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SIMULATION-BASED MISSION REHEARSAL AS A HUMAN ACTIVITY SYSTEM

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Observations of the 58th Special Operations Wing (58 SOW) Weapon System Trainer/Mission Rehearsal System (WST/MRS) during rehearsals have clearly shown that mission rehearsal (MR) effectiveness is influenced by the activities of both the people who support the MRS and the people who use it. To explain this demonstrated importance of the people involved in MR, a human activity system model of simulation-based rehearsal was developed. It provides an integrated depiction of the MRS, and specifically addresses: (1) the context for rapid database development and simulation-based MR (crisis action planning) and how the MRS fits into it; (2) MRS components, functions and structure; and (3) processes that enhance rehearsal effectiveness. Implications of this human activity system view are discussed, including: places in the mission preparation process where simulation can benefit operations; the scope of human activities that are essential for successfull simulation-based MR; the potential value of MR to provide feedback concerning the adequacy of training to support mission requirements; and the need for new procedures throughout this extended scope of players to accommodate both MRS requirements and capabilities.

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PREFACE

The work documented in this report was presented at the 17th Interservice/Industry Training Systems and Education Conference (I/ITSEC), held 13-16 November 1995 in Albuquerque, New Mexico.

The report documents work conducted under Work Unit 1123-B3-01, Special Operations Forces (SOF) Aircrew Training and Mission Preparation Research. The Laboratory Work Unit Monitor is Dr Robert T. Nullmeyer, AL/HRAU. This effort is part of an Armstrong Laboratory, Human Resources Directorate, Aircrew Training Research (AL/HRA) program to provide behavioral research support for the Air Force Special Operations Forces (SOF) community. The AL/HRA program has two major thrusts: The first is to specify measures for effectiveness and principles of technology utilization in preparing for real-world missions. The second is to develop strategies for using advanced simulators and measuring their effectiveness in combat mission training. The results of this project services both of these thrusts.

SIMULATION-BASED MISSION REHEARSAL AS A HUMAN ACTIVITY SYSTEM

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ABSTRACT

Observations of the 58th Special Operations Wing (58 SOW) Weapon System Trainer/Mission Rehearsal System (WST/MRS) during rehearsals have clearly shown that mission rehearsal (MR) effectiveness is influenced by the activities of both the people who support the MRS and the people who use it. To explain this demonstrated importance of the people involved in MR, a human activity system model of simulation-based rehearsal was developed. It provides an integrated depiction of the MRS, and specifically addresses: (1) the context for rapid database development and simulation-based MR (crisis action planning) and how the MRS fits into it; (2) MRS components, functions and structure; and (3) processes that enhance rehearsal effectiveness. Implications of this human activity system view are discussed, including: places in the mission preparation process where simulation can benefit operations; the scope of human activities that are essential for successful simulation-based MR; the potential value of MR to provide feedback concerning the adequacy of training to support mission requirements; and the need for new procedures throughout this extended scope of players to accommodate both MRS requirements and capabilities.

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ACKNOWLEDGMENTS: This model benefited greatly from the help of many individuals. Our friend and colleague Phil Bruce introduced us to the concept of human activity systems and spent many hours discussing these ideas with us. Dave Harris (58 SOW/OGU) contributed considerable time and effort to the development of this model and was instrumental in specifying how the MRS needed to fit into SOF mission preparation. The Lockheed-Martin contingent at Kirtland AFB, the people who built the MRS and make it work, provided numerous essential inputs. Jack Kelly, Rex Corbin, Mike Phelps, Mike Scott, and others generously contributed their insights and knowledge.

SIMULATION-BASED MISSION REHEARSAL AS A HUMAN ACTIVITY SYSTEM

INTRODUCTION

Simulation-based mission rehearsal (MR) became a reality for the Air Force in 1990 when the MH-53J Weapon System Trainer and Mission Rehearsal System (WST/MRS) was delivered to the 542nd Crew Training Wing (now the 58th Special Operations Wing, or 58 SOW) at Kirtland AFB, NM by a group within General Electric (who have since become part of Lockheed-Martin). It was the ability of this government-owned, contractor-operated system to use "real world" photo-texture derived from imagery, combined with Defense Mapping Agency (DMA) terrain and cultural feature data, that provided the Special Operations Forces (SOF) and Combat Search and Rescue (SAR) forces their first MR capability (Reed, 1993). This use of simulation added a level of realism to rehearsal that is not duplicated by other media. Planners have access to three-dimensional, computer-generated imagery based on Defense Mapping Agency data enhanced with cultural features and other details from a variety of sources, and mission participants can interact with other players in networked simulators. Demonstrated benefits include man-in-the-loop validation of mission plans leading to improved mission plans and tactics, heightened crew confidence and preparation, and a clearer understanding of mission dynamics and risks. (See, for example, Nullmeyer, Bruce, Conquest, and Reed, 1992).

In numerous rehearsals for training exercises, we have seen that MR is, first and foremost, a cooperative venture among people to get crewmembers maximally prepared for their mission, and it is these varied people who will determine the effectiveness of advanced simulation technology for this purpose. Integrating simulation-based rehearsal capabilities with the existing functionally, geographically, and organizationally diverse SOF and SAR mission preparation process is clearly a challenge. A key element for meeting this challenge was realizing that simulation-based rehearsal technology *and its uses by people* (both Air Force and contractor personnel) must be viewed as an integrated system that we will refer to as a *human activity system*. This point of view provides a conceptual structure to organize, understand, and facilitate the diversified activities of the many participants involved.

Banathy (1992) asserted that no single model can truly represent a complex human activity system. He was addressing educational systems. We believe his concepts are equally useful for understanding simulation-based rehearsal. He proposed three models to capture the essence of such systems: a systems-environment model, a functions/structure model, and a process model. The systems-environment model describes the context in which the system operates and provides the "big picture" for the remaining models. The functions/structure model describes the components or parts, their functions, how they are organized, and how these elements are integrated into a structured system. Finally, the process model provides a "motion picture" image of the system, addressing the receipt and transformation of inputs and other dynamic operations associated with the system, including a feedback loop to support system management, adjustment, and change. Each model portrays certain critical characteristics that must be overlaid upon each other to paint a comprehensive picture of the system as a whole. We will employ these "lenses" to illustrate the importance of people in effective simulation-based MR, using the 58 SOW MRS as the prototype.

A HUMAN ACTIVITY SYSTEM MODEL OF SIMULATION-BASED MR

The Environment - Crisis Action Planning

Because simulation-based MRSs are designed to support short-suspense missions, we chose to address the MRS within context of crisis action planning. Crisis action planning is a coordinated sequence of events involving people, procedures, communications, and support systems that leads to a military response to a time-sensitive situation. The primary participating organizations are listed on the left side of Figure 1. The major events and products for these organizations are depicted to the

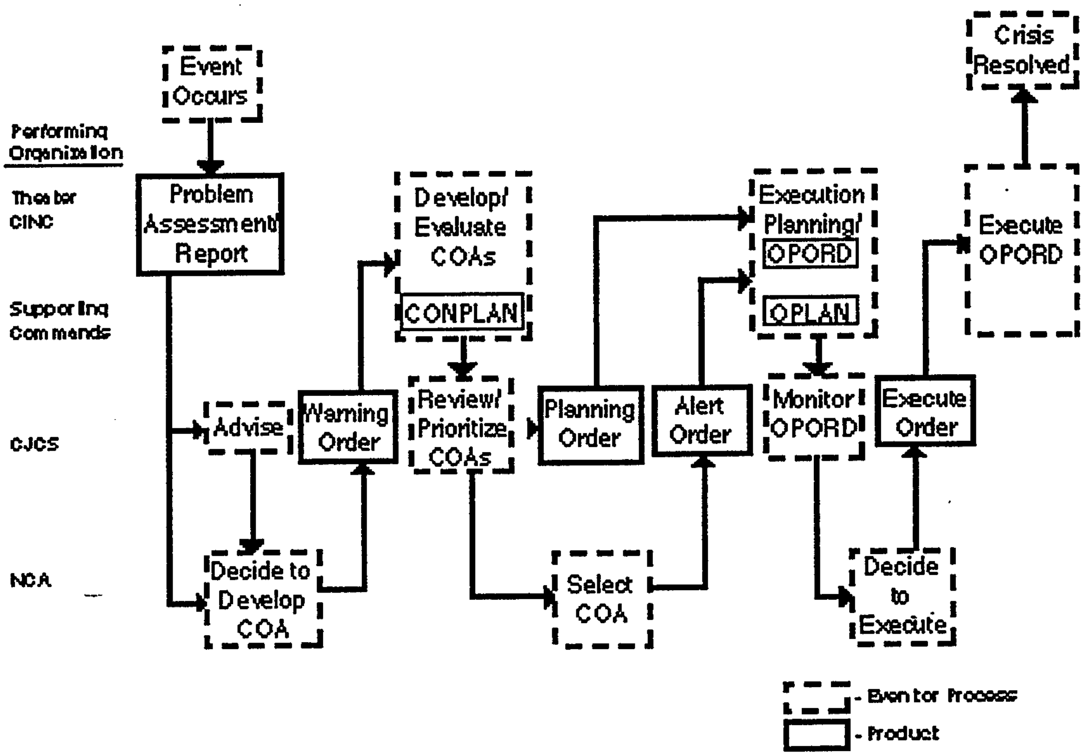

Figure 1: Overview of the Crisis Action Planning "Environment"

right of each group. Arrows show a notional sequencing of these elements, although requirements often force deviations from this template. Crisis action planning begins with the occurrence of an event having possible national security implications. The theater commander reports the event and provides his assessment to the National Command Authorities (NCA) and the Chairman of the Joint Chiefs of Staff (CJCS). The NCA evaluate the situation, determine whether a crisis exists, consider military and non-military options, and decide whether to prepare for a possible military course of action (COA). The CJCS may issue a Warning Order to the theater commander-in-chief (CINC). It defines command relationships, the mission, and resource requirements. Our focus for now will be on the places where wing participation is likely. Figure 1 shows three areas of potential participation for supporting commands (and their subordinate units) -- developing alternative courses of action, execution planning, and mission execution. All three could benefit from access to an MRS, as will be described in subsequent discussions.

Figure 2 provides a more detailed look at one of these three, execution planning. Square boxes depict the activities of aircrews who would plan and execute the mission. The wing establishes a planning cell upon receipt of a **mission tasking** in the form of a warning, planning, or alert order. **general planning** begins with an initial briefing to the planning cell to communicate planning to date, constraints, intelligence data, and situation updates. The planning cell then gathers additional information such as charts and imagery, and performs multiple analyses across various information categories such as weather patterns, weight and balance data, possible aerial refueling tracks, high altitude and low level route options, objective area terrain, threat coverage, and order of battle data to develop a general plan that includes possible landing zones, tactics, escape and evasion routes, and communications procedures. An interim assessment of plan viability is performed at the end of each planning cycle. Simulation technology has several uses at this early point in planning. Planners could use even an unenhanced digital database to analyze the terrain, assess the viability of basis tactics, and study the terminal area to determine the number and type of aircraft that can be inserted. Historically, these tasks were performed using paper maps, table look-ups, and rules of thumb estimates.

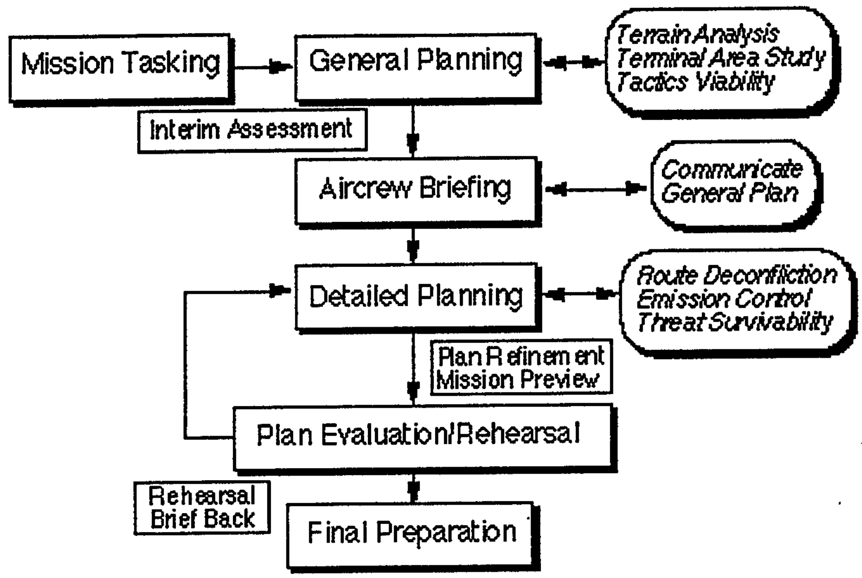

Figure 2: An Overview of Wing and Squadron Activities in the Execution Planning Phase.

An **aircrew briefing** transitions the general plan to squadron crewmembers who will complete the planning details. During this handover, the crews are briefed on the mission tasking, intelligence information, predicted weather, and available logistics. During **detailed planning**, crews insert specific elements into the general plan and make final decisions concerning key aspects of the mission. Activities are laborious and include completing high-altitude and low-level routes - specifying waypoints, initial points, and other navigation data; finalizing tanker track and ground-based refueling station locations; selecting landing zones and holding areas; determining terminal area tactics and procedures; calculating weight & balance and fuel flow; determining procedures to avoid threats, populated areas, and lines of communication; and completing the communication matrix, load plan, and mission execution checklist. Simulation can support many of these functions, such as deconflicting routes among multiple aircraft, determining suitable sites for landing zones, identifying methods for optimizing aircraft performance, honing tactics, and coordinating practice on perishable tasks like threat avoidance.

During **evaluation/rehearsal**, plan details are fine-tuned and assessed under various "what-if" contingencies. Commonly planned-for contingencies include the appearance of new threats, take-off or landing with reduced engines, bad weather, loss of communications, loss of aircraft, and key equipment failure. Here, simulation allows man-in-the-loop validation of mission plans and tactics, which heightens crew confidence in themselves and the plan. Based on assessments during rehearsals and crew "brief backs," commanders can better estimate the probability of mission success. In **final preparation,** crews coordinate with other participants; finalize the mission execution checklist; incorporate the latest mission, weather, and threat data; and complete aircraft configuration and flight procedures immediately prior to executing the mission.

MRS Components and Their Functional Relationships

Following the human activity system point of view, the people, their functions, and their organization are the system of interest. Planning and rehearsal technologies are tools that support these people. Figure 3 depicts the people who are essential for effective simulation-based MR. Solid arrows reflect person-to-person communication, and dashed arrows depict equipment-mediated information flow. It is important to note that this model extends beyond the local 58 SOW and MR contractor organizations. The **tasking agency** must provide the geographic boundaries to be modeled, timeline, available source data, routes to be flown, initial products desired

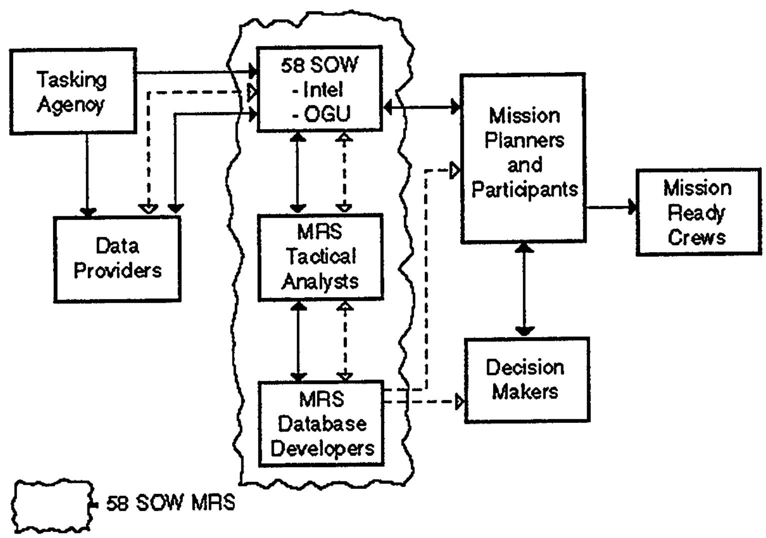

Figure 3. Human Components of a Simulation-Based Mission Rehearsal System

(hardcopy, videotape), and authorize various data providers to release mission information so that database development may proceed. The quality of the rehearsal environment is critically dependent on **Data Providers** such as planners, weather officers, and intelligence officers.

58th Operations Group Aircrew Training System Division (58 OG/OGU) and squadron intelligence personnel provide tasking and mission information to the MRS tactical analysts on the contractor team. These analysts study the tasking along with annotated maps, imagery, and threat information and begin prioritizing areas to receive high- and mid-levels of detailed database development. Clear lines of communication between MRS personnel and the supported organization are vital to insure that the latest and highest fidelity source imagery is available, the most recent routes are conveyed, and the general tactical plan is relayed. Otherwise, precious time is spent building databases for areas that are not part of the operation, less accurate geographic information is incorporated into the database, and fewer tactically relevant features are modeled.

MRS database developers use state-of-the-art software and hardware to scan maps, warp imagery, extract elevation data, manipulate contour lines, and construct object models to create a realistic database of the mission area. Information is exchanged among analysts and programmers using a mix of verbal, written, and electronic means. The quality of the source data provided to the developers—be it target imagery, hand held photos, or terrain information—is a major determinant of the accuracy and realism of the resulting digital database.

Mission planners and participants (planning cell staff, aircrews, liaisons) use the rehearsal database to revise, refine, and update their mission plan. Mission information can be delivered in a variety of forms, such as hardcopies of enhanced imagery, views of partially modeled mission areas on work stations, and completed versions of the database in a simulator. Access to the MRS by planners can benefit both planning and database development as summarized on the right hand side of Figure 2. Early mission planing decisions can help the database generation process by identifying the areas where database developers need to focus their efforts.

Senior Decision-makers (wing, squadron, and mission commanders; executive and action officers; and flight leaders) are clearly pivotal participants in the mission preparation process, and are another essential element of the MR human activity system. They can watch actual rehearsals via large repeater displays in a training observation center (TOC), communicate directly with the **Participating Aircrews** over the intercom networks, and review printouts of threat avoidance, navigation accuracy, timing, and other indices via the Instructor Operator Station (IOS). Using a combination of viewed simulations, tactical judgment, electronic what-iffing, and brainstorming, realistic estimates of mission success can be generated based on the latest and best available information. As this information is distilled, participating crews are "transformed" into a truly mission-ready aircrew by rehearsing the planned mission in the networked helicopter and C-130 Aircrew Training Devices (ATDs).

Figure 4 adds MRS technology to the human activity system. We represent equipment components and information with dashed boxes/arrows and the human components with solid boxes (people) and arrows (interpersonal communication). Interactions between people and equipment are denoted by overlapping their respective boxes. The MRS receives input from the data providers in many forms, referred to collectively as "all source data." Source data is voluminous and includes topography, meteorological, geodetic, communications, command and control, threat, and ownship performance data. The MRS is configured to receive most formats of these data, including digital and paper charts and maps, photography, imagery, sketches, diagrams, and videotape.

These data enter the 58 SOW MRS through either **data analysis systems** or electronic **mission planning/intelligence systems.** Tactical analysts use mission planning and intelligence systems to update the all source data with real- or near-real time threat location and order of battle data. The data analysis systems are a constellation of computer hardware/software that preview, enhance, modify, and augment the all source data. The **Database Generation System** (DBGS) is a vast array of contractor-operated hardware and software that creates the geo-specific visual database of the mission area. Intelligence and tactical analysts receive amplifying information from the data providers and utilize the data analysis system to extract as much information as possible from the all source data. Meanwhile, contractor-supplied database developers and terrain modelers begin constructing the digital database the aircrews will fly through during MR.

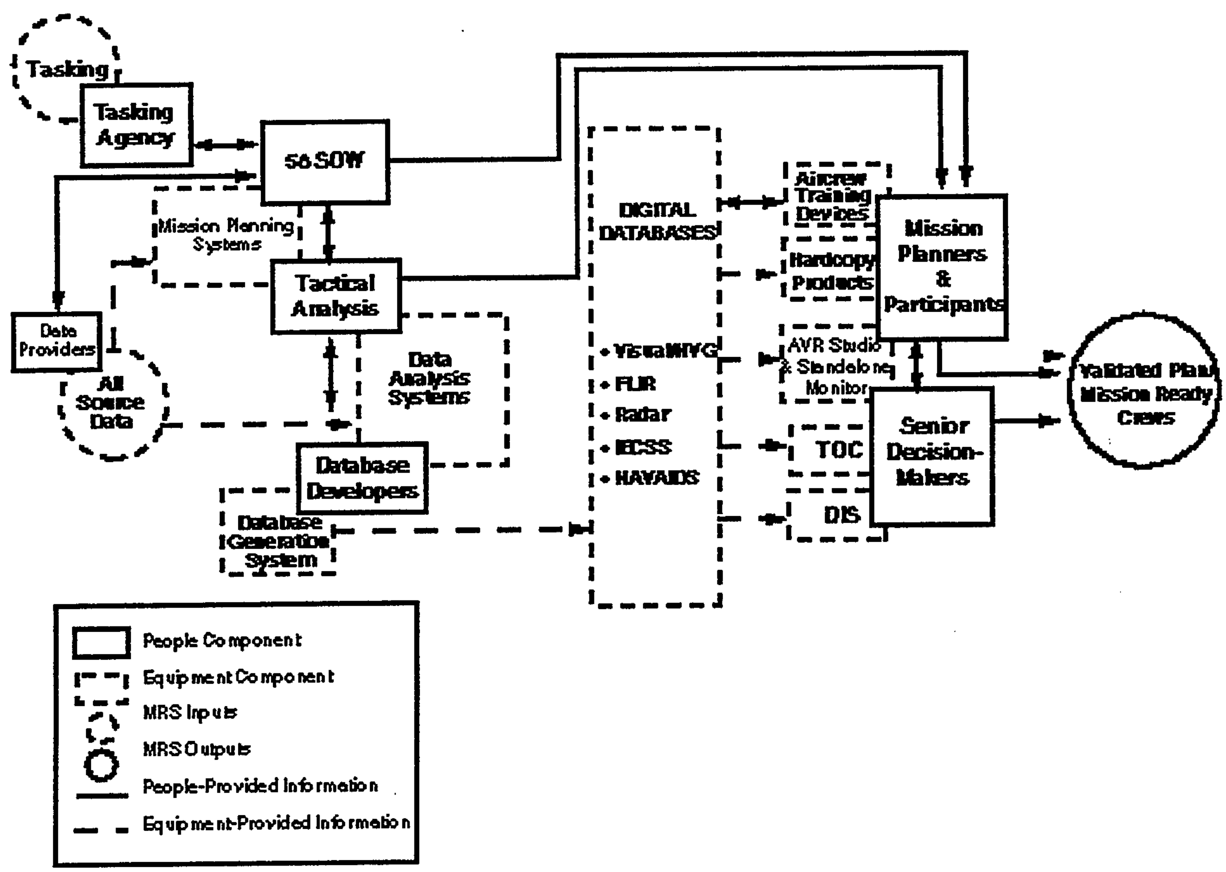

Figure 4. Human and Equipment Components of a Simulation-Based Mission Rehearsal System

The major products of the database generation system (DBGS) are the multiple **digital databases** reflecting different environmental or sensor conditions. The visual out-the-window (OTW) database can be viewed through night vision goggles (NVGs) and processed at different moon illumination levels to simulate OTW night scenes. Other databases are created to mimic the FLIR, radar, and EW environments. Five different "portals" into the Digital Databases are denoted by exiting arrows. The arrow at the top leads to the ATDs. Hardcopy printouts of any part of the visual scene (photographs, maps, combat folders, navigation logs) that can be taken on the aircraft during mission execution. A third link is the TOC, in which large repeater displays let senior decision-makers observe the participating aircrews fly through the database in the ATDs. Other outputs include a commercial-quality

audio-visual recording studio that can record the route flown through the database; a standalone work station that lets aircrews "joystick" through the Database decoupled from the aero-vehicle model; and a distributed interactive simulation (DIS) node.

Mission planners and participants can derive benefit from the Databases by taking hardcopy products onboard the aircraft, flying through the database in an ATD, and by using the Audio-Visual Recording System (AVRS) to create a video recording of the aircraft's route through the database and record crew comments during flight. Senior decision makers can view the mission unfold by watching videotapes from the AVRS, the display monitors in the TOC, or multi-group interactions over the DIS node. Inputs to mission execution come from critiques by senior decision-makers, the knowledge and experience gained by mission planners and participating aircrews.

Simulation-Based Rehearsal Processes

The process model describes the dynamic nature of the system. While each MR is unique, a core set of functions must be performed to ensure that the requisite materials, information, support equipment, and people have been coordinated. Figure 5 divides these critical functions into three phases—MR preparation, MR, and post-MR. Although the functions are sequenced temporally within each phase, we have not overlaid an absolute timeline since that depends on the complexity of the operation and whether an existing database can be modified.

MR Preparation. Before mission participants arrive at the 58 SOW facility, an intensive series of preparation activities occur. An MR begins with a **tasking**. A 58 OG/OGU representative is contacted to determine if a particular operation can be supported within a given time frame. During initial discussions, a 58 OG representative determines which organizations will be providing route and targeting data as well as **transmitting source data**. Internally, the OG representative will work with the designated MR Team Chief to line up the requisite assets to support an MR, such as simulator time, AVRS and IOS operators, data packs, Image Generators (IGs) for the proposed mission, and intersimulator networking. To facilitate data analysis and database development, the 58 OG recommends what and who the supported organizations should send ahead and/or bring with them to the training and rehearsal complex. The "what" entails identifying necessary maps, charts, imagery, and intelligence data in the region of interest. The "who" are specific crewmembers, intelligence and logistics personnel, and associated ground customers who should be on-site during the MR.

Database development in the MRS is an extremely involved function that can be organized into eight steps: 1) digital terrain elevation data and digitized source data are combined to create an underlying terrain grid of elevation values; 2) cultural features (e.g., roads, rivers, trees) are taken from digital feature analysis data, photos, and images, and added to the terrain; 3) the terrain is triangulated into polygons by positioning a given image to an exact latitude/longitude (warping) and elevation (orthorectification); 4) terrain is textured to appear more realistic by applying texture models coupled with recent real- world photos of the mission area; 5) two- and three-dimensional object models from a customized library and added to the database; 6) the database is compiled, processed, and constructed with concentric levels of resolution. (Areas around a target or landing zone having the highest resolution, areas surrounding key landmarks having moderate resolution, and ingress/egress corridors having a lower resolution); 7) the database is formatted into multiple layers—OTW/visual, radar, FLIR, EW, and NAVAID—and then correlated so they can be displayed from a common viewing point and 8) the database is processed through the IG in which scene objects are given geometrical perspective, data are transformed into a display raster format, pixels are given individualized color and brightness values,

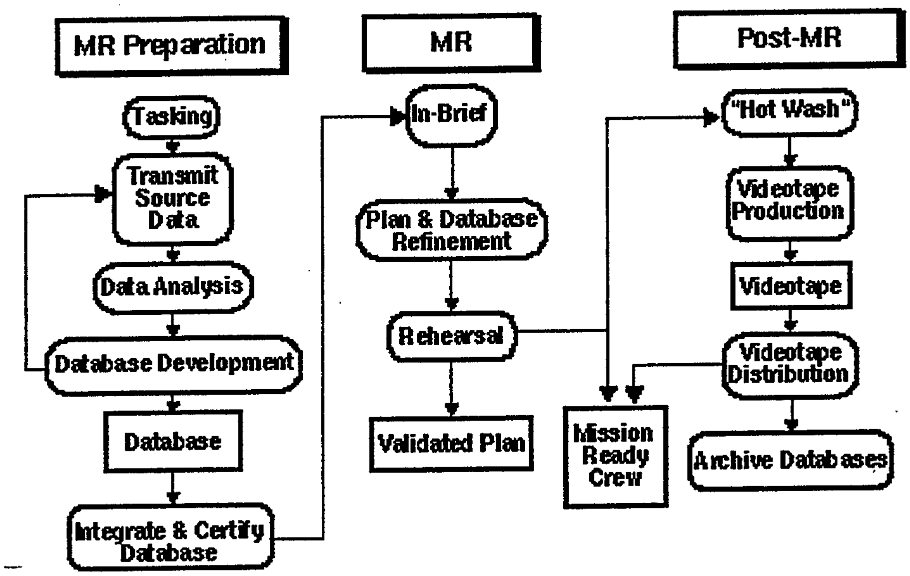

Figure 5. Functions and Products in the Mission Rehearsal Process.

and stored in frame buffers for a consistent display rate. During each step, modelers and analysts must work closely so that the most important features find their way into the database.

The visual **database** is the most obvious, but by no means, only digital product for MR. Other products are the digital record of flight planning data, photos and images digitized for subsequent manipulation (annotation, mensuration, warping), and scanned maps and charts. After the database is developed, government and contractor personnel pre-fly the database to **certify** its spatial and content integrity. 58 SOW personnel can fly the database at the headings, altitudes, and airspeeds corresponding to the mission plan. In Dry Run tests, the ATDs will be integrated with the EW environment and wired for full communication with the TOC.

MR. Upon arriving at the 58 SOW, mission participants will be **in-briefed** on MR objectives and schedule of events, the contents of the database, and importantly, what has been omitted from the database due to visual system limits, time constraints, and lack of available source data. The "maturity" of the participant's plan will dictate the activities required for **refining the mission plan** and **associated database.** Participants "trial fly" mission segments in an ATD, trying out different entry points into the area of operations, landing zones and launch points, and approach headings and profiles. With the initial planning complete, the rest of the time is spent performing tasks associated with the primary function, **rehearsal.** The type of operation (feasibility assessment, plan validation, plan verification, joint mission practice) will determine the content and extent of the activities performed here. Typically, the TOC is "up" to monitor network activities, aircrew communications, status of the EW environment, and coordinate MR activities amongst the various participants. Time permitting, participants will fly ingress routes into the target area multiple times, examining the impact of different turning radii, approach angles, altitudes, and multi-ship formations. The primary output of MR is the creation of a **mission ready crew.** Observers in the TOC, including senior decision makers, can listen to the audio on the network and evaluate the integrity of the visual database and the performance of the EW displays, and thus **validate the mission plan** while interacting with the rehearsing crews in real time.

Post-MR. Most MR operations will conclude with a **hot wash** in which mission participants and facility personnel perform self-critiques of the benefits and negative aspects to the MR just concluded. These hot washes have been instrumental in making constructive improvements to the MR process, both from an efficiency of utilization and outcome effectiveness standpoint. 58 SOW personnel may use the AVRS to **produce a videotape** of the database flown at the headings, routes, altitudes, and airspeeds planned for by the crew. With full cockpit audio, the videotape can be edited to include additional footage (e.g., 360 degree scans of target areas from different perspectives, such as ground level) to be viewed by aircrews and decision-makers at forward operating locations. Aircrews or the studio operator can also provide explanatory voice overs. Finally, mission data and databases are **archived** in the event the plan is subsequently refined, re-flown, or updated. Since many operations take place in the same geographic region, the visual database becomes a highly useful means to store and summarize previous tactical analyses.

IMPLICATIONS AND LESSONS LEARNED

The importance of people in complex systems is often acknowledged. However, it is not always easy to translate this concept into reality, as evidenced by advanced technologies being delivered with poor user documentation, or with little or no training for users. We believe the human activity system "lenses" provide useful templates to facilitate this translation. In this final section, we will explore a few implications of these templates when applied to the 58 SOW MRS.

First, the context lens of crisis action planning shows that the value of MR can extend well beyond the traditional view of practice and validation immediately preceding mission execution. Figure 1 shows the supporting command involved at three points within the crisis action planning process: (1) developing and evaluating alternative military courses of action, (2) developing the detailed operations plans, and (3) executing the plan given receipt of an execute order. All three tasks can benefit from access to a digital database representing the area of operation. Early in the planning process, alternative courses of action and other planning activities can be supported with "man-in-the' loop" queries. Similarly, simulation can provide a dynamic environment for risk analyses and decision making during mission execution. Other participants in crisis action planning could also benefit from simulation.

Second, the functions/structure lens shows that the human system that must be in place for effective simulation-based MR clearly extends beyond the locally-controlled MRS. We have seen, for example, that the quality of the MR database is limited by the quality of input data from outside sources. MR effectiveness is also determined in large part by user (participants and decision makers) knowledge of MRS capabilities, data requirements, capabilities, and utilization strategies. Of some note, early users of simulation-based MR uniformly praised the capabilities of the technology and people, while lamenting the lack of a strategy to incorporate this capability into the mission preparation process (Nullmeyer, et. al., 1992). Predictably, it has been easier to improve processes within the MRS than to coordinate activities of the geographically and organizationally diverse team comprising the larger mission preparation system. However, effective simulation-based MR requires the larger system to be functioning as an integrated whole.

Some specific examples may help illustrate this point. 1) The MRS has a photo overlay capability. Annotations were traditionally placed on photographs to add important and relevant information, but now, these annotations add work for database developers, who must remove them during database construction. For a photo-based MRS, it is clearly better for database developers to have both an annotated and an unannotated photograph. 2) Experience has taught that MR database responsiveness and quality is enhanced when the user is directly involved during database development. Today's technology does not allow all things to be modeled perfectly, so database developers attempt to find the "best fit" between MRS capabilities and mission needs. A mission participant or planner can provide valuable guidance to focus system resources on the most critical needs. This user representative can also serve as an interpreter for the other rehearsal participants to describe where the simulation is accurate and where it is not. In both examples, MR efficiency and effectiveness are impacted by people who are not part of the MRS *per se*.

The functions/structure model also shows MR databases at the center of the MRS. These databases are true "national assets" in the sense that they can easily contain more mission information, from multiple sources, packaged in a more useable structure, than is available anywhere else. With proper packaging of database contents, many users can be served and many uses can be met with this information. Using simulators, participating crews and mission planners can conduct "what if" exercises, practice difficult maneuvers, determine weapon system limits (e.g., maximum comfortable gross weight for a high altitude rotary wing operation) and conduct individual and collective risk assessments. Hard copy products, such as enhanced photographs and maps can be generated in a simple extension of the database development process. Such products have been highly valued by planners and mission participants. Videotapes are an additional medium for exporting database information. This medium provides a mission preview capability for participants and decision makers who do not have the luxury of physically going to the rehearsal system. Finally, the training observation center and the distributed interactive simulation node can connect decision makers and mission participants to the rehearsal environment and add a dynamic dimension to the information available upon which to make decisions.

Finally, Banathy emphasizes the importance of feedback as part of the process model. An extensive and diverse literature strongly indicates that mere repetition is not likely to produce optimal performance (see, for example, Ericsson, Krampe, and Tesch-Romer, 1993). Rather, feedback is needed to shape practice in ways that encourage creation of improved strategies for task accomplishment. This has relevance for both mission preparation, where measures of mission effectiveness are needed to provide the feedback needed to improve the plan and the performance of participants. Similarly, feedback is needed for the rehearsal system, to improve the MR environments, MRS elements, and related processes. Spiker and Nullmeyer (1995) developed an initial set of effectiveness measures for the MRS. These measures reflect both the context of the larger mission preparation process, and input, process, and output components of MR. Initial input measures include completeness, timeliness, and relevance to mission decisions and outcomes. Process measures include efficiency and timeliness of database development, and fidelity and relevance of the resulting database. Measures of rehearsal output include the ability of planners to create better plans, crews having more accurate mental models of the operating environment, and decision makers having better bases for decisions. Finally, MR itself can serve as a valuable external feedback mechanism for training. Performance in the rehearsal environment can provide insights into how well training is preparing crews for their operational missions, and can identify gaps and other problem areas. Lessons learned at the 58th SOW can help other systems mature as the "book" is still being written on MR in three dimensional visualization simulation.

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