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The Closed-Loop Planning System for Weapon System Readiness

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Summary

The U.S. Air Force does not have an effective way of allocating limited funding for depot-level repair across weapon systems and calculating the readiness implications of such allocations (p. 3). The RAND project discussed in this report directly addressed this problem by developing a methodology that estimates the effect of depot repair funding allocations on aircraft availability. We have called this the "Closed-Loop" Planning System because it provides this type of feedback, as opposed to the open-loop nature of the current planning system, which does not (p. 5).

The report describes the shortcomings in the current system to rationalize the development of the closed-loop methodology (pp. 9–15). It also illustrates the application of a prototype of the new planning system using a subset of real data from Air Force depot-level repair (Chapter Five). It compares the cost of achieving the same level of readiness with the current Air Force approach and the closed-loop methodology (pp. 64–68). In addition, it describes extensions of the methodology that would be useful for both long-term and short-term planning (p. 69).

Air Force depot-level component repair includes repairs of components removed at bases worldwide during flying operations and that cannot be repaired at either the base level or intermediate level. It also includes repairs of components needed to support programmed depot maintenance (PDM) and repairs contracted for with foreign militaries. This component repair operation at the depot level absorbed about $3.1 billion in fiscal year 2003 (p. 2).

A review of the planning and budgeting processes for the depot level during the U.S. Air Force Spares Campaign in 2001 identified important disconnects in those processes. In particular, it was found that decisionmaking about depot repair budgets was done in the absence of information about how those decisions affected operational readiness. It also found that there were important inconsistencies between organizations (e.g., Major Commands and the Air Force Materiel Command) in assumptions and in their planning processes. Repair capacity was not considered in either process. Additionally, the U.S. Air Force Spares Campaign found that planning and execution were disconnected—the repair scheduling did not have adequate information about the planning goals, and it was unclear how to track the correspondence between the planning goals and execution of repairs (pp. 3–4).

The goal of our research was to define and demonstrate a methodology that could overcome several of these problems. In particular it connects the budgetary planning with its impact on operational readiness in terms of the influence on aircraft availability for missions. The Closed-Loop Planning System was thus developed; the system also produces a plan that considers repair capacity constraints, carcass constraints (that is, having something to repair), and uncertainty in the demands for repair. As far as we know, no current planning system includes these features (pp. 4–6).

The Closed-Loop Planning System solves the depot-level repair planning problem by starting with a statement of readiness goals in terms of end-of-planning-period aircraft availability. The availability is defined as the fraction of aircraft that are mission capable. In the case of the planning system, the important rate is the converse of this rate: aircraft that are not mission capable, supply (NMCS)—not mission capable because of supply. Readiness goals can be set by unit, theater, aircraft type, and command. The methodology then optimizes the mix of repairs to be planned for each shop to ensure, with high confidence, that the readiness goals can be achieved. Mathematically this is the same as ensuring that, with high confidence, the supply system can provide parts to the units to meet their readiness goals and that the depot-level repair shops can each provide the repaired parts to the supply system. The methodology identifies and optimizes within constraints to meet the availability goals in terms of shop capacity limits or carcass limits. Additional capacity in the form of overtime can be included in the optimization if necessary. The primary output is the budget necessary to achieve the readiness goals. In case the budget is not satisfactory, the user of the methodology can iterate the process by selecting units or aircraft to adjust readiness goals and then view the budget implications. It is also possible to program priorities for adjusting readiness goals to achieve a given budget level. Figure S.1 shows the basic decision-level inputs and outputs of the methodology. Conflict 1, Conflict 2, and CONUS (continental United States) represent a scenario for prioritizing readiness goals. The aircraft units to be deployed first are given the tightest goal, the units to deploy next a reduced goal, and the CONUS aircraft the most relaxed goal (Chapter Three).

Figure S.2 shows additional, marginal cost information that is available in terms of the additional depot repair costs necessary to make one more aircraft available, by aircraft type. Additional displays, illustrated in Chapter Five, show how the model can point out where capacity is exceeded, overtime to exceed that capacity, and confidence

Figure S.1
Minimum Budget Determined by the Prototype to Achieve the Stated NMCS Goals When There Are No Repair Constraints

Inputs →

	Conflict 1	Conflict 2	CONUS
F-16 B40	0%	5%	20%
F-15 C/D	0%	5%	15%
F-15 E	0%	5%	15%

Output → Total budget required $120.70 million

NOTES: NMCS goal = full cannibalization of parts at time of deployment and full readiness spares package, with 90 percent confidence.
RAND *MG434-S.1*

Figure S.2
Adjustment of NMCS Goal to Fit Shop Capacity Constraints

	Conflict 1	Conflict 2	CONUS
F-16 B40	0%	5%	15%
F-15 C/D	0%	5%	15%
F-15 E	0%	5%	15%

←

	Conflict 1	Conflict 2	CONUS
F-16 B40	0%	0%	5%
F-15 C/D	0%	5%	15%
F-15 E	0%	5%	15%

Results	Work center										
	OO COMP	OO RF	OO DISPLAY	OO PNEUM	WR TISS	WR DISP	WR METS	WR EARTS	WR MICRO	HYDRL 1	HYDRL 2
Estimated capacity (estimated percentage) (regular hours)	4	0	3	13	2	0	0	0	0	3	0
Regular hours available	40,518	19,258	20,571	15,163	32,878	1,852	11,802	23,300	7,361	27,030	19,450
Overtime hours used	0	0	0	0	0	0	0	0	0	0	0
Overtime (% of regular hours)	0	0	0	0	0	0	0	0	0	0	0
Overtime cost ($ millions)	—	—	—	—	—	—	—	—	—	—	—
Budget ($ millions)	5.13	3.69	4.65	1.99	42.10	0.51	21.96	21.29	10.34	5.80	3.60
Work center confidence	0.979	0.981	0.979	0.995	0.978	0.994	0.978	0.976	0.988	0.988	0.964

Mission Design Series (MDS) confidence

F-15	0.906
F-16	0.902

MDS repair cost ($ millions)

F-15	102.00
F-16	19.05

Total repair cost ($ millions) 121.04

Carcasses needed to buy

	Number of carcasses	Number of components	Total cost ($ millions)
F-16 B40	0	0	—
F-15 C/D	0	0	—
F-15 E	0	0	—

Dollars per additional mission capable aircraft

F-16 B40	106,950.47
F-15 C/D	155,328.00
F-15 E	273,733.52

RAND *MG434-S.2*

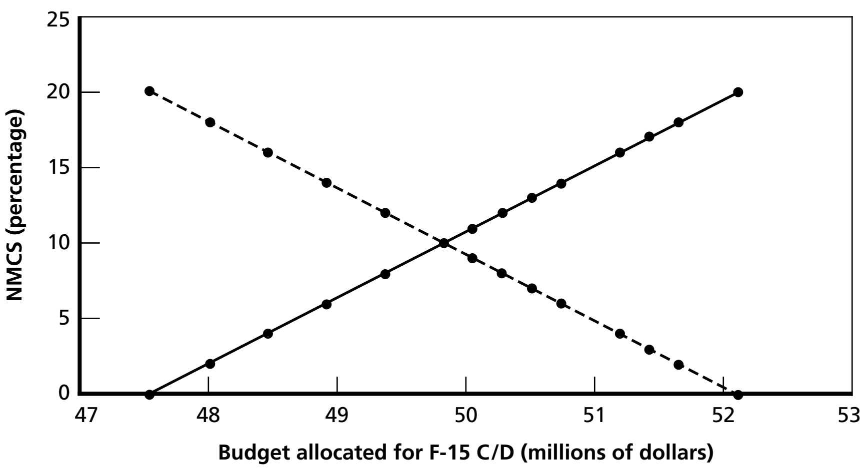
estimates that a shop will meet its repair goals. The model can also support detailed Air Logistics Center, shop, and workstation planning by producing detailed repair estimates for those entities (Chapter Five).

Perhaps the most interesting use of the Closed-Loop Planning System is when it is necessary to make trade-offs in readiness across aircraft types to achieve budgetary goals. Figure S.3 shows such a trade-off curve between the F-15 C/Ds and the F-15 Es when the overall budget is kept constant (p. 62).

In the text, we also show a comparison of an approximate representation of a plan from the current Air Force Materiel Command planning system and the Closed-Loop Planning System. When we

Figure S.3
Trade-Offs Between Weapon System NMCS at Constant Budget Levels

	Conflict 1	Conflict 2	CONUS
F-16 B40	0%	0%	0%
F-15 C/D	0%	Vary	Vary
F-15 E	0%	Vary	Vary



NOTES: NMCS percentages include budget trade-offs between the two Mission Design Series, F-15 C/Ds and F-15Es, in Conflict 2 and CONUS. The entire budget equals $124.32 million.

RAND *MG434-S.3*

hold readiness constant, the budget required for the closed-loop plan is about 6 percent less.

In the last chapter of the report, we suggest a number of extensions that could be made to the Closed-Loop Planning System (pp. 69–74). It could be used for execution planning, in which it is necessary to start the model with the current state of the supply and repair system. In a similar vein, it could be used to track performance and replan during the execution year by tying it to the execution process and data. It could also be used to plan how and when to overcome repair capacity limitations through the purchase of additional equipment, manpower, or overtime.

Most important, the Closed-Loop Planning System is meant to help Air Force planners make decisions about budgets for depot-level repair with a true understanding of the readiness consequences of those decisions (p. 75). At a minimum, it should be integrated into the Spares Requirements Review Board process to help resolve depot-level repair budgeting issues. A broader goal would be to embed the closed-loop methodology directly within the Air Force Materiel Command planning process.