Lessons Learned from Information Superiority Experiment 1.1 (ISX 1.1)

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Abstract

ISX 1.1 was conducted in the Summer 1998 in concert with the USAF Expeditionary Force Experiment (EFX) 98. The broad objectives of ISX 1.1 were two-fold. Substantively, ISX 1.1 was to confirm the hypothesis that information from multiple sources could be fused into engagement quality data and distributed in real time to achieve joint suppression of enemy air defenses (JSEAD) mission objectives against mobile medium-to-high altitude surface to air missiles (SAMs). Second, since this was the first in a planned set of experiments, there was interest in deriving lessons learned to support the efficient and effective performance of future ISXs.

Based on an assessment of ISX 1.1, several significant experimental successes and residual challenges have been identified. These successes include the innovative use of models, the implementation of a creative experimental design, and the data collection efforts. The major residual challenges include the difficulties in "piggybacking" on other experimental activities and the importance in viewing an experiment in the context of a *campaign* in which a variety of assessment techniques are employed (e.g., model, test, model,...).

1. **Background**

In response to Joint Vision 2010 (promulgated by the Chairman, Joint Chiefs of Staff) [Joint Chiefs, 1996], a plan was generated by the Director, J6, Joint Staff, to conduct a family of Information Superiority Experiments (ISXs). These experiments were structured to address many of the highest priority issues identified during the Quadrennial Defense Review [Cohen, 1997]. To initiate this experimentation program, ISX 1.1 was conducted late in the Summer of 1998 in concert with the USAF Expeditionary Force Experiment (EFX) 98. The broad objectives of ISX 1.1 were two-fold. Substantively, ISX 1.1 was to confirm the hypothesis that information from multiple sources could be fused into engagement quality data and distributed in real time to achieve joint suppression of enemy air defenses (JSEAD) mission objectives against mobile medium-to-high altitude surface to air missiles (SAMs). Second, since this was the first in a planned set of experiments, there was interest in deriving lessons learned to support the efficient and effective performance of future ISXs.

In support of the second of these objectives, the Information and C2 Systems Technical Committee (ICS TC) of the American Institute for Aeronautics and Astronautics (AIAA)[1] volunteered to observe ISX 1.1 and to derive lesson learned to enhance future ISXs. The focus of the ICS TC activities was on the overall experimental *process* that was employed from a lifecycle perspective, vice the substantive assessment of the experiment's primary technical hypothesis. To realize that objective, representatives from the group were briefed on the planning for ISX 1.1 and EFX 98, observed the activities from multiple vantage points, and reviewed relevant after action reports. Based on these activities, several significant experimental successes and residual challenges have been identified.

2. **Primary Findings**

Three major successes were achieved in ISX 1.1. First, the ISX 1.1 planning team used models creatively to help design and plan the live experiment. By doing so, the team was able to provide insights into important JSEAD issues, suggest hypotheses, reduce the scope of the problem, identify critical parameters, suggest data to be collected, identify Measures of Merit to compute, and identify selected risks. Second, they designed the live experiments as a sequence of nearly independent opportunities. These mini-tests provided useful data even though few replications of the entire operational "threads" were achieved. Third, they learned valuable lessons about data collection. These included the appropriate composition of the data collection team, the kind of data to collect, and the appropriate methods to collect data.

The experience also underscored several challenges that remain to be addressed. First, the ISX 1.1 hypothesis was not tested adequately. This was due, in large measure, to shortfalls in backup planning (e.g., inability to cope with adverse weather, failures in technology initiatives) and insufficient training of participants. Second, the concept of "piggybacking" on EFX 98 proved ineffective. There are several reasons for this shortfall which will be touched on in the "Recommendations" section of this paper. It should be noted, however, that ISX 1.1 did not interfere with EFX and ISX 1.1 participation served to enhance EFX 98 (e.g., it increased EFX live fly, significantly; it added additional live fly platforms; it shared data collection, data, and lessons learned with EFX).

Many of the problems identified here have been observed and recorded in prior experiments. Since they have not been corrected, however, they are denoted as "lessons recorded". Hopefully, they will become "lessons learned" and acted upon proactively in future experiments.

3. **Selected Lessons Recorded**

The assessment of ISX 1.1 revealed that there are a host of potential problems that can adversely affect a joint experiment in the areas of planning, preparation, execution, data collection, and administrative actions. Although no single problem is generally "lethal" to an experiment, they can

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[1] The ICS TC of the AIAA is a group of approximately thirty senior representatives from the C2 community drawn from the government, industry, Federally Funded Research and Development Centers (FFRDCs), and academia. It focuses on the issues associated with creating, evaluating, and evolving systems of systems. Consistent with that focus, the group is currently developing a Code of Best Practice (COBP) for joint C2 experimentation for the Office of the Secretary of Defense.

be like duck bites. If you experience enough of them, the cumulative effect can be devastating. The following discussion identifies these “duck bites” in five key areas: planning, preparation, execution, data collection, and administrative actions.

3.1 ***Planning***

A total of seven planning issues were recorded based on observations of ISX 1.1.

• *Limit the Number of Initiatives Introduced*. Many members of the community regard events like EFX as an important showcase for their initiatives. As a consequence, in excess of 50 initiatives were subsumed within EFX, many of which were added very late in the planning process. There are several significant consequences of this trend. First, it substantially increases the amount of training needed by all participants in the experiment, and the time and resources needed to accomplish the training. Second, by introducing many unproved concepts, systems, and technology, it provides more opportunities for failure. This is particularly significant when the initiatives are on the experiment’s critical path. Finally, there is a significant scientific downside. Each initiative increases experimental variability and decreases the amount of control that can be imposed on the experiment. Consequently, it is recommended that the number of initiatives incorporated in an experiment be curtailed to a manageable level. In addition, a “Good Idea Cut-Off (GICO)” date should be established at least six months prior to the start of the experimental event and enforced rigorously.

• *Maintain Tight Control of the Master Scenario Event List (MSEL).* In ISX 1.1 players at key experimentation nodes had ready access to the MSEL (e.g., frequently, Air Operations Center personnel had knowledge about the schedule of attack aircraft flights, affecting their decisions). Closer hold should be maintained over this information to avoid confounding the results of the experiment.

• *Institute Enhanced Configuration Control.* Changes to key EFX systems were made as late as a few days prior to the start of the live experiment. For example, a new version of the Theater Battle Management Core System (TBMCS) was installed the week before the start of live fly. Such actions make it exceedingly difficult to implement and maintain configuration control on all the hardware and software that are employed.

• *Select an Adequate Test Range.* It is critical that a venue for the experiment be selected that provides adequate air and ground space. The Eglin AFB Range posed a number of problems that adversely affected ISX 1.1. First, the environment featured very flat, benign terrain and road networks that are not representative of likely operational environments. Second, restrictions were placed on threat radar emissions that limited the realism of their use in the experiment. Third, unmanned air vehicles (UAVs) were required to fly above 4Kft, far away from target vehicles. This made it nearly impossible to use these assets realistically, particularly given the heavy cloud cover that was experienced during the experiment. Finally, the geometry of the range was not representative of the sensor - threat ranges that would be anticipated operationally.

• *Schedule ISR Assets with Sufficient Slack Time.* Experimental artificialities called for selected critical radar emissions to occur at precise, specified times. However, on several occasions, the intelligence, surveillance, and reconnaissance (ISR) assets were not on station when those triggering events occurred. This demonstrates that, unless sufficient slack time is planned for, small scheduling mishaps can have exceedingly deleterious effects on experiments.

• *Schedule Offensive Information Operations Judiciously.* In a realistic environment, US C4ISR assets would likely be subject to Information Warfare attacks. However, the fragility of the experimental C4ISR system is such, that it is of dubious value to attack it during an experiment. If such attacks are deemed necessary, they should be scheduled to occur near the end of a game period to allow recovery during breaks.

• *Plan for Work Arounds.* During the course of the experiment, numerous problems were caused by adverse weather and equipment failures. These problems were compounded by the failure to anticipate such events and to develop back-up plans to mitigate their effects.

3.2 ***Preparation***

A total of four planning issues were identified based on observations of ISX 1.1.

• *Indoctrinate Participants on Experiment Objectives.* It is important to indoctrinate the players about the objectives of the experiment. In the absence of such an understanding, the participants are prone to revert back to the objective of “winning the war” or to consider the event to be a training exercise. Under those circumstances, they do not manifest the behavior that is appropriate to the evaluation of new operational concepts.

• *Schedule Adequate Training Time.* It is apparent that all of the participants in the exercise (to include, *inter alia*, the exercise director, the players, and data collectors) must be fully conversant about their roles, equipment, and processes before the experiment begins. However, this critical need is frequently the first casualty of experimentation as the press of time continually reduces the period that is allocated to this function. In addition, it is naive to merely allocate a fixed period of time for training. It is important to establish proficiency criteria that must be satisfied before the experiment begins. This was particularly important in EFX 98 where key individuals were deliberately assembled from across the USAF to foster innovative ideas. Thus, adequate training was vital to ensure that they could work together as an effective team prior to the beginning of the experiment.

• *Check Out Communications Prior to Live Fly.* At the outset of ISX 1.1, it soon became apparent that there was a lack of connectivity between several key nodes (e.g., between the Time Critical Target (TCT) Cell and the UAV ground site). A careful check out of the communications prior to the live fly would have served to identify those issues.

• *Establish and Maintain Time Synchronization.* During ISX 1.1 it was noted that the “official time” differed at key command and control nodes by +/- one minute. Since timelines were a critical element of the experiment, these discrepancies posed a significant problem in the analysis process. In the future, a single source of time (e.g., the Global Positioning System) should be employed by all participants.

3.3 ***Execution***

A total of three execution issues were identified based on observations of ISX 1.1.

• *Synchronize Live and Simulated Events.* During the first week of the experiment, the participants were exposed to an air picture that juxtaposed live flights (over the Eglin AFB Range) and simulated flights (in a hypothetical Southwest Asia scenario). The logical inconsistency between the live and simulated events posed significant problems for the participants.

• *Maintain an Equipment Status Board.* During the course of ISX 1.1, there was frequently confusion about the status of key systems, and the underlying reasons for problems. To deal with those issues a status board is needed that would identify those systems that are experiencing difficulties and the underlying reasons for those problems (e.g., adverse weather, mechanical problems, maintenance).

• *Establish a Responsive, Flexible White Cell.* There were several instances where a more responsive, flexible White Cell would have ameliorated execution problems. For example, on several occasions, the experiment controller arbitrarily made decisions, causing MSEL deviations, yet failed to announce the changes to the Assessment Team. In addition, there were cases where departures from the original plan could have been compensated for by manually inserting cues into the experiment. However, no mechanism was created to implement such manual over-rides.

3.4. ***Data Collection***

A total of six data collection issues were identified based on observations of ISX 1.1.

• *Provide Sufficient Data Collection Tools.* One frequently praised initiative during EFX 98 was the Collaborative Virtual Workstation (CVW). Participants, using this tool, were able to meet in virtual “rooms” in which they could plan collaboratively. However, observers who did not have access to CVW were unable to determine when important decisions were made or what information those decisions were based on. If these tools are to be used extensively in future operations, data collectors must have sufficient CVW terminals.

• *Install, Check-out All Data Collection Equipment Early.* Among the data collection assets employed during ISX 1.1 were computers, printers, recording devices, storage devices, communications, electrical outlets, dataforms, databases, and assorted software applications. The complexity of these assets is such that early installation and quality assurance is mandatory. To deal with inevitable malfunctions, it is critical that at least one trained technician be included with the assessment teams.

• *Train Data Collectors/Assessors.* In view of the complexity of the experimental process and the simulation tools involved, it is critical that data collectors and assessors are provided with adequate training prior to the on-set of the experiment. As one facet of the training, these individuals need a better understanding of the planned information flow and the activities being performed. This should provide them with “enhanced situational awareness” so that they are better prepared to react to unexpected developments.

• *Debrief Air Crews Using Assessors.* In several cases, air crews were subject to debriefings that were appropriate for an actual operational event or a training event. Thus, they did not capture key insights that were appropriate to an experiment.

• *Select Data Collectors/Assessors With the Proper Backgrounds.* In several instances, data collectors and assessors were selected who lacked the proper background for the tasks and who were unfamiliar with the key systems in the experiment. Consequently, they were not sensitive to key issues and were not attuned to some of the unique demands of the experiment.

• *Develop Rapport Between the Players and the Data Collectors/Assessors.* As one vehicle for establishing this rapport, data collectors should explain to the players the experiment’s objectives and data they plan to collect prior to the collection of real data.

3.5 ***Administrative Actions***

A total of six administrative issues were identified based on observations of ISX 1.1. Although many of these issues appear to be minor, they can undermine the viability of the experiment if they are not anticipated and dealt with adequately.

• *Take Care in Scheduling Live Fly Events.* EFX 98 was scheduled to take place in Florida during the hurricane season. Although the precise impact was unpredictable, it is not surprising that adverse weather severely degraded the quality of the experiment. As examples, Hurricane Earl truncated Spiral Three, curtailing training on new initiatives and concepts of operations; a subsequent tropical depression grounded aircraft on one afternoon of the experiment; and heavy cloud cover and rain prevented the UAV from imaging the tasked targets during several other runs.

• *Schedule Critical Targeting Events Judiciously.* Several time critical events (e.g., activities associated with simulated SAMs and SCUDs) were scheduled to occur at 1100 to 1230 local time. Unfortunately, many of the people in the TCT cell were at lunch during that period, reducing the cell’s ability to respond to the events.

• *Provide Assistance on Classification Issues.* During the course of the experiment , issues frequently emerged on what was classified and what was not. To deal with such issues, an authority on classification issues needs to be designated and made available.

• *Enforce Discipline in Issuing Badges.* In ISX 1.1, a restricted set of badge types was issued. These included distinctive badges for controllers, assessors, and participants/players. Unfortunately, many contractors and visitors were provided with participant/player badges. Thus, it made it difficult for data collectors to determine who/what they should be observing.

• *Impose Greater Control on Visitors.* Visitors frequently interfered with the play of the experiment and the collection of data. Even though it is difficult to impose control on such conduct if the visitors are quite senior, it is mandatory if a meaningful experiment is to be conducted.

• *Publish a Directory of Participants.* It was frequently quite difficult to communicate to other participants during this geographically distributed experiment. To ameliorate this problem, a directory is needed for key participants that provides key voice and FAX phone numbers (e.g., commercial, DSN) and e-mail addresses.

4. **Primary Recommendations**

Three primary recommendations were developed based on the ICS TC assessment. First, it is recognized that resource limitations will inevitably prompt future experimenters to "piggyback" on planned experiments or exercises. However, it is recommended that a piggyback approach should be attempted only if there is high level visibility and leverage; formal agreement to collaborate; sufficient influence on the scenario to tailor it; early involvement in the planning process; sufficient resources for training, data collection, and analysis; and a robust experimentation environment, including an adequate number and variety of experimental events, instrumentation, and free play. It must be emphasized that "piggybacking" is a viable concept only if it is perceived to be in the mutual self-interest of all parties (i.e., a "win-win" strategy).

Second, the experimental effort should be viewed as a campaign in which a variety of assessment techniques are employed and orchestrated (e.g., model, analyze, test, model,...). Consistent with this concept, adequate resources should be provided for the pre- and post-live test activities. In addition, the logical relationships among individual experimental events must be understood and documented through a campaign plan [Note: this concept is discussed at greater length. [MORS, 1999].

Finally, there is a need for a Code of Best Practices (COBP) to guide future joint C2 experimentation efforts. The ICS TC is in the process of developing such a COBP and it should be completed during the Summer 1999.

5. **References**

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