AD-A173 698 AN EXPERT SYSTEM TO HELP ASSESS TACTICAL AIR READINESS AND CAPABILITY PHA..(U) SYNERGY INC WASHINGTON DC 30 MAY 86 F49642-85-D-0035 1/1

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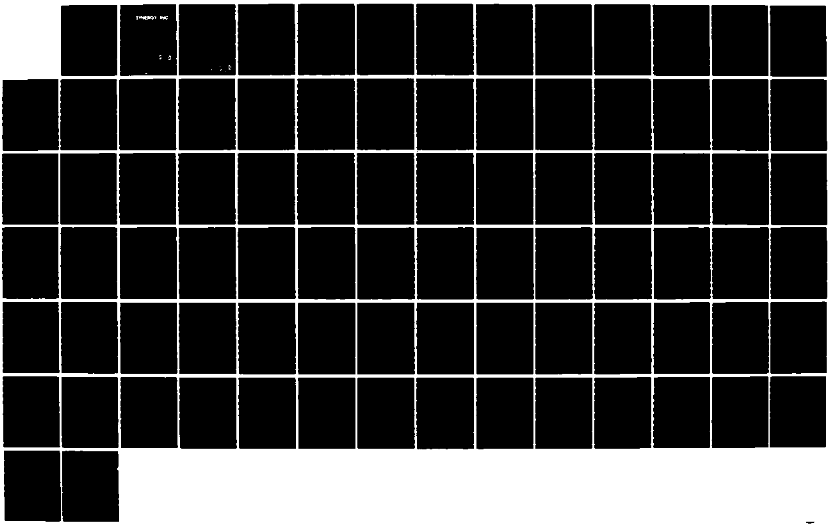

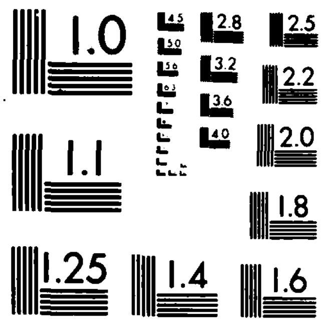

MICROCOPY RESOLUTION TEST CHART
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SYNERGY, INC.

Appendix 1

The Expert's Expertise: Raw Data for the Knowledge Engineering Process

Contract F49642-85-D-0035/5002

AD-A173 698

1824 Biltmore Street, NW
Washington, DC 20009

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Appendix 1

The Expert's Expertise: Raw Data for the Knowledge Engineering Process

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F49642-85-D-0035/S002

The material included hereafter consists of samples of raw, unedited data from which we extract syntactic patterns, vocabulary, synonyms and rules. This material is included in its raw form for the sake of completeness and to demonstrate the importance of the expert to building a system such as this.

TABLE OF CONTENTS

Introduction

This appendix contains part of the "expert's raw" knowledge. This knowledge comes from three sources. The first is a series of unstructured conversations between knowledge engineers (those people who turn an expert's thinking into a knowledge base and inference system) and substantive experts. Partly edited transcripts from some of these sessions have been included.

The second source is a series of informal "lectures" our experts gave to teach the knowledge engineers basic facts about the world of tactical air assessment. The third source is a set of "working notes" that describes different problems and how an expert might approach them. Our experts generated these notes while our knowledge engineers simply observed.

An additional source, not included in this appendix, are video tapes of working sessions between our experts and knowledge engineers. In these sessions, the experts discussed how they would approach different problems, while the knowledge engineers "probed" for "hidden knowledge" (information so obvious to the experts that they do not mention it) e.g., airfields have arresting gear), general "rules of thumb" (unwritten rules that real experts use) e.g., if you stress the entire system for 48 hours, it takes 24 hours to recover), and heuristics (ways of approaching a problem), e.g., if you have an idea of what the first show stopper will be, you start from there and work toward other resources).

In phase II, we will use this "raw" data" (and additional materiel now in notes and untranscribed tapes) to build our knowledge base and the inference engine that knows how to think about this knowledge. Part 1 of the appendix is an example of a knowledge base we created from some of the information in part 2. The knowledge base uses LISP frames to describe objects in the expert system's world. "AKO" stands for "A Kind Of." "AKA" stands for "Also Known As."

```
;;;
;;;  TAC.KB                SEMANTIC NETWORK FOR TAC ASSESSMENT DOMAIN
;;;

(Class            (ako (if-added add-instance))
                  (methods (value (describe-self describe-object)))
)

(slot             (ako (value meta-object)
                       (if-added add-instance))
                  (printname (type string))
                  (inverse (object has-component)
                           (meta-object has-component))
                  (used-in (type meta-object object))
                  (methods (value (describe-slot list-em)))
)

(countslot        (ako (value Slot))
                  (subject (type resource))
)

(rateslot         (ako (value Slot))
                  (subject (type resource))
)

([illegible]      (ako (value Slot))
                  (inverse (object has-instance)
                           (meta-object has-instance))
)

(delivered-by     (ako (value Slot))
                  (inverse (vehicle delivers))
)

(expenditure      (ako (value rateslot))
                  (subject (value weapon))
)

(fuel-load        (ako (value rateslot))
                  (subject (value fuel POL))
)

(location         (ako (value Slot))
                  (inverse (airbase includes))
)

(member           (ako (value Slot))
                  (inverse (organization member-of)
                           (person member-of))
)

(number-engines (ako (value CountSlot))
                  (thing-counted (value engine))
)
```

```
rpose           (ako (value Slot))
                (inverse (goal performed-by))
)

(count-script   (ako (value meta-object)
                     (if-added add-instance))
)

(sortie-count   (ako (value count-script))
                (subject (value sortie))
                (length (if-needed ask-user))
                (airbases (if-needed ask-user))
                (count (if-needed calculate-sorties))
                (methods (value (setup setup-count)))
)

(resource-count (ako (value count-script))
                (subject (value resource))
                (resource (if-needed ask-user))
                (airbases (if-needed ask-user))
                (count (if-needed count-resources))
                (methods (value (setup setup-count)))
)

     e          (ako (value Class))

(Mission        (ako (value Class))
                (resources-required (type FighterPlane))
                (time (type TimeFrame))
                (target (type Target))
                (objective (type Goal))
)

(AA             (ako (value Mission))
                (printname (value "air-to-air"))
                (instances (value BAI DCA ESCORT))
)

(AG             (ako (value Mission))
                (printname (value "air-to-ground"))
                (instances (value SEAD OCA))
)

(BAI            (ako (value Mission))
                (printname (value "Battlefield Air Interdiction"))
                (plane-to-use (value unknown))
)

(DCA            (ako (value Mission))
                (printname (value "Defensive Counter Air"))
                (plane-to-use (value unknown))
)

(OCA            (ako (value Mission))
```

```
                (printname (value "Offensive Counter Air"))
                (plane-to-use (value unknown))
)

(SEAD           (ako (value Mission))
                (printname (value "Suppression of Enemy Air Defense"))
                (plane-to-use (value F-4G))
)

(Sortie         (ako (value Activity))
                (purpose (value Mission))
                (munitions (type SCL))
)

(Airbase        (ako (value Class))
                (location (type Country) (card single))
)

(Bitburg        (ako (value Airbase))
                (location (value WGermany))
                (inventory (value
                        (F-15 72)
                        (AIM-9L 300)
                        (AIM-7F 350)
                        (AGM-65 630)
                        (MK-20 200)
                        (MK-82 320)
                        (MK-84 230)
                        (POL 110000.0)
                ))
)

(Hahn           (ako (value Airbase))
                (location (value WGermany))
                (inventory (value
                        (F-16 72)
                        (AIM-9L 100)
                        (AIM-7F 350)
                        (AGM-65 630)
                        (MK-20 200)
                        (MK-82 320)
                        (MK-84 230)
                        (POL 125000.0)
                ))
)

(Ramstein       (ako (value Airbase))
                (location (value WGermany))
                (inventory (value
                        (F-16 72)
                        (AIM-9L 300)
                        (AIM-7F 350)
                        (AGM-65 630)
                        (MK-20 200)
                        (MK-82 320)
```

```
                    (MK-84 230)
                    (POL 100000.0)
              ))
)

(Spangdahlem  (ako (value Airbase))
              (location (value WGermany))
              (inventory (value
                    (F-4E 48)
                    (F-4G 24)
                    (AIM-9L 300)
                    (AIM-7F 350)
                    (AGM-65 630)
                    (MK-20 200)
                    (MK-82 320)
                    (MK-84 230)
                    (POL 225000.0)
              ))
)

(Fuel         (ako (value Resource))
              (source (value FuelTruck Hydrant))
              (instances (value JP-4 JP-8))
)

              (include Fuel ako source consumption-rate instances)

(Vehicle      (ako (value Resource))
              (purpose (value Transport Fight))
              (crew (value Person))
              (location (type Airbase))
)

(Aircraft     (ako (value Vehicle Resource))
              (printname (value "An aircraft"))
              (location (type Airbase))
              (crew (value Pilot))
              (purpose (value Mission))
              (passengers (type Person))

              (SCL-preferred (type SCL))
              (SCL-alternate (type SCL))

              (takeoff-distance (units feet))
              (maint-crew (value 5) (units persons))
              (munitions-crew (value 3) (units persons))
)

(F-4E         (ako (value Aircraft))
              (purpose (value OCA BAI))
              (location (value Spangdahlem))
              (crew (value Pilot))

              (range (value 225.0))
```

```
                    (mission-duration (value 1.2))
                    (SCL-preferred (value SCL-1))
                    (SCL-alternate (value NIL))
                    (fuel-load (value 12000))
)

(F-4G               (include F-4E ako location range)
                    (include F-4E range mission-duration fuel-load)

                    (purpose (value SEAD))
                    (crew (value Pilot EWO))
                    (SCL-preferred (value SCL-2))
                    (SCL-alternate (value NIL))
)

(F-15               (ako (value Aircraft))
                    (purpose (value AA DCA))
                    (crew (value Pilot))
                    (location (value Bitburg))

                    (range (value N/A))
                    (mission-duration (value 2.0))
                    (SCL-preferred (value SCL-3))
                    (SCL-alternate (value SCL-5))
                    (fuel-load (value 10000))

(F-16               (ako (value Aircraft))
                    (purpose (value DCA OCA BAI))
                    (crew (value Pilot))
                    (location (value Hahn Ramstein))

                    (range (value 325.0))
                    (mission-duration (value 1.7))
                    (SCL-preferred (value SCL-4))
                    (SCL-alternate (value SCL-1))
                    (fuel-load (value 7500))
)

(Weapon             (ako (value Resource))
                    (purpose (type Mission))
                    (delivered-by (type Aircraft))
)

(SCL                (ako (value Class))
                    (purpose (type Mission))
)

(SCL-1              (ako (value SCL))
                    (purpose (value unknown))
                    (inventory (value (MK-82 6) (20mm 900)))

(SCL-2              (ako (value SCL))
                    (purpose (value unknown))
```

```
                    (inventory (value (AGM-45 2) (AGM-78 2)))

(SCL-3              (ako (value SCL))
                    (purpose (value unknown))
                    (inventory (value (AIM-7M 4) (AIM-9L 4) (20mm 900)))
)

(SCL-4              (ako (value SCL))
                    (purpose (value unknown))
                    (inventory (value (AGM-65 6) (20mm 900)))
)

(SCL-5              (ako (value SCL))
                    (purpose (value unknown))
                    (inventory (value (AIM-7F 4) (AIM-9J 4) (20mm 900)))
)

(SmartMunition      (ako (value Weapon))
)
(DumbMunition       (ako (value Weapon))
)

(20mm               (ako (value weapon))
                    (purpose (value OCA BAI DCA))
                    (used-in-mission (value OCA BAI))
                    (used-per-mission (value 300))
)

(Bomb               (ako (value Weapon))
                    (purpose (value OCA))
                    (weight (type number) (units pounds) (card single))
                    (guidance (default FREE-FALL))
                    (delivered-by (type Aircraft))
                    (targets)
)

(MK-20              (ako (value Bomb DumbMunition))
                    (purpose (value unknown))
                    (weight (value 500))
                    (guidance (value FREE-FALL))
                    (targets (value Armor))
)

(MK-82              (ako (value Bomb DumbMunition))
                    (weight (value 500.0))
                    (guidance (value LASER))
                    (delivered-by (value unknown))
                    (targets (value unknown))
)

(MK-84              (include MK-82 ako guidance delivered-by targets)
                    (weight (value 2000.0))
)
```

```
(CBU           (ako (value Bomb DumbMunition))
)

(CBU-52        (ako (value CBU DumbMunition))
               (purpose (value unknown))
               (weight (value 800))
               (delivered-by (value unknown))
               (targets (value EnemyPersonnel SoftMaterial))
)

(CBU-58        (include CBU-52 ako purpose weight delivered-by targets)
)

(Missile       (ako (value Weapon))
               (purpose (type Mission))
               (delivered-by (type Aircraft))
)

(AIM-7F        (ako (value Missile SmartMunition))
               (aka (value Sparrow))
               (weight (value 500.0))
               (guidance (value ActiveRadar))
               (purpose (value DCA))
               (delivered-by (value F-4E F-15))
               (used-in-mission (value DCA))
               (used-per-mission (value 2))


(AIM-9L        (ako (value Missile SmartMunition))
               (aka (value Sidewinder))
               (weight (value 200.0))
               (guidance (value PassiveIR))
               (purpose (value DCA))
               (delivered-by (value F-15 F-16))
               (used-in-mission (value DCA))
               (used-per-mission (value 1))
)

(AGM-45        (ako (value Missile SmartMunition))
               (aka (value Shrike))
               (purpose (value SEAD))
               (weight (value unknown))
               (guidance (value PassiveRadar))
               (targets (value SAMSite AAASite))
               (used-in-mission (value SEAD))
               (used-per-mission (value 2))
               (delivered-by (value F-4G))
)

(AGM-65        (ako (value Missile SmartMunition))
               (aka (value Maverick))
               (purpose (value unknown))
               (weight (value 500.0))
               (guidance (value TV))
               (targets (value Armor HeavyDefense))
```

```
                    (delivered-by (value F-4E F-15 F-16 A-10 F-111))
                    (used-in-mission (value BAI OCA))
                    (used-per-mission (value 2))
)

(AGM-78             (ako (value Missile SmartMunition))
                    (aka (value ARM))
                    (purpose (value SEAD))
                    (weight (value 1000.0))
                    (guidance (value ActiveRadar))
                    (delivered-by (value F-4G))
)

(AGM-88             (ako (value Missile SmartMunition))
                    (aka (value HARM))
                    (purpose (value SEAD))
                    (weight (value unknown))
                    (guidance (value ActiveRadar))
                    (delivered-by (value F-4E F-4G F-15 F-16))
                    (used-in-mission (value SEAD))
                    (used-per-mission (value 2))
)

(tasking (ako (value class)))

(4409-tasking (ako (value tasking)))

(capability (ako (value class)))

(sortie-capability (ako (value capability)))

(4409-tasking-day-1
  (ako (value 4409-tasking))
  (day (value 1))
  (sortie-requirements
    (value
      (hahn        (total 190) (dca 171) (bai 19))
      (bitburg     (total 180) (dca 180))
      (Spangdahlem (total 187) (sead 187))
      (Ramstein    (total 188) (dca 169) (bai 19)))))

(4409-tasking-day-2
  (ako (value 4409-tasking))
  (day (value 2))
  (sortie-requirements
    (value
      (hahn        (total 187) (dca 140) (bai 47))
      (bitburg     (total 184) (dca 184))
      (Spangdahlem (total 193) (sead 193))
      (Ramstein    (total 192) (dca 144) (bai 48)))))

(4409-tasking-day-3
  (ako (value 4409-tasking))
  (day (value 3))
  (sortie-requirements
```

```
    (value
      (hahn         (total 183) (dca 60) (oca 31) (bai 92))
      (bitburg      (total 198) (dca 198))
      (Spangdahlem  (total 187) (sead 187))
      (Ramstein     (total 184) (dca 61) (oca 31) (bai 92)))))

(4409-tasking-day-4
  (ako (value 4409-tasking))
  (day (value 4))
  (sortie-requirements
    (value
      (hahn         (total 140) (dca 24) (oca 46) (bai 70))
      (bitburg      (total 159) (dca 159))
      (Spangdahlem  (total 130) (sead 130))
      (Ramstein     (total 123) (dca 20) (oca 41) (bai 62)))))

(4409-tasking-day-5
  (ako (value 4409-tasking))
  (day (value 5))
  (sortie-requirements
    (value
      (hahn         (total 139) (dca 23) (oca 46) (bai 70))
      (bitburg      (total 145) (dca 145))
      (Spangdahlem  (total 128) (sead 128))
      (Ramstein     (total 164) (dca 28) (oca 54) (bai 82)))))

(4409-tasking-day-6
  (ako (value 4409-tasking))
  (day (value 6))
  (sortie-requirements
    (value
      (hahn         (total 152) (dca 26) (oca 50) (bai 76))
      (bitburg      (total 123) (dca 123))
      (Spangdahlem  (total 135) (sead 135))
      (Ramstein     (total 149) (dca 25) (oca 49) (bai 75)))))

(4409-tasking-day-7
  (ako (value 4409-tasking))
  (day (value 7))
  (sortie-requirements
    (value
      (hahn         (total 132) (dca 22) (oca 44) (bai 66))
      (bitburg      (total 145) (dca 145))
      (Spangdahlem  (total 136) (sead 136))
      (Ramstein     (total 132) (dca 22) (oca 44) (bai 66)))))

(4409-tasking-day-8
  (ako (value 4409-tasking))
  (day (value 8))
  (sortie-requirements
    (value
      (hahn         (total 132) (dca 22) (oca 44) (bai 66))
      (bitburg      (total 145) (dca 145))
      (Spangdahlem  (total 116) (sead 116))
```

```
    (Ramstein    (total 132) (dca 22) (oca 44) (bai 66)))))

(4409-tasking-day-9
  (ako (value 4409-tasking))
  (day (value 9))
  (sortie-requirements
    (value
      (hahn        (total 152) (dca 26) (oca 50) (bai 76))
      (bitburg     (total 145) (dca 145))
      (Spangdahlem (total 136) (sead 136))
      (Ramstein    (total 132) (dca 22) (oca 44) (bai 66)))))

(4409-tasking-day-10
  (ako (value 4409-tasking))
  (day (value 10))
  (sortie-requirements
    (value
      (hahn        (total 132) (dca 22) (oca 44) (bai 66))
      (bitburg     (total 111) (dca 111))
      (Spangdahlem (total 136) (sead 136))
      (Ramstein    (total 121) (dca 21) (oca 40) (bai 60)))))

(4409-tasking-day-11
  (ako (value 4409-tasking))
  (day (value 11))
  (sortie-requirements
    (value
      (hahn        (total 112) (dca 19) (oca 37) (bai 56))
      (bitburg     (total 145) (dca 145))
      (Spangdahlem (total 156) (sead 156))
      (Ramstein    (total 132) (dca 22) (oca 44) (bai 66)))))

(4409-tasking-day-12
  (ako (value 4409-tasking))
  (day (value 12))
  (sortie-requirements
    (value
      (hahn        (total 112) (dca 19) (oca 37) (bai 56))
      (bitburg     (total 145) (dca 145))
      (Spangdahlem (total 176) (sead 176))
      (Ramstein    (total 132) (dca 22) (oca 44) (bai 66)))))

(4409-tasking-day-13
  (ako (value 4409-tasking))
  (day (value 13))
  (sortie-requirements
    (value
      (hahn        (total 112) (dca 19) (oca 37) (bai 56))
      (bitburg     (total 122) (dca 122))
      (Spangdahlem (total 136) (sead 136))
      (Ramstein    (total 132) (dca 22) (oca 44) (bai 66)))))

(4409-tasking-day-14
  (ako (value 4409-tasking))
  (day (value 14))
```

```
 sortie-requirements
  (value
    (hahn         (total 132) (dca 22) (oca 44) (bai 66))
    (bitburg      (total 125) (dca 125))
    (Spangdahlem  (total 131) (sead 131))
    (Ramstein     (total 110) (dca 19) (oca 36) (bai 55)))))

(4409-tasking-day-15
  (ako (value 4409-tasking))
  (day (value 15))
  (sortie-requirements
    (value
      (hahn         (total 172) (dca 29) (oca 57) (bai 86))
      (bitburg      (total 145) (dca 145))
      (Spangdahlem  (total 136) (sead 136))
      (Ramstein     (total 132) (dca 22) (oca 44) (bai 66)))))


(wargoers       (ako (value class))
                (no             (value ))
                (high-risk      (value ("NAVIGATIONAL LIGHTS"
                                        "TACAN"
                                        "ILS"
                                        "ALL WRCS MODES"
                                        "ANGLE OF ATTACK PROBE"
                                        "VERTICAL VELOCITY INSTRUMENTATION"
                                        "NEEDLE/BALL INSTRUMENTATION"
                                        "CLOCK"
                                        "AIR TO GROUND BEACON TRANSPONDER"
                                        "BEACON RADAR MODE"
                                        "AIM-7 AND AIM-9 SUBSET OF FIRE CONTROL"
                               "EMERGENCY SLAT/FLAP LOWERING SYSTEM"
                                        "EMERGENCY BRAKES"
                                        "COCKPIT LIGHTING"
                                        "EITHER COCKPIT RHAN INDICATOR"
                                        "FRONT COCKPIT VSD"
                                        "PITOT HEAD"
                                        "ECM POD"
                                        "SPEED BRAKES"
                                        "FLAP SYSTEM"
                                        "AUTO PILOT"
                                        "FIRE EXTINGUISHER"))
                                (also-includes medium-risk))
                (medium-risk (value ("TAIL HOOK RETRACTION"
                                        "DRAG CHUTE"
                                        "LEADING EDGE WING SLATS"
                                        "EMERGENCY LANDING GEAR SYSTEM"
                                        "COCKPIT PRESSURIZATION"
                                        "OPERABLE TRIM"))
                                 (also-includes low-risk))
                (low-risk       (value ("EXTERNAL LIGHTING"
                                        "NAVAID"
                                        "FULL MUNITIONS LOAD"
                                        "ENGINE INSTRUMENTATION"))))
```

THE ARTIFICIAL INTELLIGENCE EXPERT SYSTEM

DEMONSTRATION SYSTEM DEFINITION

PREFACE AND SUMMARY

This introduction summarizes major factors and important points that need to be raised and defined for each of resultant subordinate components. It is important not to "wire" the analysis to a preconceived hierarchical structure associated with these factors, as this would imply a static set of relationships. Since the relationships are situation dependent and dynamic, no factor is considered to be more important than another. For example, when asked how many sorties a base can produce, the gross number reported initially to the ATOC or the next higher level of command is the number of sorties that could be produced by the constraining factor for the specific situation. However, the first question generally asked by a battle commander is the number of available aircraft. Once this figure is determined, from the general sortie profile from the ATOC, then the commander's next question to his staff is: "Are there any other factors which would limit our sortie production capability to less than the number based on aircraft availability?" The above is an example of the iterative nature of the "expert interview" process and the types of information (rules, grammar, and situational characteristics) the ES will attempt to codify.

This analysis is structured as follows: First introduce the question as framed by the ATOC with some expansion and clarification; then describe it by the methods used to determine the number of available aircraft. Subsequent factors are discussed in an order-independent manner.

As this analysis examines sortie production factors, rules of thumb and defaults are specified for wartime-the most demanding situation.

Different rules of thumb and defaults necessarily apply in peacetime and contingency operations. Thus, the Expert System allows considerable situational tailoring.

This system was designed for war: Preliminary research has showed that a system rigorous enough for wartime can be appropriate for peacetime and contingency situations, but that a system designed for peace may not be adequate for wartime. It does not make sense to build a system that is helpful only in peace when a system that is always useful can be produced at the same cost.

LEVELS OF COMMAND

The areas of concern at various levels of command are tied tightly to their overall areas of responsibilities. The responsibility of the Headquarters Air Force staff is the overall capability of the Air Force. Therefore, when preparing for or involved in a conflict, they would be especially concerned with the overall conditions in the theater. The types of problems that these managers would be dealing with and be the most concerned about would include analysis of the total threat directed toward the particular theater of action; any "hot spots" that might be developing such as areas of locally intense activity; the gross resource availability within the theater and the methods by which these resources can be augmented, if needed; and the long-term total mission capability of the forces within that area. There would also be concerns, especially in a hostile situation, about the deployment of units into the theater of operations.

The concerns of the major command or theater command are, of course, much more localized than those of the Headquarters Air Force. In this respect, the major commander is concerned not only about his total mission performance capability, but also the localized capabilities on the various fronts or areas of action rather than about the long term (30-, 60-, 90-day) capabilities. A theater commander is more interested in his short-term mission capability i.e. his capability to form missions up to 7 to 10 days in response to the perceived or known threat along the forward edge of the battle area. Additionally, the major commander needs to know where his aircraft are and how much support is available, both in terms of resources that are currently available and those that will be available in the future.

Since some future capabilities depend on relocation of these resources, he would also need to be certain about the availability of transportation to move these parts or resources within the theater of action.

The local commander is more interested in those areas or threats which intrinsically related to his base (within approximately 50 miles of his point of operations). In this respect, he would be concerned with enemy or hostile forces within that immediate area, the security of his immediate local resources as well as availability of aircrft both to respond to the local threat and to respond to taskings received from the higher headquarters. In this respect he would want to make sure he could meet the very short-term known and projected mission requirements, i.e., within 1 to 3 days. These short term requirements would promote a very high level of concern for aircraft availability as well as stockage and resupply of critical parts and other assets including munitions and fuels, the local aircraft generation capability and the availability of all locally required resources.

HOW DOES IT ALL FIT TOGETHER?

Perhaps the best way to explain how all of the three levels of command fit together in exercising either a peacetime or a wartime scenario is to explain it on the basis that the Headquarters Air Force staff is primarily responsible for planning and for monitoring the execution of the scenario. The major commander or theater commander is responsible for directing the scenario while the local commander is the person on whom the primary responsibility for execution lies. Within this framework, and for the purposes of this paper, we will break the responsibilities into two separate parts. One is pre-attack actions and concerns, and the second is action and concerns during the attack or active hostilities.

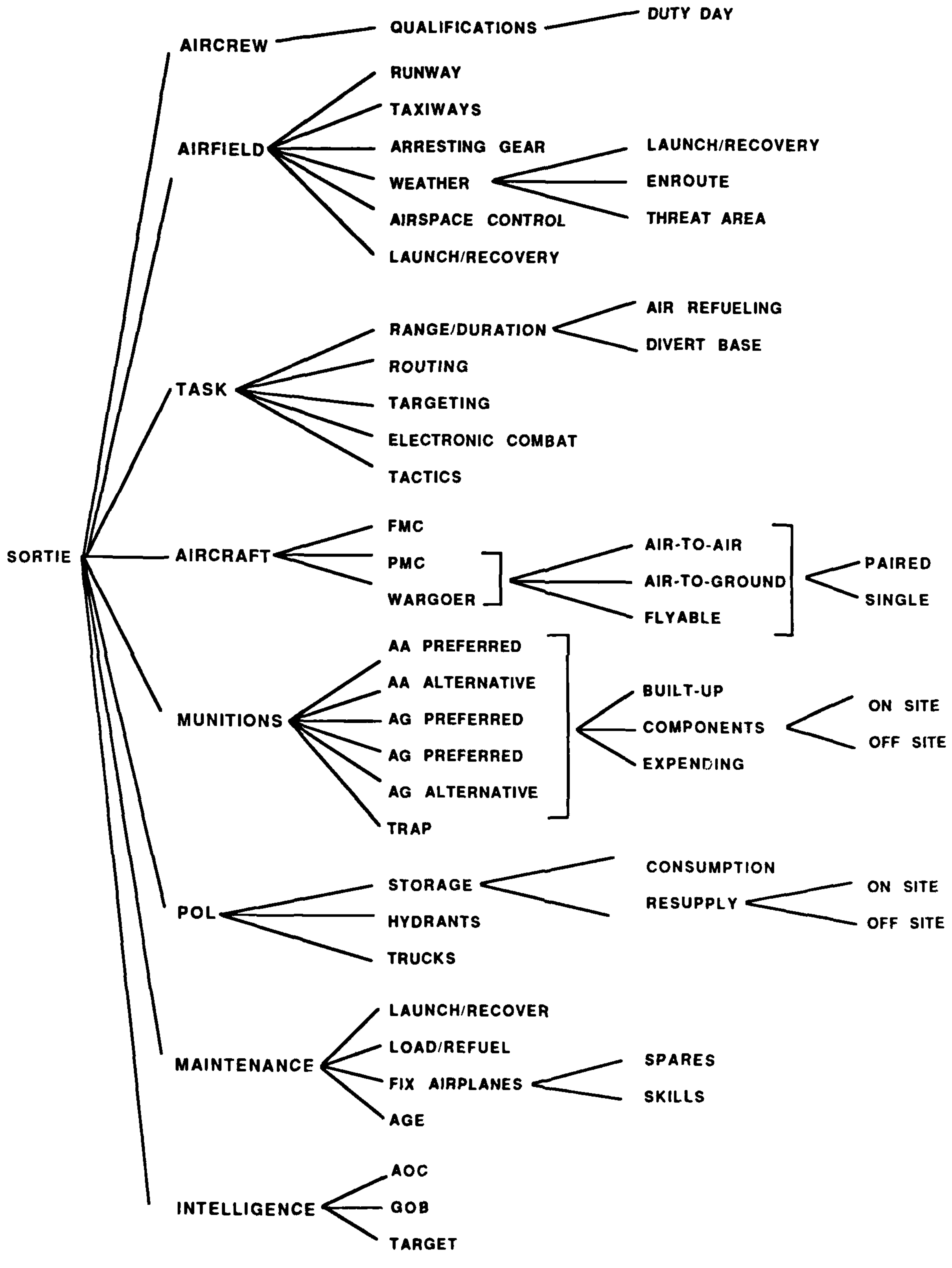
During the pre-attack phases at the Headquarters Air Force, the primary responsibility is to mobilize and monitor the execution of the deployment of forces into the theater of operations. These actions will be initiated when we become aware of unusual hostile troop build-ups or actions. At this time, the Headquarters Air Force staff would begin reviewing in-place units and CONUS units which are tagged for deployment into the theater. They would also probably start the deployment of forces into the theater and initiate the redistribution of assets from CONUS to the engaged units or soon-to-be engaged units, increase the defense readiness conditions, and other necessary or preplanned, pre-attack actions.

At the major command or theater command level, the commander would respond by making preparations to receive the deploying units (for example, activating COBS) and will begin the deployment of any in-theater forces which would be deploying to other bases as well as increasing vigilance and reporting from subordinate units in order to get all of the available assets into their preplanned positions.

On the more local or base level the local commander would begin recalling any troops that might be on leave or temporary duty, instituting extended shifts, and preparing to deploy any local units which are tasked for deployment and to receive units deploying. Additionally, the local commander would also begin building up stored muntions and wing tanks and dispersing local assets. He would maximize aircraft availability through increased maintenance and supply action. Once the hostilities begin, the responsibilities of the Headquarters Air Force staff revert to monitoring and exception action. In this regard, the Headquarters-level staff would be concerned with monitoring the position and condition of the total engaged force, monitoring, and revising where necessary, the deployment schedules of units which have not yet deployed into the theater of operations, as well as directing CONUS support activities and responding to the major command request for additional resources.

The major command or theater commander will primarily be concerned with the individual actions and localized conditions within the whole theater. This will entail such things as directing the deployment or redeployment of in-theater resources to meet the localized threats, monitoring and directing the placement of incoming assets, and planning and directing the response to the immediate theater threats as well as planning near-term responses such as air interdiction and other actions required beyond the forward edge of the battle area.

The local commander is, in many respects, now restricted to a reactionary mode. His primary responsibility is to counter any local threats that are directed against his particular installation as well as responding to and reporting to the major command or theater commander. In this aspect, it becomes extremely important for the local commander to maintain an accurate picture of the availability of his local assets and the status of all of his local resources.


SORTIE
AIRCREW
QUALIFICATIONS
DUTY DAY
AIRFIELD
RUNWAY
TAXIWAYS
ARRESTING GEAR
WEATHER
LAUNCH/RECOVERY
ENROUTE
THREAT AREA
AIRSPACE CONTROL
LAUNCH/RECOVERY
TASK
RANGE/DURATION
AIR REFUELING
DIVERT BASE
ROUTING
TARGETING
ELECTRONIC COMBAT
TACTICS
AIRCRAFT
FMC
PMC
WARGOER
AIR-TO-AIR
AIR-TO-GROUND
FLYABLE
PAIRED
SINGLE
MUNITIONS
AA PREFERRED
AA ALTERNATIVE
AG PREFERRED
AG PREFERRED
AG ALTERNATIVE
TRAP
BUILT-UP
COMPONENTS
EXPENDING
ON SITE
OFF SITE
POL
STORAGE
HYDRANTS
TRUCKS
CONSUMPTION
RESUPPLY
ON SITE
OFF SITE
MAINTENANCE
LAUNCH/RECOVER
LOAD/REFUEL
FIX AIRPLANES
AGE
SPARES
SKILLS
INTELLIGENCE
AOC
GOB
TARGET

I. DATA CAPTURE FORM

The data capture form was created to insure that we consistently captured all of the pertinent information about each factor in the sortie production stream. This section of the report will explain each of the headings on the form and its relevance to the AI/ES process.

A. Question: As explained elsewhere the initial query from the ATOC will generate a number of other questions at the unit. This entry captures the primary question whic must be answered ineach factor area. It is generally percieved to be the question asked of the functional area expert (Battle Staff member) by the Battle Commander.

B. Subquestion: The subquestion(s) are those that the functional expert must answer in order to provide an answer to the primary question.

C. Desired Output: The information included under this heading should focus on the form of the response that will be given to BC rather than the actual content of the response. This is necessary so the completed system can produce responses with language that is familiar to the user.

D. Expert: The functional expert who will be asked the question and be expected to provide an answer.

E. Source: This section describes the source of the information the expert uses to determine his answer.

F. Process: What steps are necessary to gather information from the source(s)?

G. Influences: List other factors whic may be impacted by the response to this question. E.G., The number of aircraft that are available will affect the amount of maintenance required.

H. Influenced By: What other factors will directly influence this factor.

I. Defaults: What nominal values should we use (does the expert use) when detailed data is not available.

J. Boundary: As previously discussed, the expert system must be realistically bounded to function properly. This section of the form is used to describe the level of detail that is acceptable to the system.

F4 G/E Aircraft

Question: Can we man 3 supression caps from first light to dusk with SCL 1 and 2?

Subquestion:
1) Whats the transit time to and from each cap point?
2) Whats the flying window?
3) How long can aircraft remain in each cap?
4) What launch and recovery pattern is needed to do the mission?
5) What is SCL 1 and 2?
6) What are limiting factors within our control that we could change to do the mission?
7) What are the limiting factors within higher headquarters control that could be changed to do the mission?

Desired Output: Number of aircraft. (FMC + PMC + Wargoers)

Expert: MA for FMC and PMC aircraft.
DO/MA for wargoers (consultation).

Source: Determine number from greaseboard in WOC that depicts FMC and PMC airplanes. MA/DO verbal discussion wargoers - to determine total offered.

Process: MA phones job control if he doubts greaseboard answer. Other automated systems may be interrogated.

Influences: Directly influences sortie answer and number of aircraft for each turn.

Influenced By: Wargoer rules

Defaults: Greaseboard in WOC and maintenance job control.

Boundary: WOC numbers are believable. Know how many wargoers there are.

F4 G/E Aircrew

Question: How many mission qualified aircrews do you have?

Subquestion: 1) How many defense suppression qualified do you have?

Desired Output: Number of aircrews (filtered through duty day)

Expert: DO

Source: Each Tactical fighter squadron. AFORMS/UNITREP/UNIT LEVEL AUTOMATION (ULA)

Process: DO calls fighter squadron because information from other systems may be dated. Intuitive answers based on how many aircraft you have and scehduling of aircraft.

Influences: Iterative process.

Influenced By: Duty Day/Weather

Defaults: TFS operations board/(28 per squadron)

Boundary: Resources are efficiently allocated.

F4 G/E Airfield

Question: Are there any airfield constraints on sortie generation? This question cannot be answered prior to asking the following subordinate questions.

Subquestion:
1) Do I have sufficient runway to launch and recover my aircraft? (Defaults provided)
2) Do I have access via runways.
3) What is status of the arresting gear?

Desired Output: No constraint. That is, airfields are not a limitation. If there are constraints, what is the nature of the constraint?

Expert: DO/SRC

Source: SRC type of information

Process: To be amplified by Mr. Devorshak

Dependent upon task

Influences: May influence fuel load and/or SCL choice.

Influenced By: Will weather impact take off or landing?
GCA
Navigation Aids
Airspace Control

Defaults: See default table

Boundary: SRC & Weather

F4 G/E Task

Question: Is there anything in the task that will affect sortie generation capability?

Subquestion: 1) Can they reach target?
2) Where is target?
3) Is there any extraordinary routing that will affect this?
4) Can the aircraft reach home after this mission?

Desired Output: No task oriented limitation.

Expert: DO

Source: Combat Plans at SOC

Process: 1) Measure distance to and from each cap point.
2) Convert that distance into transit time.
3) Add transit time to first light and dusk to determine flying window.
4) Subtract total transit time from total endurance to determine how long aircraft can stay in each cap.
5) Plot launch and recovery pattern.

Influences: Munitions
Maintenance

Influenced By: Intelligence order of battle.

Defaults: All aircraft are equipped with ICS.

Boundary: Tasking

F4 G/E POL

Question: Can you fuel my airplanes?

Subquestion: (1) How many can I fuel shelterd?
(2) If all can't be sheltered, can I schedule refueling without movement?

Desired Output: Yes no shortfall exists or explain nature of constraint, i.e., insufficient fuel on hand or refueling units.

Expert: RM

Source: Fuels control center, CFMS (not used at this level of analysis)

Process: (1) Calculate truck refueling rate
(2) Calculate total fuel available (See appendix for defaults)

Influences: Sortie production can be a constraint.

Influenced By: Storage Capacity
Dispensing Capacity
Turn Pattern
Airfields

Defaults: Standard consumption by MD (stored in default table)

Boundary: We will stay within the range of the defaults.

F4 G/E Maintenance

Question: Are there any maintenance constraints on sortie production capability?

Subquestion: Do I have enough people to launch and recover?

Desired Output: No constraint and not maintenance manpower limited. If constrained and no redistribution is possible, MA provides lower number of sorties.

Expert: MA/DO/RM

Source: MA, RM for Spares. Potential system sources: CAMS/MMICS/ULA/WSMIS/AFIRMS/CFMS/CSMS/CAS

Process: MA will call AGS (Aircraft Generation Squadron) squadron commander and ask if he can support the task. RM will determine refueling. MA consults with job control to determine critical spares status.

Influences: Launch and recovery patterns. Turn patterns.

Influenced By: Skilled manpower available; BLSS/WRSK fill

Defaults: See appendix

Boundary: Not below job control AGS commander for launch/recovery and AGE; RM for fuel and some spares.

F4 G/E Intelligence

Question: Are there any intelligence factors that would influence sortie production?

Subquestion: Referred to classified model (TBD by SRA)

Desired Output: No limiting factors or statement of constraing factors. May result in ECM pods being constraining resource.

Expert: DO, Battle Commander

Source: Unit level intelligence

Process: DO gets intelligence briefing with focus on AOB and target factors.

Influences: Decisions on wargoers. AOB and GOB will influence programming ECM pods. (Time to accomplish task)

Influenced By: AOB/GOB/target intelligence

Defaults: No limitations for this demonstration

Boundary: WOC intelligence officer/higher level headquarter intelligence inputs/TAC mission planning systems.

F-16 Task

Question: Is there anything in the task that will affect sortie generation capability?

Subquestion: 1) Can they reach target?
2) Where is target?
3) Is there any extraordinary routing that will affect this?
4) Can the aircraft reach home after this mission?

Desired Output: No task oriented limitation.

Expert: DO

Source: Combat Plans at ATOC/unit.

Process: Rules of thumb which are changed if needed.

Influences: Munitions
Maintenance

Influenced By: Intelligence/order of battle.

Defaults: See Attachment A

Boundary: Tasking

F-16 Munitions

<u>Question</u>: Do I have enough iron bombs to support 141 sorties tomorrow?

<u>Subquestion</u>: (1) If we don't have enough built, can we build them?
(2) How many sorties do I have? SCL's?

<u>Desired Output</u>: Yes. You do have enough (expressed in sortie loads).

<u>Expert</u>: MA and RM

<u>Source</u>: Munitions control for munitions, job control, MA. TRAP information comes from Supply Control Center and Job Control Center.

<u>Process</u>:

<u>Influences</u>: Tasking
Aircrew Selection

<u>Influenced By</u>: Airfield

<u>Defaults</u>: Model SCL contained in default table.

<u>Boundary</u>: Capability demonstration boundary.

F-16 POL

Question: Can you fuel the airplane on time?

Subquestion: (1) How many can I fuel shelterd?
(2) If all can't be sheltered, can refueling be scheduled without aircraft movement?

Desired Output: Yes no shortfall exists.

Expert: RM

Source: Fuels control center, CFMS (not used at this level of analysis)

Process: (1) Calculate truck refueling rate
(2) Calculate total fuel available (See appendix for defaults)

Influences: Sortie production can be a constraint.

Influenced By: Storage Capacity
Dispensing Capacity
Turn Pattern
Airfields

Defaults: Standard consumption by MD (stored in default table)

Boundary: We will stay within the range of the defaults.

F-16 Maintenance

Question: Are there any maintenance constraints on sortie production capability?

Subquestion: Do I have enough people to launch and recover?

Desired Output: No constraint and not maintenance manpower limited. Is constrained and no redistribution is possible then MA provides lower number of sorties.

Expert: MA/DO/RM

Source: MA, RM for Spares. Potential system sources: CAMS/MMICS/ULA/WSMIS/AFIRMS/CFMS/CSMS/CAS

Process: MA will call AGS (Aircraft Generation Squadron) squadron commander and ask if he can support the task. RM will determine refueling. MA consults with job control to determine status of the spares shortfalls and critical spares status.

Influences: Launch and recovery patterns. Turn patterns.

Influenced By: Skilled manpower available; BLSS/WRSK fill

Defaults: See appendix

Boundary: Not below job control AGS commander for launch/recovery and AGE; RM for fuel and some spares.

F-16 Intelligence

Question: Are there any intelligence factors that would influence sortie production?

Subquestion: Refer to classified model (TBD by SRA)

Desired Output: No limiting factors or statement of constraing factors. May result in ECM pods being constraining resource.

Expert: DO, Battle Commander

Source: Unit level intelligence

Process: DO gets intelligence briefing with focus on AOB and target factors.

Influences: Decisions on wargoers. AOB and GOB will influence programming ECM pods. (Time to accomplish task)

Influenced By: AOB/GOB/target intelligence

Defaults: No limitations for this demonstration

Boundary: WOC intelligence officer/higher level headquarter intelligenc inputs/TAC mission planning systems.

F-15 Aircraft

Question: Can we man 3 lane CAP positions with a minimum of two aircraft from light to dusk with SCLB?

Subquestion:
1) Whats the transit time to and from each cap point?
2) Whats the flying window?
3) How long can aircraft remain in each cap?
4) What launch and recovery pattern is needed to do the mission?
5) What is SCL 3?
6) What are limiting factors within our control that we could change to do the mission?
7) What are the limiting factors within higher headquarters control that could be changed to do the mission?

Desired Output: Number of aircraft. (FMC + PMC + Wargoers)

Expert: MA for FMC and PMC aircraft.
DO/MA for wargoers (consultation).

Source: Determine number from greaseboard in WOC that depicts FMC and PMC planes. MA/DO verbal discussion wargoers - to determine total offered.

Process: MA phones job control if he doubts greaseboard answer. Other automated systems may be interrogated.

Influences: Directly influences sortie answer and number of aircraft for each turn.

Influenced By: Wargoer rules

Defaults: Greaseboard in WOC and maintenance job control.

Boundary: WOC numbers are believable. Know how many wargoers there are.

F-15 Aircrews

Question: How many mission qualified aircrews do you have?

Subquestion: 1) How many air-to-air qualified people do you have?

Desired Output: Number of aircrews (filtered through duty day)

Expert: DO

Source: Each Tactical fighter squadron. AFORMS/UNITREP/UNIT LEVEL AUTOMATION (ULA)

Process: DO calls fighter squadron because information from other systems may be dated. Intuitive answers based on how many aircraft you have and scehduling of aircraft.

Influences: Iterative process.

Influenced By: Duty Day/Weather

Defaults: TFS operations board/(28 per squadron)

Boundary: Resources are efficiently allocated.

F-15 Airfield

<u>Question</u>: Are there any airfield constraints on sortie generation? This question cannot be answered prior to asking the following subordinate questions.

<u>Subquestion</u>:
1) Do I have sufficient runway to launch and recover my aircraft? (Defaults provided)
2) Do I have access via taxiways.
3) What is status of the arresting gear?

<u>Desired Output</u>: No constraint. That is, airfields are not a limitation. If there are constraints, what is the nature of the constraint?

<u>Expert</u>: DO/SRC

<u>Source</u>: SRC type of information

<u>Process</u>: To be amplified by Mr. Devorshak

Dependent upon task

<u>Influences</u>: May influence fuel load, SCL choice, launch and recovery pattern.

<u>Influenced By</u>:
Weather
GCA
Navigation Aids
Airspace Control

<u>Defaults</u>: See default table

<u>Boundary</u>: SRC & Weather

F-15 Task

Question: Is there anything in the task that will affect sortie generation capability?

Subquestion:
1) Can they reach target?
2) Where is target?
3) Is there any extraordinary routing that will affect this?
4) Can the aircraft reach home after this mission?

Desired Output: No task oriented limitation.

Expert: DO

Source: Combat Plans at SOC

Process:
1) Measure distance to and from each cap point.
2) Convert that distance into transit time.
3) Add transit time to first light and dusk to determine flying window.
4) Subtract total transit time from total endurance to determine how long aircraft can stay in each cap.
5) Plot launch and recovery pattern.

Influences: Munitions
Maintenance

Influenced By: Intelligence/order of battle.

Defaults: All aircraft are equipped with ICS.

Boundary: Tasking

F-15 Munitions

Question: Do I have required SLC?

Subquestion: (1) If we don't have enough built, can we build them?
(2) How many sorties do I have? SCL's?

Desired Output: Yes. You do have enough. This would be expressed in sortie loads. If alternate munitions must be used specify what they are.

Expert: MA and RM

Source: Munitions control for munitions, job control, MA. TRAP information comes from Supply Control Center and Job Control Center.

Process:

Influences: Intelligence
Tasking
Aircrew Selection

Influenced By: Actual expenditures

Defaults: 1.8 Aim 7's expended per sortie
.8 Aim 9's expended per sortie
300 Rounds of 20 millimeter per sortie
SCL's listed in default table

Boundary: Estimated expenditure rates

F-15 POL

Question: Can you fuel my airplanes?

Subquestion: (1) How many can I fuel shelterd?
(2) If all can't be sheltered, can I schedule refueling without movement?

Desired Output: Yes. If constrained, is constraining factor fuel quantity or refueling units?

Expert: RM

Source: Fuels control center, CFMS (not used at this level of analysis)

Process: (1) Calculate truck refueling rate
(2) Calculate total fuel available (See appendix for defaults)

Influences: Sortie production can be a constraint.

Influenced By: Storage Capacity
Dispensing Capacity
Turn Pattern
Airfields

Defaults: Standard consumption by MD (stored in default table)

Boundary: We will stay within the range of the defaults.

F-15 Maintenance

Question: Are there any maintenance constraints on sortie production capability?

Subquestion: Do I have enough people to launch and recover?

Desired Output: No constraint and not maintenance manpower limited. If constrained and no redistribution is possible then MA provides lower number of sorties.

Expert: MA/DO/RM

Source: MA, RM for Spares. Potential system sources: CAMS/MMICS/ULA/WSMIS/AFIRMS/CFMS/CSMS/CAS

Process: MA will call AGS (Aircraft Generation Squadron) squadron commander and ask if he can support the task. RM will determine refueling. MA consults with job control to determine critical spares status.

Influences: Launch and recovery patterns. Turn patterns.

Influenced By: Skilled manpower available; BLSS/WRSK fill

Defaults: See matrix

Boundary: Not below job control, AGS commander for launch/recovery and AGE; RM for fuel and some spares.

F-15 Intelligence

Question: Are there any intelligence factors that would influence sortie production?

Subquestion: Referred to classified model (TBD by SRA)

Desired Output: No limiting factors or statement of constraing factors. May result in ECM pods being constraining resource.

Expert: DO, Battle Commander

Source: Unit level intelligence

Process: DO gets intelligence briefing with focus on AOB and target factors.

Influences: Decisions on wargoers. AOB and GOB will influence programming ECM pods. (Time to accomplish task)

Influenced By: AOB/GOB/target intelligence

Defaults: No limitations for this demonstration

Boundary: WOC intelligence officer/higher level headquarter intelligence inputs/TAC mission planning systems.

AI CAPABILITY DEMONSTRATION DEFAULT VALUES*

	F-15	F-16	F-4E	F-4G
Mission Elements:				
Range [1]	N/A	325 nm	225 nm	225 nm
Man Duration [2]	2.0 hr	1.7 hr	1.2 hr	1.2 hr
Target Flow [3]	2/CAP	4/10 min	4/10 min	4/10 min
Targets/Flight [4]	N/A	4	4	4
SCL Pref [5]	3	4	1	2
SCL All [5]	5	1		
ECM	ICS	1/2 AC	1/2 AC	1/2 AC
Launch Factors:				
Take Off Dist. [6]	1200 ft	1200 ft	2500 ft	2500 ft
Launch Rate [7] [8]	4/2 min	4/2 min	4/2 min	4/2 min
Crews-Maint. [7] [8]	5	5	5	5
Crews-Muns.	3	3	3	3
Recovery/Turn Factors:				
Landing Dist. [8]	2500	2500	4000	4000
Recovery Rate [9]	(see footnotes)			
BAK 14 recy times [10]	2 min	2 min	2 min	2 min
BAK 13 recy time [10]	10 min	10 min	10 min	10 min
Fuel Load lbs. [11]	12,000	7500	14,000	14,000
Fuel Load gal. [11]	1900	1200	2400	2400
Refuel Time [11]	10 min	10 min	10 min	10 min
Ref Units/AC [11]	2/3	1/3	2/3	2/3
Turn Time (total)	(condition code dependent)			
Turn Rate [12]	(see footnotes)			

SCL	SCL LOAD	CONDITION CODE	TURN TIME
1	6 MK 82 900 20 mm HEI	1 2 (def.) 2 (non-def.)	1 hour 1 hour 4 hours
2	2 AGM 45 2 AGM 95	3 soft 3 hard	4 hours 8 hours
3	4 AIM 7M 4 AIM 9L 900-20 mm HEI		
4	6 AGM 65 900-20 mm HEI		
5	4 AIM 7F 4 AIM 9J 900-20 mm TP		

FOOTNOTES

1. Notional - takes into account enroute tatics.
2. Unrefueled, lift-off to touch-down.
3. For A-G, A/C per flight/separation between flights.
4. Targets per mission.
5. Standard Configuration load, unclassified-notional.
6. Determines minimal usable runway required.
7. Required for end-of-runway check.
8. Includes on crew to recover aborting aircraft.
9. Landing rates, 1 aircraft or 1 twoship element every 30 seconds.
10. Average barrier reset time.
11. Nominal planning factors.
12. All available A/C on first launch, 80% on second launch, 64% on third. (80% of second)

* All values are nominal planning factors or notional data.

** Full explanation of footnotes attached.

AI Capability Demonstration Default Value Footnotes

The AI capability demonstration default value chart contains the default values that will be entered into the AI/Expert Systems. This document will serve as an adjunct to the default value chart and will attempt to fully explain the shortform footnotes contained on that chart.

Footnote 1: Range

The range for any given aircraft is dependent on, not only its internal fuel capacity, but also the configuration of external fuel tanks and the tactics employed enroute and in the target area. Therefore, we elected to present some notional values which seem to be representative of the aircraft being portrayed in this demonstration. For the F-15, we have chosen not to include a range value since the F-15 is purely an air-to-air aircraft and mission duration is much more important than the actual out and back range. The only assumption that we have made in this area is that all F-15 targets are going to be within the effective combat range of the F-15.

Footnote 2: Mission Duration

This factor assumes that the aircraft perform their missions unrefueled with normal external fuel tanks, that is, the arrangement of external fuel tanks that would be allowed by the munitions SCLs. The mission duration is assumed to be the time from liftoff to mission touchdown. Thus the time to taxi the aircraft to perform pre-flight tests and post-flight tests, etc. is not included in this category.

Footnotes: Target Flow

This factor is intended to portray the flow of aircraft over the target area. For the F-15 in air-to-air mission we assume that it is performing combat air patrol (CAP), therefore it would be tasked in two ship CAP sorties and would fly a predetermined lane and therefore would maintain two aircraft per lane in that area. For the air-to-ground mission with the F-16, F-4E and F-4G, we assumed that they would arrrive at the target area in flights of four and for any target receiving multiple strikes that there would be a minimum separation of 10 minutes between attacking flight arrivals.

Footnote 4: Targets Per Flight

This value is used to account for the probability that no single airplane or single flight of airplanes will expend all of its munitions on one target, rather it is more realistic to assume that each flight will be assigned a number of targets with one pass per target. We have assumed a figure of 4 targets per flight for the air-to-ground missions. We have also noted that this is not applicable to the F-15 air missions, since it would be flying a CAP mission and would be attacking targets of opportunity. There are, however, commonly accepted expenditure rates which would be applicable to the F-15 in this role.

Footnote 5: Standard Configuration Loads (SCL)

The SCLs specify the assortment of munitions that would be carried by an aircraft on a combat mission. There are a large number of Air Force SCLs, most of which are classified and all of which are highly dependent upon the actual target that would be attacked on a mission. Therefore, we have created five notional SCLs. These notional SCLs are used by the capability demonstration to evaluate the sufficiency of munitions at the individual locations we are portraying.

Footnote 6: Take Off Distance

This is a nominal figure which assumes that the aircraft are taking off under average conditions with a full combat load. This is an attempt to set bounds on the amount of usable runway that will be required at a base in order for the aircraft to depart for their missions. It should be noted that the aircraft SCL, the availability of air refueling, weather and other factors can have a significant impact on this figure.

Footnote 7: Crews

The crews in this case, the maintenance launch crews and missions crews, are those personnel who are required at the take off at the end of the runway in order to perform the final per-flight maintenance checks, and to arm the weapons immediately prior to aircraft take off.

Footnote 8: Crews

The numbers included for this factor include one launch and recovery crew and one munitions crew dedicated to recovering any aircraft which may abort during or immediately after take off. These personnel are essential in order to ensure the runway stays clear and the take off flow is not interrupted.

Footnote 9: Recovery Rate

This factor is actually our notional landings rate, that is, the rate at which a single runway airfield could handle aircraft landings. We have assumed for purposes of this demonstration that the rate is either one aircraft or one two-ship formation landing every 30 seconds.

Footnote 10: BAK Recycle

In the airbases which we are going to consider for this demonstration, we have specified that there is a BAK 14 and a BAK 13 located at each end of the runway. These capable barriers are required to recovery aircraft that are landing with serious deficiencies. We have specified what we feel is an average minimum time between barrier engagements. This allows the approrpriate civil engineering personnel to respond to the barrier engagement and to ready the barrier for the next landing. It should be noted that the aircraft recovery stream will be interrupted from the time the barrier is engaged until the barrier can be reset.

Footnote 11: Fuels Planning Factors

It is impossible to know ahead of time how much fuel any given aircraft is going to use or how long it will take to fuel that aircraft. We have included some "commonly accepted" factors which the demonstration will use along with actual fuel inventory and refueling unit availability in order to ascertain if there is sufficient fuel to support the recovery of all the aircraft within the time windows that will be established.

Footnote 12: Turn Rate

For this demonstration, we are attempting to make our assumptions as realistic as possible. Therefore, since we do not know the aircraft break and attrition rate and the demo does not interface with any predictive models, we have used what we consider a reasonable planning factor to compensate for these degradations and fleet conditions over the period of the three launches. Therefore, for these purposes, we assume all aircraft available for the first launch of the day are launched as required. Further, we assume that of those aircraft which flew the first sortie, 80% will be available for flying on the second launch, and of those, 80% (64% of the original number) will be available for the third launch of the day. This figure takes into consideration the probability of aircraft attrition, aircraft being battle damaged and unusable, and aircraft that are broken and cannot be fixed in time for the subsequent launches.

SCENARIO

This hypothetical scenario was prepared and is presented strictly for use as a background for the design and testing of the AI/EKS system. Any similarity between this scenario and any "official" scenario is purely coincidental.

I. Pre-Engagement

Buildup of hostile forces in Eastern Europe convince national leaders that a conflict is imminent. Decision is made to activate appropriate OPLANS.

II. Engagement

Hostilities break out with enemy forces concentrated in NATO Central Region and flanking attacks at northern and southern extremes.

HQ/USAF QUESTIONS AND ANSWERS

I. Pre-Engagement

Q: Should deployment proceed as planned in OPLAN XXXX?

A. Deployment should proceed as planned with the following exceptions.

a) YYTFS should be deployed instead of ZZTFS.

b) AATFS should be deployed to Base H.

Logic Trail

a) Comparing intelligence reports to OPLAN assumptions shows high degree of correlation, so deployment should proceed as planned.

b) ZZTFS is reporting C-3 in UNITREP, review of supply (CSMS) and CAMS data bases show critical WRSK shortages and low aircraft availability over past 30 days. It is doubtful that unit could fight effectively. YYTFS is reporting higher readiness and should be moved up in the deployment schedule.

c) Intelligence reports indicate high probability of more intensive conflict near Base H than planned. Placing AATFS here will increase probability of success without significantly affecting probability of success at the originally targeted deployment location. Review of base reported resources - ARMS, CFMS, etc. - shows sufficient resources to support unit.

II. Engagement

Q: Are in-place forces and resources adequate?

A: No. Additional F-99 aircraft are needed to meet the threat.

Logic Trail

The system will compare reported aircraft availability, attrition rates, and sortie rates to the OPLAN factors. In this example it determines that more aircraft are needed to meet the threat.

Since the original question also asked about resources, the system would also review the reported supply, POL, munitions, etc. positions to determine if they were adequate. If not, the system would recommend augmentation of the deficient resource.

Additional questions from the user would cause the system to recommend the units to be tasked for deployment, and recommend a deployment schedule and beddown site.

THE ATOC PLANNING QUESTION

The production of an ATO by the ATOC is a procedure of many steps. The first step determines the number of sorties by task each base can produce the following day. Next, the ATOC reviews its known and predicted mission requirements to assign sorties and missions to bases predicated upon the bases' sortie production capabilities. The third step is the transmittal of the ATO to individual units. Activity shifts to executing specified tasks. Initial planning is focused on defining the number of sorties to be offered to ATOC. The basis for this planning is the following hypothetical question:

> "How many air-to-ground sorties with 'iron bombs' can you produce tomorrow under an early light, midday, late afternoon generation schedule, unrefueled?"

The battle commander answers this by formulating subordinate questions within the unit to derive the final number of sorties. At this point, it should be noted that an ATOC-reported "answer" may be a rule of thumb, a default, or (in the case of a problem) a cascading set of detailed questions. This analysis attempts to identify major questions. At the detail level, questions are answered by individual experts to provide human input to functional area experts.

Minutes of Meeting

Expert Interview

The general and common question from the ATOC is: "How many sorties can you generate for a first light, midday, and afternoon sortie pattern using dumb bombs in an air to ground role?" To answer this the battle commander needs to know the contributions from eight functional unit areas: aircraft, aircrews, airfields, tasking, munitions, POL, maintenance and intelligence.

While most of the above areas are order independent, we choose aircraft production as a logical starting place. Whenever a functional area came in with a lower number aircraft product number, that number defined the limiting factor. (For example, if 58 aircraft could be produced by MA and aircrews could produce 43 sorties for the first turn of the day, then 43 sorties would become the limiting number.)

While no task is totally independent, each has been considered with as much independence as possible. The eight functional areas were given structure by a form generated during the meeting. The form has: a context setting question; a specific sub-question; desired output; the expert used; the expert's source; the process; what would be influenced; and the expert's decision process.

We define the AI demonstration limits, the boundaries and the defaults. The basis is a matrix of the above components as provided by SRA. The focus never left the decision maker's default assumptions. (For example, in the POL area, it is commonly understood that an F4E will take 15,000 pounds of fuel and the refueling will take 15 minutes.)

Default values will be used where better information is not available. When used, they will be made as visible as possible to allow the expert or user to change them at will. This "what if" capability should be a definite advantage: As familiarily increases, the system's performance will improve.

The goal is to define the information used by a decisionmaker whenever accurate information is limited and quick plans must be laid. As a caveat, all experience-based rules of thumb will be replaced whenever accurate detailed functional information becomes available. (In this AI capability model, we will leave until later the problems of hypothesizing data interfaces into supporting systems such as AFCAP, CFMS, CAMS and ULA.)

TASKING

Responding to the ATOC question in the tasking area, can, at best, provide a rule-of-thumb answer. In this scenario, all that is known is that we will fly air-to-ground missions with iron bombs and no air refueling. The battle commander makes assumptions about the target locations, electronic countermeasures, tactics, etc. The default target information is: a nominal range of 225 miles, considering tactics, for the F4 and 325 miles for the F16. Further, we assumed a nominal sortie duration of 1.2 hours for the F4E/G, 1.7 for the F-16 and 2.0 for the F-15.

The next category is Task. The question is: "Is there anything in the Task that would limit the number of sorties I can produce?" The answer should be "no" but if it is "yes", I ask if they can reach the target unrefueled. I also like to know where this target array is, as you need to know how long the airplanes need to be airborne. If you can't get to the target and back in those airplanes, you might have to reallocate the airplane to other bases. This will effect the turn pattern.

The thought process behind the range/duration was targets that they have to go to and/or the duration of flight. Can they reach home after the mission? At this point, you can't tell. Another question is, "Are there any extraordinary routings that would affect sortie generation?" or "What is the nature of the targets that will affect it?" If they are all very hard targets, and I am out of delayed fuses, that may be a constraining factor. The target might be such that I can only put one or two over that target in a minute, and if I launch all 58 then I couldn't use them on the target right away. But none of that is known yet. This information is necessary to build an ATO. We haven't gotten into that process yet. It will be there later, however. Our guess right now is that these are average defended targets. Put only one ECM pod per aircraft. The defaults are good range/duration and no air-to-air refueling. The defaults for this part of the tape are listed in the matrix. The numbers in the parameter table are notional, not classified. Classified numbers may be input by the user using what-if situations. It would be up to XOOIM to use their numbers.

These numbers will then be handed over to a guy who does formal planning. It will be handed over and may come back as "you will do 62" or "you will do 61."

For routing, for anything that headquarters can change, airspace control measures minimize the distance that guy has to fly. If they route you from "A" to "B" but you have to do it a certain way, and you can't do it that way, there might be a way that routing can change so that it is possible. We have range of 225 miles for the F-4 and 325 miles for the F-16 in the matrix. That does not mean as the crow flys. Routing is not always the most direct. There is a lot of interaction that goes on over the routing. Routing depends on airspace control, latitude, etc.

We have not included a nominal range for the F-15 in the default matrix. The reason for this is that the F-15 is flying pure air-to-air missions, and, therefore, the important question is not how far out and back the F-15 can fly, but how long can it remain on station once it reaches its assigned air patrol position.

Targeting was below altitude attack. You have to space airplanes about every 30 seconds because of fragmentation and debris involved. Depending on the target, the number of airplanes you can put on it changes. "What is the rate of ordinance release?" The question might be, "How many ordinance releases can you put on the target at any one time?" We are not considering coordination with the Army, or coordination between air defense boundaries. A logical default would be four aircraft every five minutes. The weapon release rate default would be one set per 30 seconds. The default for ECM pods was one ECM pod per two aircraft. The ground order of battle environment was dense enough that you might need more than one ECM pod per two aircraft.

AIRCRAFT AVAILABILITY

The first question asked in response to the ATOC query is: "How many aircraft am I going to have available tomorrow?" The response desired by the battle commander will be a single figure. However, this single availability figure may consist of three categories of aircraft. The first is fully mission capable aircraft (FMC), the second category is partially mission capable aircraft (PMC), and the third category is colloquially called "wargoers". The first two categories of aircraft, fully mission and partially mission capable are well defined and institutionalized. The chief of maintenance tracks them continually. The third category of aircraft -- wargoers -- is a much more nebulous area and is dependent upon many external factors. A wargoer, by our definition, is an aircraft that has been formally coded as non-mission capable (NMC) but which in the joint opinion of the chief of maintenance (MA) and the director of operations (DO) would be able to accomplish the requested missions, given a number of factors. For example, aircraft that has a defective inertial navigation unit (INU) would be NMC. However, in an air to ground scenario, where the aircraft was paired with an aircraft with a fully operational INU and under the right weather conditions, that aircraft might be considered a wargoer, and counted as available for the coming day.

We will start with an initial number of aircraft available for the morning launch. We apply a "generally accepted" rule of thumb that says that of the aircraft that take off on the first launch, approximately 80% will be available for a second launch and 80% of those (64% of the original number) would be available for a third launch. This provides a rough planning estimate of the number of aircraft that would be available for each launch pattern and sets the stage for estimating recover/ maintenance action that might need to be accomplished between launches and the number of aircraft likely to return from maintenance and be ready for launch in the subsequent turn pattern. Using this rule of thumb, we might find that, if for example, 58 aircraft are available for the early morning launch, then 46 will be available for the midday launch and 37 should be available for the late launch. The battle commander might then ask: "Are there any areas or factors which would reduce this total sortie production capability?" (which in our example is 141 sorties).

AIRCREWS

To determine if there are enough aircrews available to fly 141 sorties, the DO contacts each of his squadron operations centers to determine the total number of aircrews available. He then creates a rough schedule (considering crew rest restrictions) matching aircrews with sorties.

If the result of this process is not constraining when compared with other "factor" results, then there are enough aircrews and no further action is needed from the AI system. However, if the pool of available aircrews is inadequate, the battle commander will have to decide whether to accept the lower sortie capability or implement other measures such as extending the crew day.

Another factor in the pursuit of this question as to how many sorties we can fly is: "How many air-to-ground qualified aircrews do we have?" This is a subquestion of "How many qualified aircrews do we have?" The first question is implied, but this cannot be answered until the second question is dealt with first. Desired output is the quantity of aircrews. The expert is the DO. The source of this information is the fighter squadron or a reporting system output, both supported by unit level automation. In the real world, the DO calls the tactical fighter squadron because the information from AFORMS and UNITREP is old, while the tactical fighter squadron knows the current data.

The subquestion is duty day. Part of the process will be an intuitive answer based on the first question of "How many aircraft do you have?" If you are going to maximize the number of sorties you're going to produce in the beginning of the day you have to man all of those aircraft. However, if you fly turn patterns and the flying day is longer than a normal 12 hour crew duty day, what will happen is that this tactical fighter squadron will go through maximizing the number of aircraft .... at the first launch, second launch, etc. They'll then bring in crews gradually to conserve crew duty day since you can't launch all 58 aircraft at one time.

What we are seeing here is that we will attempt, based on the turn pattern and the number of aircraft that we think will be available for each turn, to schedule an aircrew against each potential sortie since the take off could quite possibly be 15, 18 or more hours from first launch. Then, it will be necessary to bring the aircrews in on a staggered basis so that they will not run out of crew rest prior to being able to fly. It is also important to understand that the aircrews must arrive on the duty site anywhere from an hour to two hours prior to scheduled launch in order to receive a mission briefing and to do their mission planning. Therefore, if we have, for example, a 15-hour flying day from first takeoff to last touchdown, we may have as many as a 17-or 18- hour total duty day for the aircrews, including the post-flight debriefings. Therefore, if we have 80 aircrews available, then we would schedule 58 of them to fly the first sortie. We also could have those same aircrews fly the second sortie, or we could bring in other aircrews to fly the second and subsequent sorties. It is important to remember the goal in this area is to have an aircrew available for every sortie.

We started with aircraft because that's the nearest thing we have to an independent entry-level variable. We do aircrews next because they are generally independent of lower level things, but aircrews are related to how many aircraft you came up with. The patterns by which you use your aircrew will be dependent upon the mission requirement for early light, midday, and late afternoon launch patterns. It is also dependent upon the number of airplanes that you have just come up with. The first thing you are going to get out of this is aircrews per turn, aircrews per next turn, and then aircrews per third turn. If that equals the total number of aircraft I need, then that's a good turn pattern.

For example, let's say the battle commander calls scheduling and says "how many people do I have qualified in air-to-ground sorties?" The scheduler looks at three status boards and say "70." This number will then be run through a mental filter with regard to factors such as duty day and number of aircraft available. The result is the number of aircrews.

MUNITIONS

"How many of the preferred or alternate air-to-ground munitions are available?" is our first question. We also considered TRAP under this scenario and noted that the same inquiry dialogue exists and the explanations and conditions that apply to TRAP apply to munitions. The munitions availability is composed of three deterministic factors. First, the number of built-up munitions on hand, second the number of individual components and the associated build-up rate, and third, the expenditure rate. For an air-to-ground mission, we assume that all munitions are expended on each sortie. Therefore, we would take the expected number of sorties (141) and multiply that by the number of munitions of each type that are to be loaded on each sortie and assume that the product is the requirement for tomorrow's flying activity. Normally, the amount of built-up munitions would not be sufficient to support an all day surge of the type that we are discussing. It will be necessary for the system to be able to predict how many sortie sets of munitions can be assembled between the time the question is asked and the time that munitions are required in the turn pattern. The rule of thumb is expressed as a heuristic:

Built-ups + (time until need x build up rate)

assuming enough component parts are available. When the total availability is divided by the sortie load, the result is the number of sorties that can be supported. The same heuristic is valid for the TRAP.

Mr. Devorshak discussed the determining of the gross number of munitions required for the 140 sorties needed. The original tasking request from the ATOC did not specify a bomb load, therefore based on our knowledge that we are using iron bombs, we would assume a Standard Configuration Load (SCL) and then multiply the number of bombs and rounds of ammunition for one sortie times the total number of sorties that we know we could support. The products become the requirement for munitions for the next day, and, consequently, they are then the goal to which we will attempt to meet through our munitions determination process. Mr. Devorshak also defined at this point high explosive incendiary (HEI), a type of 20 millameter ammunition. We then went into a discussion about how the question would be framed through the chief of maintenance by the battle commander. The most likely form of the question would resemble: "Do we have enough to support 140 sorties?" Since the answer depends on the SCL chosen for the mission, we went into a short discussion on the SCLs. Mr. Devorshak emphasized that the SCLs are maintained in a book by the Chief of Maintenance or the munitions maintenance officer, (who for instance, might look up SCL 27, and get the quantities per sortie from that source). Then he would proceed to determine the number of built up munitions he had and the number of component sets that could be assembled by the time when they were required for takeoff. At this time there was a discussion about the SCLs themselves, and Tom Scalf suggested that it should be possible to store the SCLs in the demonstration. However, some of the SCLs are classified. Therefore, the group decided that we would construct our own unclassified set of model SCLs for the purpose of the demonstration to avoid classification problems.

The discussion of storing SCLs brought up another important point: Can all this information be stored by the system? Dr. David Reel introduced system frames (which are the implementation terms for objects stored in the system) and the various types of information are stored or handled both in and out of the frames. There are: Procedures; rules; and data. Procedures are the actual code of the system. Therefore, procedure changes require the system code to be rewritten. The second (higher) level of information are rules, for example, that we never fly

F-111s on BAI missions. With this rule, the system, when allocating tasking, would never task an F-111 unit with a BAI sortie. This level of information could be accessed and changed by the user. However, this requires users to recompile the rules section. The third level of information is data, and changing data presents no problem at all for the system (except that it may invalidate previous conclusions). Changing the data in the middle of a system affects only what it does in the future. After quite a bit of discussion, we came to an agreement that our prime objective would be to store as much information as possible in the form of data, therefore giving the user maximum access and flexibility.

We then, discussed TRAP and agreed that the availability of these assets and their impact on the mission was exactly the same issue and they were, in fact, treated the same. Tom Scalf did most of the talking and provided this heuristic: "The amount of munitions or TRAP available for use is equal to the amount that is presently built up plus the munitions or TRAP build up rate times the time duration until needed." Mr. Scalf also discussed the split of responsibility for munitions and TRAP between the RM and the MA. Munitions are stored by the chief of maintenance, however, there is an AFK which is an Air Force munitions supply account and supply personnel within the maintenance organization who are actually responsible for the accounting and inventory control of these munitions. Therefore, when the munitions require maintenance, then they are issued by the munitions supply people to the chief of maintenance for repair, routine maintenance, or use. The MA does most of the tracking and control. However, for TRAP the TRAP assets are stored and are accounted for within the supply organization. They are issued to maintenance for build-up, repair, or use. Therefore, both the chief of maintenance and the RM would track in various levels of detail the status and quantity available of both TRAP and munitions. This concluded the discussion in this area.

MAINTENANCE

Maintenance answers require knowledge of four distinct areas: Launch and Recovery, Loading, "Fixing", AGE.

The first area is the manpower available versus the required amount to launch and recover aircraft. That is, how many people are needed for the final check at the end of the runway (to pull the safety pins and perform the various final checks required prior to take off) and how many people are needed to receive the aircraft once it returns from a sortie and goes through the initial post-flight, etc.

The second category is the number of people needed to load munitions and refuel. Assumptions concerning crew availability and crew scheduling may be provided by the user.

The third area is fixing airplanes. We need to know how many people are going to be needed to perform the various skilled maintenance jobs, and if there are sufficient parts available. The manpower question is answered by MA and supply questions are answered by the chief of supply.

The fourth component of maintenance is the availability of AGE. In this case, we have assumed, for example, that the F-4 would require a power cart in order to start the engines, that is, they would not be using the MXU1 starting cartridge although that would be a viable option. We have included some default values for estimating how many AGE (power carts) would be required. We also assume that the F-15s and F-16s would not require power carts because of their on board JFS capability.

The topic is F-16 maintenance. The expert is the MA/RM for spares. The sources for this are CAMS/MMICS/ULA. The process is that the MA will call the squadron commander and query him whether he has enough launch and recovery crews. He will ask whether the AGS can support four launch/recovery crews tapering down to three for the rest of the day. It is higher in the morning because of the greater number of sorties. He will also do the same thing for load crews. He will ask the RM to see if he has enough refueling people to handle that. The MA will then talk to his job control regarding amount and number of skills that he has got, and turnaround times for any planes that need to be fixed. He will then look to the RM for any shortfalls in spares. Sources would also include AFCAP and WSMIS. Also for sources list CFMS/AMS/CSMS. Much of the information used comes off of the greaseboard. The process will also involve interaction on AGE. He will check with the RM for refueling and spares. He will check on the status of spares for aircraft that are broken. They do not project out to tomorrow or the next day.

Unit level and ATOC level personnel are not normally in the mode of attempting to predict what parts will be needed, or what parts may break in the coming days, although these people normally have some feeling for what parts are likely to be required, that is, they know, for example, that the INU platform on the F-4 is a problem item. However, the chief of supply, the RM, the chief of maintenance at the base level, are predominently in a reactive mode rather than an initiative mode, that is, they react to events as they occur rather than attempting to predict when these events will occur and what event will, in fact, occur.

Influences include launch/recovery rates and turn patterns.

Influenced by manning levels, skilled manning levels, and BLSS/WRSK fill. Process for maintenance. MA calls AGS squadron commander as an interaction with job control and he speaks with the RM.

If we intend to go any further indepth, then what we did describe, we would have to go more indepth into major problems.

The .2 that drops out of the sorties every turn because we are assuming a .8 return factor because we are not assuming attrition will drop out due to maintenance factors. There are many considerations that go into whether the aircraft will stay in the launch or will be part of the .2 that will stay out for maintenance reasons. There are many tradeoffs involved. This can change the sortie generation for the next go.

The aircraft condition code as reported by the pilot when approaching the airfield is a general indication to the maintenance personnel as to what level of maintenance may be required on the aircraft, given the pilot's experience on this flight. Code 1 indicates that the aircraft has no major or reportable deficiencies, and therefore will only require a nominal post flight check. Code 2 indicates that the aircraft has got minor system failures that require maintenance. The extent of the Code 2 is determined and then the chief of maintenance, in conjunction with the DO and after consulting the MESL, can make the determination as to whether or not to defer maintenance on the item. A Code 2 deferred aircraft would be one that has a minor system deficiency but which is going to be released to fly without repair. A Code 2 nondeferred is an aircraft with a minor deficiency but which is going to be repaired prior to flight. The determination in this manner is normally, if the repair can be accomplished within an hour or without unduly disrupting aircraft turn patterns and the parts are available, then the Code 2 will be repaired rather than be deferred.

A Code 3 indicates that the aircraft is landing with major subsystem deficiencies. When speaking of Code 3, the experts will normally speak of a soft break versus a hard break. A Code 3 soft break would be a major subsystem deficiency that can be repaired in time for the aircraft to rejoin the turnaround stream and launch with the next set of sorties. We have considered this to be nominally one hour. A Code 3 hardbreak is a major subsystem deficiency which will ground the aircraft and which will require a substantial period of time to repair or for which there are no spare parts available.

When we state that a Code 3 hardbreak aircraft becomes part of the risk, what we are actually saying is that because of the seriousness of the aircraft malfunction, the aircraft is going to be an immediate candidate for cannibalization if there are supply shortages in order to repair any other aircraft that may be broken and requiring a part.

In effect, a Code three hardbreak becomes part of WRSK. It is a candidate for cannibalization, or you would have to fix it at night. This alters the flying pattern. In one hour you can make an engine change on an F-16 or an F-15.

Another aspect is, do we want to talk about the number of launch and recovery crews? We will say that a maintenance launch crew is two people. A load launch crew is three people. How many of these do we need? For a flight of four every two minutes, we will need one for every two airplane maintenance launch crews. Depending on the airplane, it takes roughly 30 minutes to upload . . . munitions. But we are not loading, we are involved in launch and recovery right now. You will need four launch crews and two load crews. Two launch crews per launch.

You don't want to draw down that manpower. You need a launch crew and load crew at the recovery end positions in order to keep flow going. We just established five launch crews and three load crews. We need one of each at the recovery end just in case of ground abort. This is so that you can get those airplanes out of the way.

Load crews. One load crew per aircraft per hour. For default we will use one load crew per aircraft per half hour. For AGE we will need one per two per launch.

Any particular base aircraft might be geographically dispursed such as Ramstein where you have a lot of transit distance. And in that case, these defaults might be different. The system should be able to handle that because the operator should be able to change parameters. For F-15 and 16 you don't have to have power carts. They like to use them, but you don't need them.

There are so many restrictions on the MXU/1 that we ought to consider them not used. A default for the F-4 would be no cart starts.

All these pacing parameters are written down somewhere. The wing has those. George said that those might be written down somewhere but the MA has his own, because on any given day, it might be raining, snowing or middle of the night and he needs his own to work with. We are not far enough ahead at this point to use standard Air Force planning factors. Each MA will have his own numbers in this case. We decided that spares were not the limiting factor. We are assuming that whatever we do, there will be a .8 sortie planning factor. We are assuming that 80% of those launched on the first sortie we are able to regenerate and launch on time for the next turn. To do an engine chnge in an F-4, the airplane will miss a turn. In an F-15 or F-16, it may or may not.

Boundary is the AGS commander, for launch recovery, load and fix. It is job control for fix. RM for refuel and some spares. One load crew can launch one airplane every two minutes. We don't know yet what the launch pattern is. But whatever it is, this is what we need. This means one load crew can pull the pins on an airplane every one minute. This covers the normal part of the turn. When you talk about the condition code, somebody has an eyeball figure that every airplane is going to require X. If you defer because of a Code 2 or any other code, the expert system would need to know why. The other expert in this is the DO or battle commander.

If you have three airplanes and each one of them has one thing broke, i.e., one of them has a navigational system broke, one of them has something else broke, and one of them has something else broke, how do you allocate those airplanes? There can be problems in resource allocation at this point.

The expert would be the MA.

This is the area where aircraft and part cannibalization really come to the forefront, even in peacetime situations. The local command will attempt to maximize the number of aircraft that it has that are fully or partially mission capable. Therefore, in a case such as this where we have three aircraft broken for three separate components, the most probable course of action would be for the chief of maintenance to decide that from those three broken aircraft he would be able to make two fully operational aircraft and one very broken aircraft. This in fact is what normally will happen.

AIRFIELD

The next factor relates to the airfield. The question is, "Are there any airfield limitations." As outlined in the diagram, the one major consideration is:

a. Do I have enough runway for all of my sorties to take off and land? The answer takes into consideration the possibility of runway damage.

We began by establishing default rules of thumb to be used as values for the amount of runway required. For the F4 E/G, the nominal take off distance is 2,400 feet and landing distance is 4,000 feet; for the F-15 and F-16, 1,200 feet and 2,500 feet respectively. For the taxiway question, the rule was that sufficient taxiways existed to gain access to the runway from the aircraft parking area. For arresting gear considerations, we specified that there is a BAK 14 and a BAK 13 on each end of the runway. We provided default values of two minutes to recycle the BAK 14, ten minutes to recycle the BAK 13. Weather is included as a subfactor since weather at the airfield will impact our launch and recovery pattern decisions and enroute/threat area weather would affect the decision as to whether an NMC aircraft is a wargoer. We also included airspace control as a factor which would influence airfield limitations to aircraft offered. We specified that aircraft take off in elements of one or two and that we would normally expect to be able to launch four aircraft every two minutes. The maximum recovery rate is stated as a pair of aircraft every thirty seconds.

Another problem for airfields is, "Do I have an airfield or facility factor that might constrain sortie production?" "Do I have sufficient runway to take off and land?" And, "Do I have access to those positions vis-via taxi ways?" This of course can vary depending upon which direction you are taking off. For example, there might be approach barriers on only one end. Also, "What is the status of the arresting gear?" So, if any of these are constrained by damage to runways or accesses then there are some dynamic problems to consider. Some important questions that would be asked are: "How much of the runway surface do I have?" "Where is it located?" "Do I have access to those take off and recovery positions?" "What is the condition of the arresting gear for launch and recovery weather?"

FUELS

Here we consider petroleum, oil, lubricants (POL), specifically JP-8 POL. Two very basic considerations exist: "Do I have enough fuel to support all sorties?" and the second is "Do I have enough trucks or hydrants to get that fuel to the aircraft at the proper time?" (We mainly address availability and servicing though we recognize other factors may become important, such as liquid oxygen).

For the above planning question, we use a "standard" load per aircraft per sortie, multiplied by the total number of sorties. This is compared with the amount of fuel in storage. Our total fuel availability will be the amount on hand plus projected receipts in that day. In order to determine if there are sufficient trucks or hydrants to service all of the aircraft, we assume a 5,000 gallon refueling unit actually supplies 4,500 gallon on average. From this, the ES can calculate the required truckloads of fuel. The calculation considers our known standard consumpton, and derives how many aircraft each truck might service. Given a standard of 10 minutes per servicing (approximately 3 minutes to position the truck and connect to the aircraft, 5 minutes active fuel pumping and 2 minutes to disconnect) refueling time must also include transit time to the storage location, time to refill the truck, and transit time back to the aircraft parking area. The ES may then determine if the trucks available are sufficient.

As a general rule, if any answer requires more than two additions and a multiplication, we are probably trying to get too complicated for this initial demonstration system. Further, they stressed we must also phrase our questions so that the positive answer is always "yes". For Example, rather than asking, "Are there any constraints on POL?" ask: "Do I have sufficient POL to support my mission?" A negative answer generally requires further detailed explanations, but a "yes" answer does not need an explanation.

We then entered a general discussion about the fuels area. There were some misconceptions about how a fuel section was physically operated, (for example, that fuel could be entered into trucks directly from the receiving pipeline). However, we were able to resolve this problem by deciding to delete the word "pipeline" from a sortie diagram and, instead, to divide the storage into on-site and off-site areas. Lou Drew then said we should do the same thing for munitions since munitions in the European environment are stored at both on-site and off-site munitions storage areas. Once this procedural question was answered we went into an in-depth discussion of the fuels question.

Purpose: To demonstrate operational capability by calculating the refueling rate and the fuel available.

CFMS is the source. CFMS and combat scheduling and combat munitions by output systems. They are base level reporting systems.

Subfactor: "Do we have enough people to launch and recover those kind of rates? Do we have the refueling people?" If the answer is "yes," continue; if the answer is "no" ...get those people when you are limited by launch crews. For example, 58 airplanes in a relatively constrained time period launch. Perhaps it might take three launch groups. WE get another launch crew out there. So we pull them from fix. Do we need to redistribute your resources? So, if the resources can't be redistributed then MA goes to the battle commander and says, "now the number of sorties is 53."

We create a number of sorties within the system on crew availability and take a look at the air refueling limitations and if I don't get a "no" the number is still 58. If you get a "no", you have a limitation and the output factor is a lower number of sorties. The output will be a lower number per hour (timeframe). For the sake of the model, there needs to be some hierarchy involved. The limit of these hierarchy steps should be a limit in time. For example, I can make 46 turns but I need four hours. Fuels officers will attempt a rough schedule of a truck to every airplane within the required time parameters.

The discussion then continued for some time concerning the various ways that unit fuels officers and RM and battle commander would interact. Probably one of the very important points that was brought up was that the battle commander or the DO is probably going to talk about fuel in terms of pounds of fuel since one of the concerns of an aircrew is how much the plane weighs at takeoff and landing. The fuels officer will probably speak of fuel in terms of gallons of fuel since that's how he measures the fuel in his tank. For the purpose of this demonstration, we feel that both figures in some fashion should be entered into the system along with a conversion factor of 6.3 pounds of fuel per gallon of fuel. This discussion continued until the end of this tape.

INPUT DATA FOR ARTIFICIAL INTELLIGENCE/EXPERT SYSTEM

Purpose: Answer questions from earlier meetings concerning data sources and the Expert System.

Our first question was: "What information sources does the Air Force currently use. The information needed by the Air Force falls into three types. The first is information used by the Headquarters Air Staff at the Pentagon. These are the UNITREP, CSMS, CFMS, WSMIS, ARMS, and CAMS. They provide usable sources for the definition of the outputs that the Air Staff needs to monitor and direct forseeable contingency operations. The second type of information for exploration is message traffic between the Worldwide Military Command and Control System and the theater of operations. Lastly, we consider intelligence reports from reconniasance activities. (It is not yet clear how automated these sources are, beyond transmission and reception).

The primary difference in the information sources used at the theater level and by the Headquarters level is that the major command level information is much less aggregated. For instance, the major command uses base status information for decision-making, while at the Headquarters Air Force level, information is usually aggregated into area- or theater-wide data before presentation to managers.

Most of the reports used by local commanders are manually generated, even though computer programs and printouts form much of their basis. The reports typically include items such as: fuel inventories; projected fuel remaining; munitions inventories; the status of repair parts ordered for NMCS and PMCS aircraft; the status of physical facilities; and manually generated local intelligence reports on hostile activity.

EXAMPLE

This is an example of a question which would be asked by the TAC Control/ATOC Battle Commander, who is generating questions to his units:

> "How many air-to-ground sorties loaded with dumb bombs can you produce tomorrow with early light, midday, and late afternoon launch, unrefueled?"

This question already establishes some parameters and bounds. The parameters were set and categorized by saying "air-to-ground," "tomorrow," and establishing three flying windows, "early light," "midday," and "late afternoon." Also, the airplanes are unrefueled, i.e., airplane duration is finite. These questions determine what aircraft will be used for the day.

These are subordinate questions related to the higher level question, such as "How many FMC and PMC airplanes do I have? How many wargoers, air-to-ground, do we have?"

Wargoer rules are:

1. Need not be air-refueling capable.
2. Need not be navigation capable if paired with FMC or PMC airplane.
3. If flyable with risk that DO will determine.
4. Only one ECM pod per two aircraft.

Desired output for this question is the number of aircraft FMC, the number of aircraft, and the number of wargoers.

The desired output of the subquestions and initial questions are the raw number of aircraft that can meet the conditions. This answer would be a summation of FMC, PMC, and wargoers. This is not a number of aircraft per type; it is merely a raw number of aircraft available. We assume there is only one MD aircraft at each base. This raw number is important so the unit battle commander can move to the next step. He combines this number with other factors to answer their questions. This number comes from the MA, the director of maintenance, with the exception of the wargoers. Wargoers is an MA/DO answer because it is the next level of detail. The weather may be bad enough to preclude wargoers. This is an expert judgment that the MA and DO have made. The concept of a wargoer aircraft is not contained in any Air Force official publications. The concept is that, during war, aircraft that normally are not mission capable, but flyable, would fly based on such things as target and availability of other fully mission capable or partially mission capable aircraft. The final determination is based upon the aircraft MSEL, and the expert judgment of the MA and DO and the battle commander. The MSEL is the official Air Force position on the aircraft subsystems that are necessary for the aircraft to perform various types of missions. The battle commander and his staff would have the final say in which aircraft are going to fly missions, regardless of their MSEL availability. The source will be the WOC, the Wing Operation Commander. This will be a greaseboard in one form or another that graphically depicts the numbers of FMCs and PMCs, and if the MA has any reason to believe that the number is different than that, he will pick up the phone and call job control. It will go over system by system in the airplane. The MA will call job control if he does not believe the big board and the WOC. The board is defaulted on a by-exception basis, and if he does not believe it, he goes to a lower level. The board is default except for wargoers. Throughout the course of these transcriptions we speak of information being gathered from greaseboards. By greaseboards we mean a very generic term. We are speaking specifically of unit-level maintained manually updated information monitoring systems. These could range from a notebook maintained and updated regularly by the commander to an actual greaseboard in a control center all the way to a PC or microcomputer in a control center using locally produced programs. The reason we have concentrated on greaseboards throughout this system of expert interviews is that the information available on the greaseboard is normally only that information that is required by the local decision-makers, and it is much more up-to-date and more readily usable than the information that would be contained in the larger-level standard Air Force automation systems. For the question that we are trying to answer now the number of FMCs and PMCs is essentially fixed. What really influences the total number of aircraft available are the rules for determining what is and what is not a weapon. It is the final influencing factor.

END

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