Richard Antony from the Army laboratory at Vint Hill, VA. stepped in. All of us were strongly attracted to the notion of the expanded Fusion charter and the Data Fusion Subpanel was formally established in 1985. As the DFS hashed out a way forward, it became evident that three individuals were wholly inadequate to address the subject and the Subpanel would have to reach out to the broader community, not only among government agencies, but industry and academia as well. On a personal note, the idea of expanding the sub panel was facilitated by some serendipitous events.

- Jim Llinas, in San Diego on other business in 1985, stopped by NOSC to visit his old friend, Vic Monteleon, who happened to be the JDL TPC3 program manager. In their discussions, Jim expressed his interest in data fusion and was promptly dragged into my office. Jim at the time was at HRB Singer and as we discussed fusion, we realized how much we had in common, centered around a passion for Data Fusion.
- About the same time in 1985, the Navy funding sponsor from the Navy Electronics Systems Command (NAVELEX) informed me that NAVELEX had sponsored a fusion conference in early 1984, chaired by Mr. Otto Kessler at Naval Air Development Center in Warminster, PA. We were informed that there would no funding for travel or other contributions the DFS unless Otto was included. I called Otto and invited him to our next meeting, where we discovered a common thread in the passion for fusion.

The creation of the Data Fusion Subpanel acted like a seed crystal dropped into a supersaturated solution, a surprising number of individuals from across the services, agencies, academia, and industry had been working on Fusion problems for years, often in relative isolation, and many were fervent about solving Fusions problems. Early in the existence of the DFS, the group reached out to Industry, Academia, and researchers from various agencies to join or brief the group. Many researchers were attracted to the DFS as it reached out to gather information. Initially the DFS grew by adding Jim Llinas and Otto Kessler as "associate members" since the DFS was a U.S. Government organization and under ASDC3I and the JDL TPC3 charter the responsibility for management of the Subpanel rested solely with the three designated representatives from the Service Laboratories. As more individuals from across a range of organizations became involved, the informal "associate" became unwieldy and the DFS petitioned the TPC3 to expand official membership. The petition was granted to add members, but voting members had to be U.S. Government employees but most "associates" could now be official members. In 1987 Otto Kessler was officially added as a second Navy representative. Additional members from Navy (later Mark Owen); Air Force (Mike Hinman, Joe Antonik, later Eric Blasch); Army (Kim Langdon, Joe Karakowski, Bennett Hart, Larry Cook, later Ray Freeman, Dale Walsh); were added along with official representation from NSA (Fred McHugh, Dick Napolitano, David Lange); DIA (Sam Fisher); CIA, the Intelligence Community Staff (Richard Baer, LtGen. Norm Wood) and the Office of the Assistant Secretary of Defense for Intelligence (OASDI – Richard Baer). Members from industry and academia continued to be added, some as "associates", others as members, in particular, Dave Hall, Ed Waltz, David Noble and Alan Steinberg were early active members who made major contributions. The distinctions were immaterial as the collegial group seldom held an official vote; decisions were made by consensus across the expanded panel. The TPC3 program also provided funding for a Subpanel secretary, essential to documenting discussions and decisions, a role ably filled by first, Clancy Hatleberg and then for most of the time the DFS was active under the TPC3, Bill Doig. If I have forgotten any individuals and I am sure that I have, I apologize, Figure 2 shows the composition of the DFS circa early 1987.

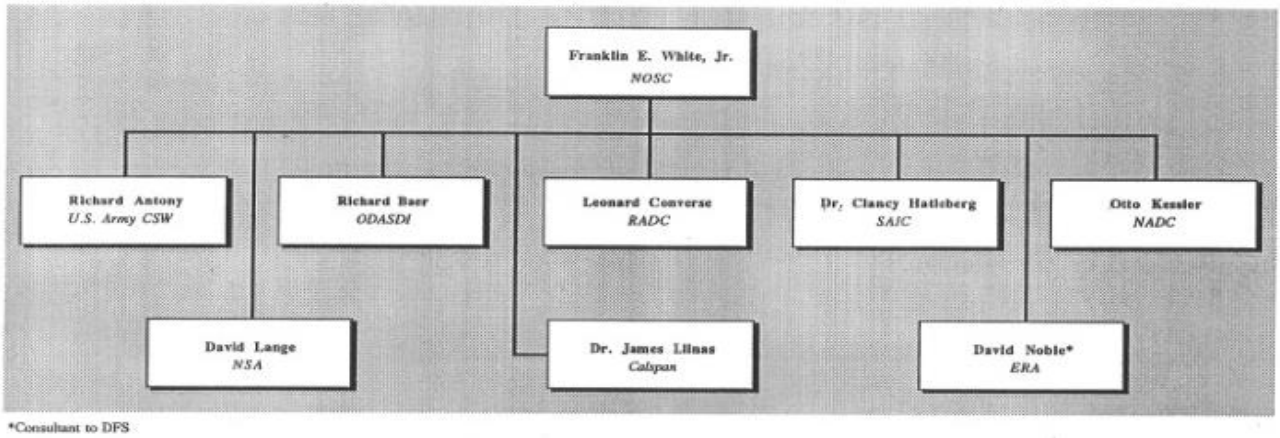


Figure 2 Data Fusion Subpanel (1987)

The DFS began to appreciate the scope of the fusion domain and the number of fusion research projects and programs that were being conducted across multiple communities. Each of these efforts was trying to solve some aspect of sensor or information fusion, from researching sensors, creating an algorithm to building a fusion tool or even a fusion "system". Much of this effort was happening without understanding what anyone else might be doing or what aspect of the Fusion problem was being addressed. As the expanded DFS wrestled with ways to approach addressing Data Fusion, writ large, they moved progressively toward a fundamental decision which impacted their success but constrained their resources. Exactly when the decision was made is lost to memory, but the group decided that the DFS would not take on a project of building fusion systems, tools or even algorithms, but rather focus on developing a data fusion community. This decision had profound effects. First, the decision not to have a Joint "build something" project cut the DFS off from nearly all TPC3 funds which were, by direction, project oriented. Conversely, it took the DFS out of competition with the researchers and developers working in the domain, facilitating open sharing. This was particularly important with the Joint Tactical Fusion Program Office (JTFPO), that by Congressional charter was building the Fusion System (ASAS) that would, when fielded, solve Fusion for the Joint services. The DFS decision, resolved some initial conflict between the JTFPO (primarily its senior management) and the Data Fusion Subpanel. The JTFPO contributed two members (Bennett Hart and their cryptological lead, Larry Cook) who became active members of the DFS. Also on the plus side, the decision earned us the respect and strong backing of principals in the office of the ASDC3I, Mr. Al Lubarsky and Mr. Tom Quinn (Quinn served twice as the acting ASD C3I in the Reagan administration). This high-level backing continued and provided the DFS with immediate recognition and the perception of the DFS as a safe place to brief and coordinate Data Fusion research and programs.

Having made the decision, the subpanel had to decide how to develop a Data Fusion community, decide what activities would be essential in the process and gain the approval of the JDL TPC3. The TPC3, concurred with the DFS decision and requested the group develop a charter. The DFS charter stated:

"The purpose of the DFS is to enhance the efficiency of individual and Joint Service data fusion programs through the exchange of technical information, the enhancement of coordination and cooperation between related research efforts, and by initiating new multi service cooperative research programs and technology demonstrations. Accordingly, the JDL TPC3 has sought out recognized experts in the field of data fusion to serve as members of the DFS."

With the charter and the ability to expand membership as required, the DFS began the community building efforts, many of which continue to present. The scope of the community building task was potentially overwhelming, so the group decided to begin by kicking off an evolutionary process that could lead to a more complete understanding of Data Fusion. To accomplish this the group undertook the following:

1. Developing of a functionally oriented Data Fusion model to provide a common frame of reference to relate many levels of understanding regarding Data Fusion.

2. Providing a definition of Fusion and a lexicon to define terms to enable the community to converse in a common framework.
3. Developing a Taxonomy of Fusion techniques and activities to allow a common understanding of Fusion endeavors.

The Subpanel wrestled with these tasks over the early years their existence. The most significant of their endeavors was the development of what has become the JDL Data Fusion model. Since the evolution of the model and its continuing impact is the subject of another paper and discussion in this plenary session, suffice it to say that numerous illustrative models were proposed and discussed from 1985-1987 with the first consensus model published in 1987/1988 with feedback and revision over the next several years, leading to what has been called the "original" JDL model published in 1991. The evolution continues with revisions through community interaction and feedback to the present. The Model process was instructive and central to the Panels work for years, providing a framework for understanding data fusion needs, the role of data fusion, and organizing the data fusion environment. However, there were other elements the DFS considered that a vital, active technical community should have. In their thinking, the DFS identified three constituencies of the data fusion community that rarely interacted:

- Mathematicians and scientists working the fundamental mathematics of combinatorics and algorithm development.
- Practitioners in the field; the soldiers, marines, sailors, airmen and civilian analysts at intelligence centers, air defense centers, combat, and weapons control centers etc. All who were constantly performing fusion functions without necessarily understanding the underlying processes. When they were able to articulate needs and requirements, after analysis, they often turned to be a fusion requirement in the end. Their concerns needed to drive the fusion community.
- Program managers, computer scientists and software engineers building fusion tools into systems or building Fusion systems.

The DFS hoped to bring the three disparate groups together to have the beginnings of a community of interest. To do so the DFS proceeded to develop:

- A Community Forum: the establishment of the Tri-Service Data Fusion Symposium was one the most important community endeavors undertaken by the DFS, with the first Data Fusion Symposium held June 1987 and annually since, continuing today as the NSSDF.
- Some Defining Documents:
    - White, Franklin E. Jr., *Data Fusion Lexicon*, prepared for Joint Directors of Laboratories, Technical Panel for C3, Data Fusion Sub-Panel, Naval Ocean Systems Center, San Diego, 1987
    - The DFS also produced with Funding from the Office of Naval Technology, the *Functional Description of the Data Fusion Process*, November 1991. This is the where the "original" JDL Data Fusion Model was first widely published.

    - With the Office of Naval Technology, the DFS published the *Data Fusion Development Strategy*, January 1992, which included the first DFS Community Data Fusion Survey results.
- Encouraged writing Textbooks: There are now many but the first was a breakthrough:
    - Waltz, Edward and James Llinas, Multisensor Data Fusion, Artech House, 1990
- Encouraged the development of Academic Courses:
    - Courses in Data Fusion were established at George Mason University by Harry Van Trees and Dennis Buede.
    - Fusion Courses and a Research Center the "Center for Multisensor Information Fusion" (CMIF) were established at the University of Buffalo by Dr Jim Llinas

Over the years the Data Fusion Subpanel panel attempted to execute these functions but struggled to build the community, lacking funds for travel, conducting symposia, and other basic functions. Fortunately, strong support from ASDC3I and funding for critical organization functions (secretariat) from TPC3, the group achieved success. The support of ASDC3I provided top cover and created recognition of the subpanel's efforts. That and the dogged pursuit of funding by the members of the panel, in particular, Otto Kessler, through his contacts at the Office of Naval Technology (ONT) and his program at ONR were able to pull together funds to publish documentation and to put on not only the first Data Fusion Symposium in 1987, but with funds from various sources continue the Annual Symposium for the next 7 years.

As reported in Section I, the original JDL concept was crippled when Navy's Chief of Material was abolished in 1985. However, under ASDC3I, the evolving JDL and the TPC3 continued to execute their charter until the emergence of Project Reliance, after which, the TPC3 and other sub panels shifted their efforts toward oversight and Joint planning. The DFS, continued to prosper but became more isolated from Project Reliance, although the Chair and panel members reported periodically to Project Reliance. Under DDR&E, when the JDL was disestablished in 1997 and the evolved TPC3 became the Tech Panel for Information Systems Technology (TP - IST), the sub panel became more disconnected. The name was changed to the Data Fusion Group (DFG) and ultimately subordinated under the IST Decision Aids Panel. To support the IST work, the DFG expanded membership dramatically but there were essentially two DFGs, one supporting the DDR&E IST and the other the community building efforts. For practical purposes, the DFG chair and the expanded membership contributed to the Information Systems Technology Area Plan (ISTAP) and briefed the TPIST, but although Charles Holland (DDR&E) was attracted, there was little interest in the DFG's community objectives from most of the TPIST.

The DFG continued to meet periodically and expanded their community building vision, even as their connections to the evolving JDL/DDR&E superstructure were eroding community building efforts. As the TPIST effort wound down in the mid to late 1990s, the DFG realized that to reach the next level of community outreach, they would have to find another senior level, sponsored, organization, the ASDC3I, JDL TPC3 were no longer viable support. The DFG could not continue alone. The group had identified and was tracking a rapidly proliferating number of fusion efforts across all services, DoD, and Intelligence Agencies, but the survey work was overwhelming the

group, and issues of policy and advancing technology were not being addressed. At the same time the Data Fusion Model, Lexicon and Taxonomy were in widespread use. Feedback from the growing community was pouring in with suggestions for evolving the model, changing definitions, etc. and the DFG had no way of resolving them. Fortunately, the Data Fusion Group had continued to expand, and several members came from other coordinating groups that were directly or peripherally involved in Data Fusion. One group focused on Sensors and Sensor Fusion were already associated with an IAC, the Infrared Information Analysis Center (IRIA) and had been conducting a Sensor Fusion Symposium. To expand the community and unify the Organizational approach, Alan Steinberg (a member of both groups) spearheaded the effort to combine elements of the group's efforts, creating in 1996 a new organization and a single symposium and leveraging benefits of the IAC structure as shown in Figure 3

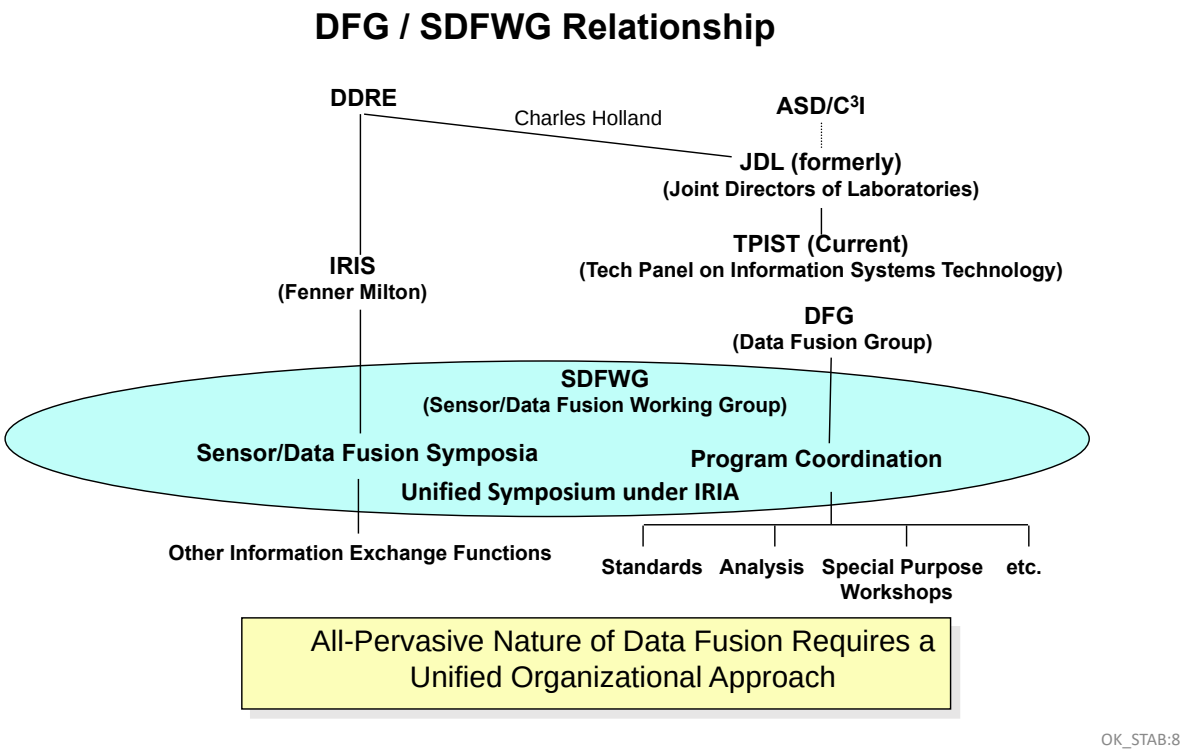


Figure 3.

This unified symposium became the National Symposium on Sensor and Data Fusion, which we know today as the National Security Sensor and Data Fusion (conference).

After a few years, this expanded DFG group decided a Data Fusion Information Analysis Center (DFIAC) was still necessary, since IRIA had limited resources to support the underlying infrastructure the DFG felt was necessary for the Fusion community. Specifically, the infrastructure was to accelerate operational introduction of data fusion by providing:

- A common environment for coordination and communication

- Standardization and interoperability support to key technologies (including inter alia; algorithm and software libraries)
- An environment for comparing benefits of alternative techniques (including inter alia; test data sets)
- Performance criteria for transition of products (including inter alia; MOEs/MOPS)

This was a tall order but the DFG and fleshed out the needs and detail and presented a formal proposal to DTIC for a fusion information analysis center, a FUSIAC, in 1999. The timing was bad since DTIC was under congressional review and was unable to create any new IACs. However, a virtual FUSIAC was established under the auspices of the InfraRed Information Analysis Center (IRIA) and the Information Assurance Technology Analysis Center (IATAC) and the NSSDF symposium went forward. In the meantime, DTIC was reviewing their IAC structure and moved IRIA and other Sensor IACs into a new IAC called the SENSIAC which now runs the Military Sensing Symposia (MSS), one of which is the NSSDF. This series of Symposia has been very successful and although the SENSIAC charter calls out sensors, sensor processing and sensor and data fusion, many of the objectives of the FUSIAC concept, inter alia, Fusion Community management policy, technology leveraging, and code/algorithm libraries have not been implemented. Although it was hoped the NSSDF would be a forum for continuing dialogue and a decision forum for the evolution of the JDL model and other community products and issues, that has not been the case. While community and fusion model issues are often presented at the NSSDF, the constraints of classification level, which excludes some important participants, and time, which doesn't allow thoughtful dialogue and the interchange of ideas needed to decide on a way forward with the model and other community issues. This is not the fault of the MSS or the NSSDF, but it begs the question of how to address pressing community issues in a community which is now international in scope, since members of the DFG working with IEEE established the International Society for Information Fusion (ISIF) in 1999.

These are important questions, the original DFS and follow-on DFG, when most successful met at least quarterly for three or four days in an environment conducive to study and dialogue, often including breakfast, dinner, and social time. The regular meetings and larger workshops, like the topical series at Beaver Hollow in New York and others, are what led to the breakthroughs in thinking that created the functional model, definitions, framing notions, products, and tools that we as a Fusion community use every day. However, the meetings also identified needs and challenges to our future success as a Fusion community which is part of the larger military and national endeavors requiring fusion capability. Many of the identified needs and challenges have not been met, nor do we have a forum to address them.

This is the brief history of the JDL Data Fusion Sub-Panel/Group. We should look to that history to guide the future, including the missteps and failings along the way of which there many. It would be desirable not to repeat them. Many of those who participated in the development of the Fusion Community are gone and most of the rest of us are aging. None of us knew what we were getting into when we started, nor that it would become a lifetime's effort. The work is not over, much is left to be done, but it is good work! Fusion for many of us has been about supporting our military, ensuring their safety and success. But Fusion now is important in

medicine, transportation, air traffic control, rail safety etc. … and it's of Global importance. Of course, it's importance has always been there, the truth is we are just discovering how vital Fusion is across the board. It is up to the new generation to carry the work forward and since I know many of you, I am reassured that the future is bright.