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STATE OF ISRAEL

Ministry of Defense / RAFAEL Armament Development Authority

CEMA - Center for Military Analyses

The Price of Attrition

by

Itzhak Netzer

Presented at 12 ISMOR

September 1995

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Abstract

In cost-effectiveness studies of aerial weapon systems, the effect of **attrition** - the loss of aircraft - is traditionally accounted for by adding the **attrition cost** - the expected number of aircraft lost multiplied by their price - to the "cost" portion of the calculus.

In future major regional conflicts, aircraft attrition-rate will probably be controlled by commanders: when survivability is sufficiently high, greater risks will be taken; when it becomes too low, dangerous missions will not be undertaken.

A different methodology is therefore recommended as an alternative for the traditional approach:

a. Regarding investments for enhancing aircraft survivability - the **value-function** is increased by the value of missions that would not otherwise be executed since they are considered as too risky.

b. Regarding investments for munitions that enable mission accomplishment with fewer sorties - the **value-function** is increased by the value of additional missions that will be executed with the sorties that were made available.

Traditional Approach

- The essence of this approach is to add the attrition cost (i.e. the number of lost aircraft multiplied by their unit cost) to the cost portion of the cost-effectiveness formula.
- A mission's value is usually defined by the number of targets destroyed or by similar physical criteria. It should however be emphasized that destruction of the same number of targets may have a different military value under various battlefield situations.
- This methodology enables the quantitative estimation of the military value of survivability-enhancement systems, either avionics such as ECM or munitions such as stand-off missiles.
- The methodology also helps to decide whether the contribution of very efficient munitions justifies their cost.
- This methodology is very popular and its use is common practice. A recent example is the Cost Operational Effectiveness Analysis (COEA) of the Joint Direct Attack Munition (JDAM) as reported in NAECON '94.

Traditional Approach

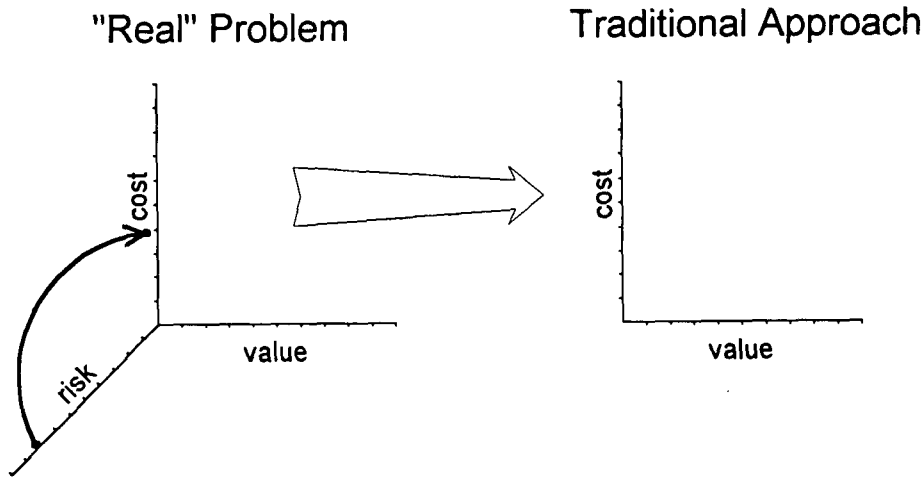
Effectiveness:

Value of missions accomplished

Cost:

Cost of munitions or avionics

+ *Attrition cost* (lost a/c * a/c cost)



Drawbacks

- Although this approach is very convenient, it has several drawbacks:
  a. Aircraft cost is hard to define, and is often irrelevant to decisions concerning avionics or munitions procurement.
  b. Attrition is hard to estimate, and probably does not adequately reflect the penalty-function (*the price*) of risking aircraft.
- The following slides elaborate on these issues.

Drawbacks

a/c value ≠ a/c cost

Penalty of risk ≠ number of lost a/c

Cost of Lost Aircraft

- Generally, during a war *all* available aircraft are allocated to operational missions; none are kept in storage to replace downed aircraft. Therefore only post-war replacement is relevant for pricing.
- Before the war it is impossible to define the type and number of aircraft that will be purchased to replace the losses. Moreover, old aircraft are eventually replaced even if war does not break out.

Replacement cost cannot be adequately defined before the war.

- Small budgets such as those for avionics and munitions are managed by military officers, often not high-ranking.
- Budgets for aircraft - very large budgets - are managed by highest-level decision-makers (e.g. final decision regarding procurement of attack helicopters for the Dutch army was resolved in their parliament). That is due to the fact that the number and type of aircraft has political and economic impacts far greater than those of munitions or avionics; they may even outweigh military considerations.

It is therefore meaningless to compare the price of aircraft to that of munitions or avionics, as one cannot be traded for the other.

- No satisfactory method has been determined for pricing lost air crews. Certainly taking only the cost of training into account is inadequate; air crews are scarce and losing any of them reduces combat capabilities. But this is not the whole picture: loss of air crews has a great psychological effect on commanders and colleagues.

Although the price of losing air crews is hard to define, it cannot be ignored.

Cost of Lost A/C

- **Type (i.e. cost) and number of replacement a/c may be different from those of lost a/c.**
- **Budget for a/c and budget for avionics or munitions *may not be interchangeable.***
- **Cost of a/c does not account for lost crew.**

a/c cost does not influence tasking.

a/c value (i.e. military capabilities) does.

Risk to Aircraft

- This observation is based on results of the Israeli-Arab wars. The average attrition rate (i.e. loss probability per sortie) was similar in the Six Day War and in the Yom Kippur War, although their scenarios were very different. In the Six Day War, after neutralizing its main threat - the Air Forces of Egypt and Syria - the Israeli Air Force (IAF) committed its aircraft to rather dangerous strike profiles to support the ground combat. In the Yom Kippur War, after suffering initial high losses, the Israeli pilots employed more cautious tactics.
- Similar phenomena were observed in the Gulf War [Keaney & Cohen 1993]:

  a. "After three days of actual combat and loss of several aircraft, commanders restricted all bombing missions to medium altitude. [...that] increased survivability, but at the expense of bombing accuracy."

  b. "Following the loss of two A-10s 60 nautical miles north of Kuwait City in mid-February, which prompted General Horner to restrict A-10s to targets along the Saudi-Kuwait border in Kuwait,..."

- This observation was discussed with IAF commanders. They confirmed the observation and even stated that in future wars, the IAF will probably continue to control the attrition rate.

It is therefore meaningless to compare the number of lost aircraft in different scenarios. Commanders' decisions will probably cause the attrition to be almost the same for all scenarios of war.

Risk to A/C

- **Risk does influence a/c tasking; missions considered too dangerous are not carried out.**

Attrition *can be* (and is) *controlled.*

Commanders' decisions - rather than the enemy's capability - determine the attrition.

New Approach

- The essence of this approach is to consider the effects of risk on mission *value*, rather than on mission cost.

- A weapon system reduces the risk to aircraft, actually enhances the value of missions carried out by these aircraft. It encourages commanders to task the aircraft with higher value - but more dangerous - missions. It may also enable the air crews to achieve better results in each sortie by executing a more effective - but more dangerous - flight profile (e.g. medium level bombing or multiple passes per sortie).

- Very efficient - but very expensive - munitions reduce the number of aircraft required to accomplish a mission. Although this *does not* reduce the number of aircraft lost, it enables commanders to assign *more missions* to the same number of aircraft, and thus to achieve *higher total military value*.

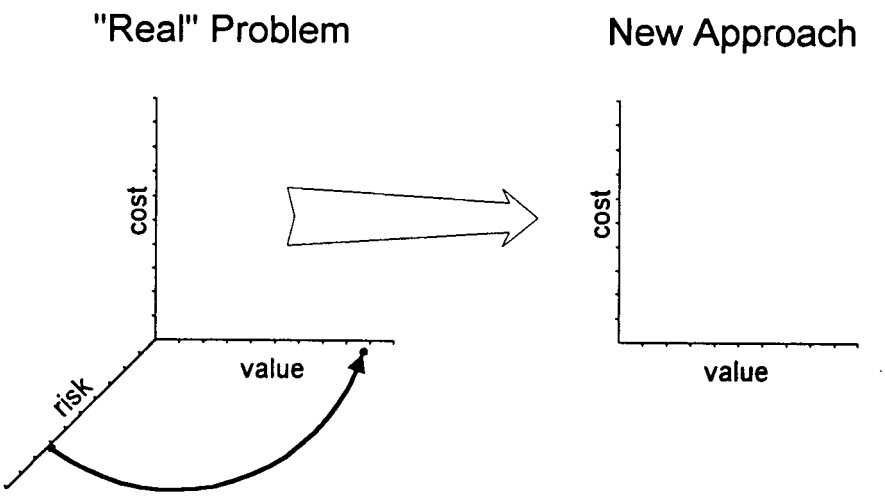
New Approach

Effectiveness:

Value of missions accomplished
(at the predetermined risk level)

Cost:

Cost of munitions or avionics



Quantifying Intangibles

- At present, interviews with commanders and mission-planners in the IAF are the only source for quantitative estimation of these intangibles. Their subjective opinions as to which missions have higher values than others, and as to how many missions of one type they would be willing to trade for a mission of another type, form the basis for a quantitative estimate of missions' value.

- This solution for quantifying the intangibles is unsatisfactory. We are still searching for a better one. It is difficult to believe that a clear-cut solution will be found, but one can expect better methods (i.e. methods that produce more refined estimates) to be developed.

- Although their estimates are vague and subjective, it was found that in some cases they are sufficient for reaching definite conclusions, upon which procurement decisions can be based. Two examples are presented in the following slides.

Quantifying Intangibles

- Risk - *expected attrition rate.*
- Mission value - ?
- Risk thresholds for various missions - ?
- Degradation in execution due to risk - ?

Low-cost ECM

- A complex model has been developed to estimate the total number of losses during the entire war with and without the proposed ECM.
- Although the difference between the numbers of lost aircraft in these cases was statistically significant, it was small compared with the total number of losses. It was even smaller than the variability in the losses estimation.
- The proposed system does not contribute to effectiveness. The money required for its procurement, could be better invested in other projects.

Case Study

Low-cost ECM

- Proposed system cost ~ price of one a/c.
- Expected reduction in losses ~ 2-5 a/c.

- By traditional approach: *cost-effective.*
- By new approach: *not cost-effective.*

  The system does not enable new missions, as survivability enhancement is negligible.

PGM for Single-Seaters

- In this case, the attrition of aircraft employing the proposed PGM was estimated as negligible in both cases. By the traditional approach, the price of each sortie was governed by munitions cost.
- All two-seaters were already allocated to high-value missions. Most single-seaters were allocated to lower-value missions. Armed with PGM they could be switched to higher-value missions.
- The difference in mission values due to utilization of PGM was much greater for single-seaters than for two-seaters. Commanders in the IAF who were consulted said that the difference in mission values outweighed the difference in price of the two PGM types.

Case Study

PGM for Single-Seaters

- Current PGM for two-seaters are cheaper and equally effective.

- By traditional approach: *not cost-effective.*
- By new approach: *cost-effective.*

  Two-seaters are currently tasked with higher-value missions than single-seaters. PGM for single-seaters will enable the execution of *more* high-value missions and is therefore better.

Concluding Remarks

- The methodology described in this paper is a generalization of several studies that were carried out for the IAF.

- Currently it applies only to the impact of attrition on decisions regarding acquisition of aerial munitions and avionics. We believe however, that it can be adapted - with some modifications - to deal with land and sea weapon systems as well.

Summary

- **The suggested new approach is based on the following assumptions:**
  - **a. Attrition is controlled by commanders.**
  - **b. Risk reduction encourages commanders to task a/c with higher-value missions.**
  - **c. Risk reduction enables air-crews to execute the mission more effectively.**
- **Using the new approach, risk is accounted for by reducing effectiveness rather than increasing cost.**
- **The new approach can be applied to real-life cases. The results obtained may be different from those of the traditional approach.**

References

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