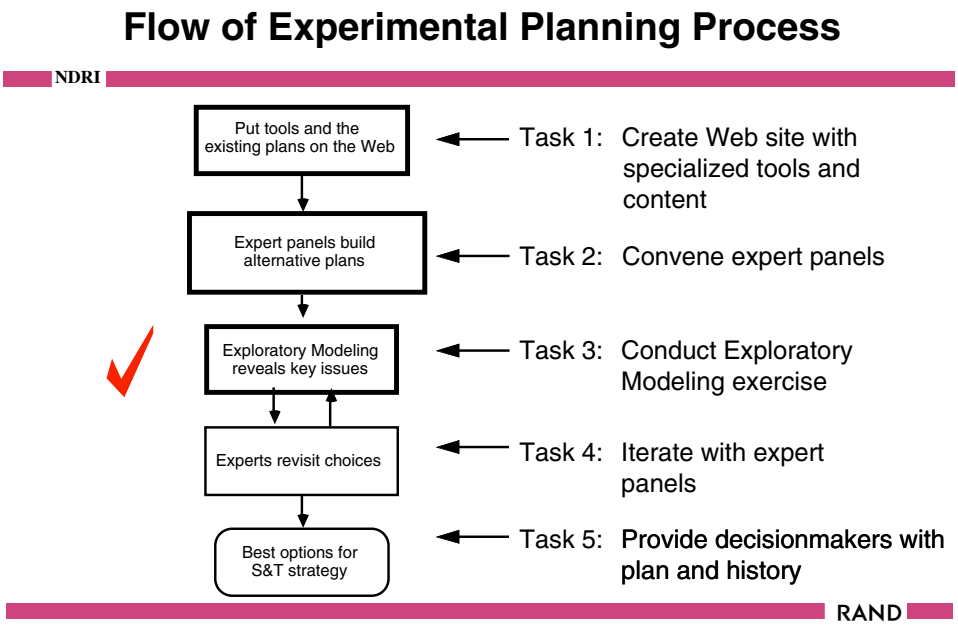
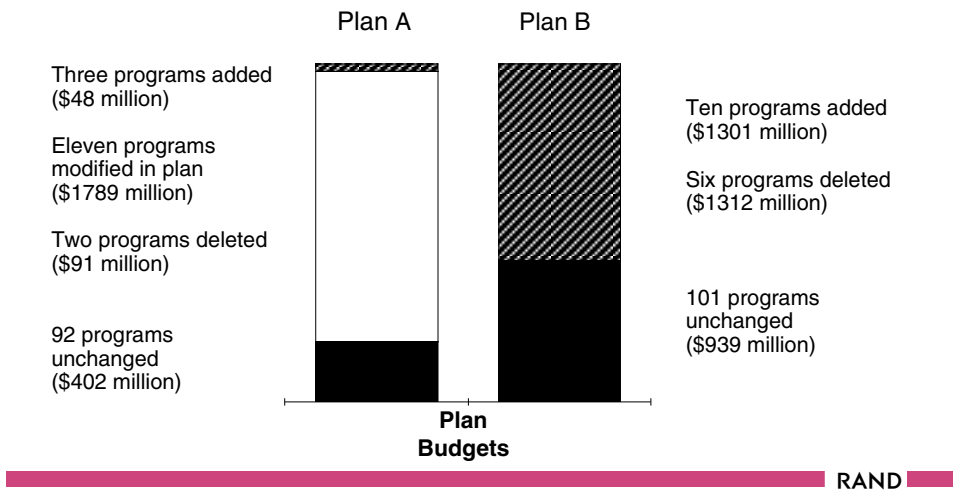


4. TASK 3: CONDUCT EXPLORATORY MODELING EXERCISE

The two teams in our expert panel produced two technology plans, each assessed against different future military scenarios. But policymakers need a single technology plan that is robust against multiple futures. In this section of the briefing, we describe a simple application of the Exploratory Modeling ideas to suggest how the two teams' plans can best be combined into a single, robust technology plan.

We describe how we can automatically generate new technology plans that are mixes of the programs from Plans A and B and that have the same overall budget as Plans A and B. We then describe how we can estimate the military contribution of each of these new plans in our two military scenarios. This process is designed to produce a small number of candidate technology plans, successful in both military scenarios, that in a real planning process would be given back to the expert panels to help them recommend a single, robust technology plan.

Team A Modified Existing Programs; Team B Added New Programs



As a first step in explaining our method of combining technology plans, it is useful to examine in more detail the results produced by our expert panel. This slide shows a budgetary summary of how the two teams modified the JWS&T Plan. The differing shaded areas in the bars indicate the very different responses of our two teams to their respective scenarios.

The Information Superiority portion of the JWS&T Plan had a total budget of $2.2 billion. As shown in the figure, Team A added three new programs costing a total of $48 million, modified eleven programs accounting for $1789 million, deleted two programs totaling $91 million, and left unchanged 92 programs totaling $402 million. Team B added ten new programs costing $1301 million, deleted six programs totaling $1312 million, and left 101 programs totaling $939 million unchanged. Team B did not modify any programs.

The contrast between these two sets of results makes sense in light of the different scenarios given to the two teams. Team A's No-Warning MRC scenario was close to the dominating MRC scenario considered by the government in creating the original JWS&T Plan. Accordingly, Team A could focus on modifying existing programs. Team B's Urban Combat scenario was very different from the situations considered in ABIS and in the Information Superiority section of the JWS&T Plan. The panelists responded by creating new programs designed especially for these new circumstances.

As an aside, it is interesting to note the relatively small budget for the large number of unchanged programs. This owes to the fact that many programs in the original JWS&T Plan, especially those beyond the 5-year budget-planning cycle, had no budget. Consequently, there was no incentive to remove or change them.

Changes Made by Teams A and B

NDRI

Team A

Additions to Plan

Rapid Terrain Visualization - Mod
Adaptive Force Package Tailoring
Joint Theater Information & Spectrum Dominance

Modified Programs

Distributed Situation Assessment
Robust Tactical/Mobile Networking
Joint C4I for Rapid Force Projection
Precision Guided Mortar Munition
IW [Information Warfare] Battle Management
Survivable Armed Reconnaissance on the Digital Battlefield
Rapid Battlefield Visualization
Battlefield Awareness & Data Dissemination
Operator Intelligence Interface
Small Satellite SAR [Synthetic Aperture Radar]
Counter Camouflage, Concealment, & Deception

Deleted from Plan

Precision Rapid Counter Multiple Rocket Launcher
Rotocraft Pilot Associate

Team B

Additions to Plan

MOUT [military operations on urban terrain] Command, Control, Comm, Computers and Intelligence
MOUT Survivability
MOUT Modeling and Simulation
Full-Scale MOUT Demo
Urban Combat Training ACTD
Netted Sensor ATD
Mirage
Context-based Information Distribution 2
Robotic Sensors
Smart Assistant for the Infantryman

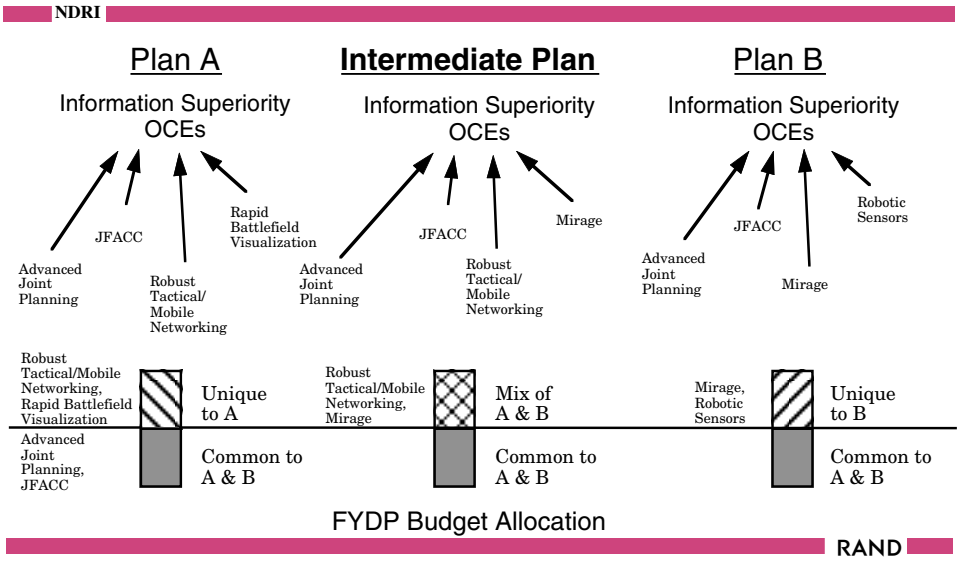
Deleted from Plan

Precision Rapid Counter Multiple Rocket Launcher
Precision Guided Mortar Munition
GEODSS [Ground-Based Electro-Optical Deep-Space Surveillance System] Upgrade
Small Satellite SAR
Wide Area Tracking System
Context-Based Information Distribution

RAND

This chart names the specific programs added, modified, and deleted by our expert panels. All the modifications made by Team A had to do with the budget, as opposed to the substance, of the programs in question. Team A increased or decreased the budgets of programs to provide more or fewer capabilities. They did not modify or create new programs to provide a significantly different capability. Many of the programs added by Team B were taken from other parts of the JWS&T Plan—specifically, the Military Operations in the Urban Terrain JWCO—rather than being created from scratch. Important exceptions are Team B's Mirage program, which we discussed earlier, and their Netted Sensor ATD, Robotic Sensors, and Urban Combat Training ACTD.

Interpolating Technology Plans



If we knew with certainty that the future would look like the scenarios given to Team A, we would choose Plan A as our new JWS&T Plan. If we knew with certainty that the future would look like the scenario given to Team B, we would choose Plan B. But since we do not know the future, we want to examine whether some composite of Plans A and B is reasonably robust against both scenarios.

Accordingly, we developed an automated routine for interpolating two technology plans, as shown in this chart. An automated plan is not really necessary with only two plans; however, we wanted to demonstrate our ability to expand in the future to many dozens or hundreds of plans to cover many more futures.

We start by noting that each plan has programs unique to that plan and programs common to both plans. The total budget for the programs unique to A is the same as the total budget for the programs unique to B, since the budgets of the plans common to A and B are the same and both plans have the same total budget.

Any plan intermediate between Plans A and B will have all the programs common to A and B. The remainder of the budget is then used to buy programs unique to A or B for the intermediate plan. For instance, an intermediate plan that is 75 percent A and 25 percent B, uses 75 percent of its "Unique to A or B" budget to buy programs unique to A and 25 percent of the budget to buy programs unique to B. (See the example on page 40.)

Finally, we need to determine the military contribution of the intermediate plan. As shown in the chart, each individual program contributes to some OCEs, as measured by the white-/black-dot weighting discussed above. Assuming there are no *important* synergies[8] among programs, we sum the contributions of each program for each OCE to estimate the military contribution of the intermediate plan.

Note that this process *does not* distinguish contributions in different scenarios. Rather, a contribution of some weight to some OCE, say, Information Acquisition, is the same in any scenario. Although the contribution of any one program is always only a few percent of the total contribution for any OCE and does not have a huge effect, it has some distorting consequences for the method. These consequences are discussed in the chart after next and could be changed with a more elaborate weighting methodology. We adopted this interpolation process because it was, literally, the closest analogy that we could find to the subjective JWS&T methodology. That methodology does not discuss contributions in different scenarios; rather, it presents the entire plan and contributions. Additionally, even this method is time-consuming, so elaboration in this experiment was implausible.

---

[8]*Synergies* are enhancements produced in one program by the presence of another. For example, there are synergies between improved long-range weapons and improved long-range battlefield surveillance, since the former are more useful if a military force knows what is in the battlefield to shoot at. Generally, there are synergies among technology programs, although most often they are not considered explicitly in most analyses, including the JWS&T Plan and ours.

Interpolation with 75% Plan A and 25% Plan B

NDRI

PLAN A PROGRAMS	Score	Budget
Robust Tactical/Mobile Networking	5	$61.5
Context-Based Information Distribution	4	$0.0
Rapid Terrain Visualization - Mod	4	$4.5
Distributed Situation Assessment	4	$30.0
Joint Theater Information & Spectrum Dominance	4	$35.0
Joint C4I for Rapid Force Projection	4	$110.0
Battlefield Awareness & Data Dissemination	4	$225.7
Adaptive Force Package Tailoring	3	$8.0
IW Battle Management	3	$33.0
Wide Area Tracking System	2	$3.0
GEODSS Upgrade	2	$6.6
Counter Camouflage, Concealment, & Deception	2	$25.0
Operator Intelligence Interface	2	$60.0
Rapid Battlefield Visualization	2	$61.3
Small Satellite SAR	2	$546.4
Survivable Armed Reconnaissance on the Digital Battlefield	0	$125.0
~~Precision Guided Mortar Munition~~	~~0~~	~~$511.3~~
		$1,335.0

PLAN B PROGRAMS	Score	Budget
Full-Scale MOUT Demo	11	$140.0
MOUT Command, Control, Comm, Computers and Intell	11	$295.8
~~Battlefield Awareness & Data Dissemination~~	~~9~~	~~$185.7~~
~~Smart Assistant for the Infantryman~~	~~8~~	~~$100.0~~
~~Mirage~~	~~8~~	~~$230.0~~
~~Urban Combat Training ACTD~~	~~7~~	~~$90.0~~
~~Netted Sensor ATD~~	~~7~~	~~$90.0~~
~~MOUT Survivability~~	~~6~~	~~$27.0~~
~~Robotic Sensors~~	~~6~~	~~$230.0~~
~~Distributed Situation Assessment~~	~~4~~	~~$23.0~~
~~Robust Tactical/Mobile Networking~~	~~4~~	~~$23.0~~
~~Joint C4I for Rapid Force Projection~~	~~4~~	~~$50.0~~
~~Context-based Information Distribution 2~~	~~4~~	~~$93.9~~
MOUT Modeling and Simulation	3	$4.0
~~IW Battle Management~~	~~3~~	~~$22.0~~
~~Operator Intelligence Interface~~	~~2~~	~~$45.0~~
~~Rapid Battlefield Visualization~~	~~2~~	~~$58.3~~
~~Counter Camouflage, Concealment, & Deception~~	~~2~~	~~$127.5~~
		$435.8

RAND

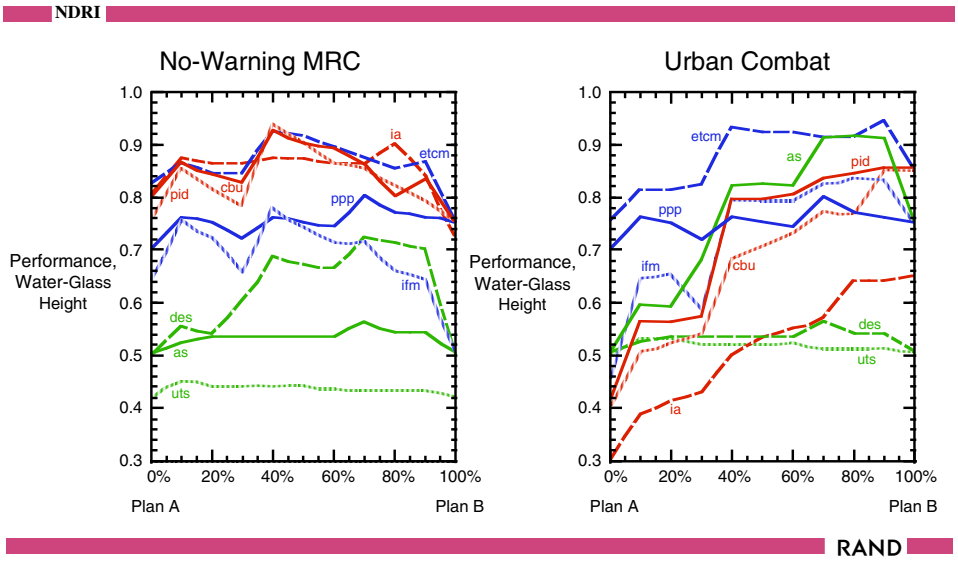
The interpolation routine requires that the programs unique to each plan be prioritized. We employed a simple scheme of ranking the programs in each plan according to their military contribution. We broke ties between programs having equivalent military contributions by ranking those programs with smaller cost higher than programs with higher cost.

This is obviously a crude prioritization scheme, although it is closely based on the assessments used in the ABIS project. In future work, it would certainly be possible to employ other schemes. It is also possible to compare the technology plans resulting from several prioritization schemes, so that the panelists need not come to a consensus on any single ranking of the programs.

Note too that synergies between programs, or dependencies among them, can be captured with elaborations of this method. Although we built tools that can capture such relationships—allowing, for example, one program's failure to "force" the degradation of another—it was clear that our panels had neither the time nor the expertise to use such linkages. Indeed, such relationships are also largely ignored in other planning methods we have seen.

These other methods might be able to capture and to display the implications of such relationships, creating new insights for S&T planning. For now, however, that ability remains a speculation.

Mix of 40–70% Plan B Gives Most Robust Overall Plan



Next, we found the most robust combination of the technology plans produced by our expert panel. The results of our analysis of the combinations is shown in this chart.

The left and right panels show how a variety of intermediate plans perform in the No-Warning MRC and Urban Combat scenarios, respectively. Each curve in the panels represents the performance of one Information Superiority OCE, measured along the 0-to-1 water-glass scale, as a function of the fraction of the "Unique to A or B" budget allocated to Plan B programs. For instance, the Information Acquisition (ia) OCE in the Urban Combat scenario has a score of 0.3 when the entire budget is allocated to Plan A programs and increases monotonically to a score of 0.65 when the entire budget is allocated to Plan B programs. This behavior is not surprising, since the technologies needed to locate enemy forces are quite different for an MRC and for Urban Combat.

This chart shows us that the technology plans most robust against our two military scenarios are those in which 40 to 70 percent of the budget is allocated to Plan B programs. Note that below 40 percent, a technology plan performs relatively poorly in the Urban Combat scenario. Above 70 percent, a plan provides relatively poor performance in the No-Warning MRC scenario.

This represents the final step in our demonstration project. In a real-world planning process, this result would be given the panelists, who would then use this information as a starting point to craft an S&T plan robust against these two military futures.

Note that the OCEs for the No-Warning MRC scenario improve when about 10 percent of the Plan A budget is allocated to Plan B programs and for the Urban Combat scenario when about 10 percent of the Plan B budget is allocated to Plan A programs. The reason is that Plans A and B both have a small number of programs with negligible contribution to the Information Superiority OCEs. Our interpolation scheme replaces these programs with the highest-scoring programs of the other plan, and thus increases the overall performance of the intermediate plans.

This is one example of a potential distortion coming from our simple weighting method. Presumably, the new programs would contribute most in the other scenario, and so give less of a boost when they are added. This effect is also, in part, due to difficulties in the then-current JWS&T Plan, which included programs having low contributions.