Aalto-yliopisto
Perustieteiden
korkeakoulu

Selection of Air Combat Tactics using a Multi-Attribute Decision Analysis Model with Incomplete Preference Information

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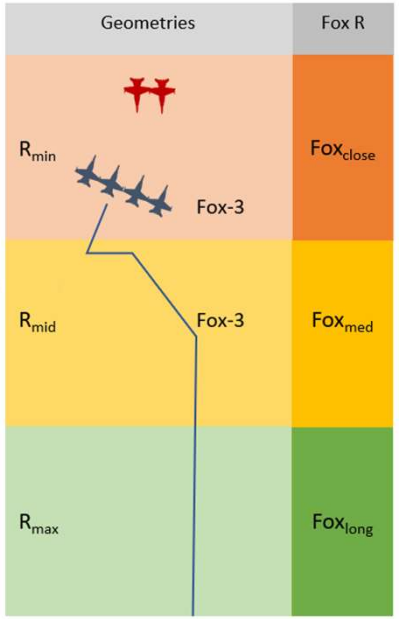
Decision Making in Air-to-Air Combat

- A **flight** comprises four fighter aircraft
- Fighter controllers and Fighter allocators
- Tactics, Techniques and Procedures (TTP)
  - Geometry alternatives (Range)
  - Engagement alternatives (Fox)

”Viper 1, Wizard, single group straight ahead, two contacts, hostile.”

Photos by Finnish Defense Forces (puolustusvoimat.fi)

”Viper 1, fox 3 on eastern.”
”Viper 3, fox 3 on western.”
”Viper 1, splash, bugging out.”



Course of Action (COA)

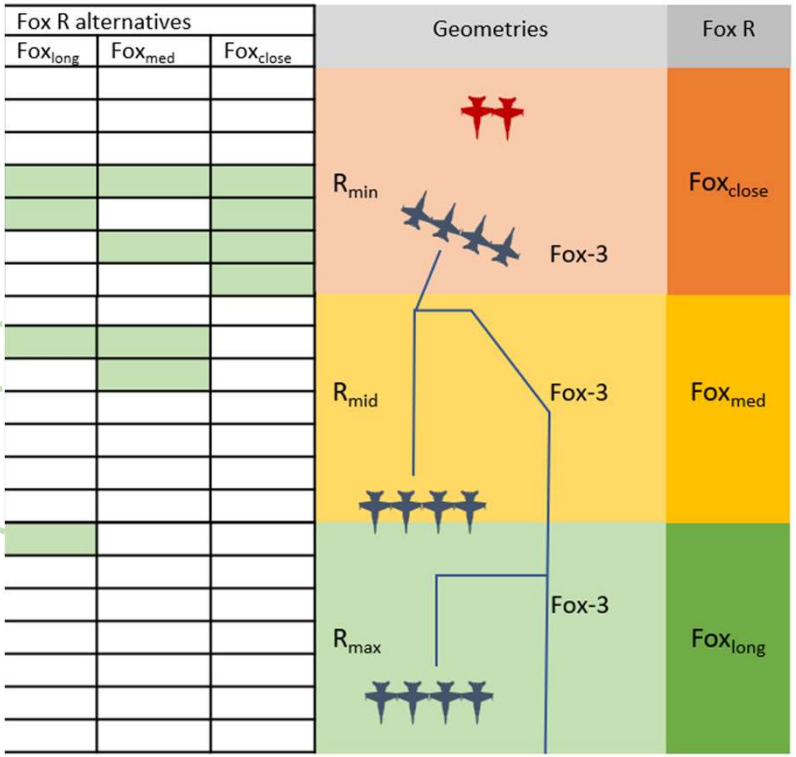
- COA consists of four separate TTPs – one for each flight
- Seven viable TTPs

4 close-range TTPs

2 mid-range TTPs

1 long-range TTP

⇒ 7×7×7×7 = 2401 COAs



Commander's Intent

Which COA should we choose?

Objective: Multi-Attribute Decision Analysis Model Providing "Best" COAs

- Additive value function to measure and rank COAs

Overall value of COA *x*: $$v(x) = \sum_{i=1}^{n} w_i v_i(x_i),$$

w_i weight of attribute i; v_i single attribute value function of attribute i

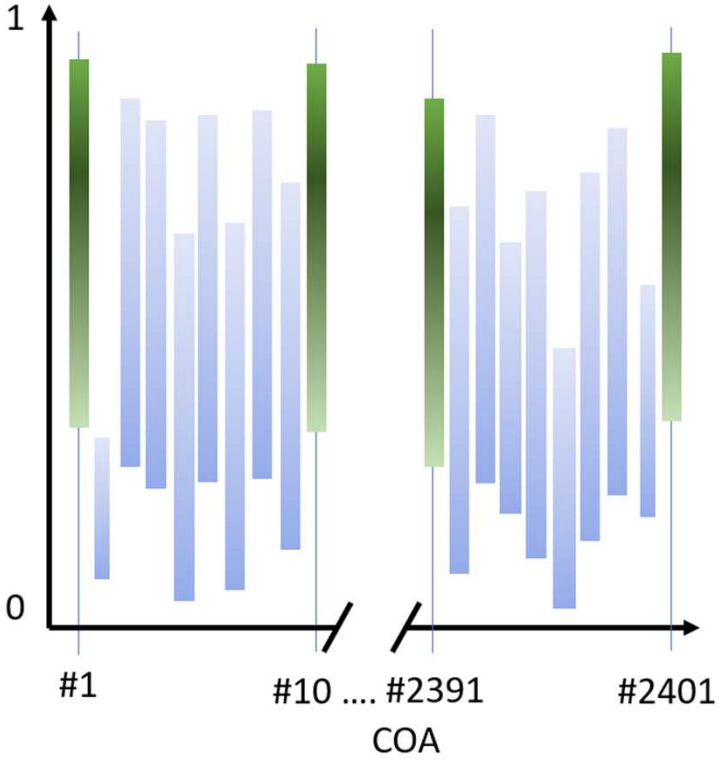
- Attributes: Kill prob. P_k, Survival prob. P_s, Efficiency Eff, …
- Commander's intent represented as **incomplete** preference information - Feasible weights

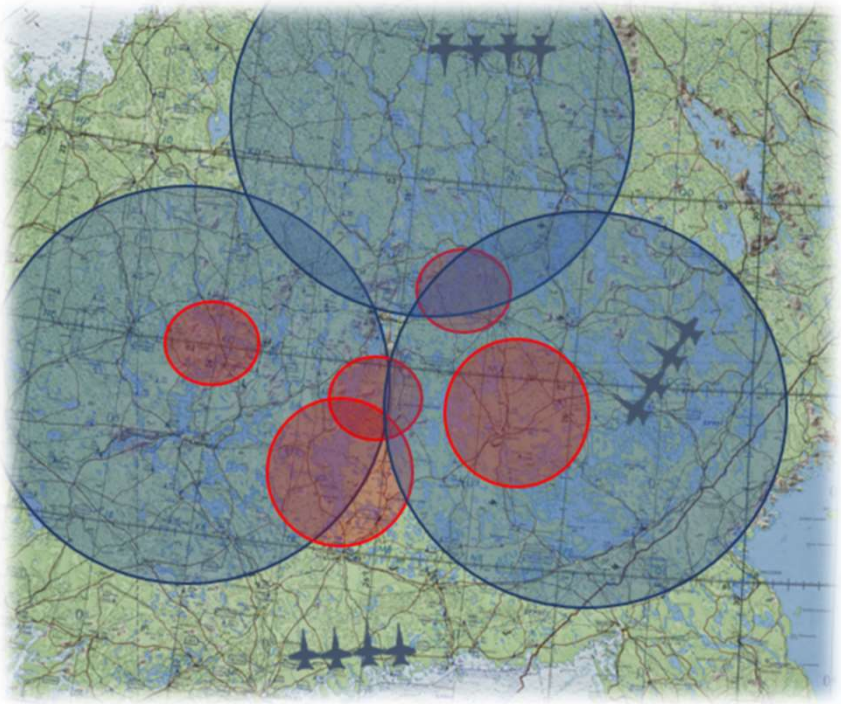
$$w_1 \geq w_2 \geq w_3 \quad \textit{Trade-off} \quad \textit{SWING} \quad w_2 \leq w_1 \leq 2w_2$$

SMARTS

Specifications

- Find a set of non-dominated COAs
- Ignore all geographical / additional restrictions





Tools and software

- MATLAB
- Microsoft Excel

```
%% Determine pairwise dominance relations between the alternatives
DD1=zeros(n,n); %binary n by n matrix; D(i,j)=1 if alternative i dominates
DD2=zeros(n,n);
tic %start timer
for ii=1:n-1
    v_ii = v(ii,:);
    parfor j=ii+1:n
        f=v_ii-v(j,:); %objective function (row vector containing coefficie
        %Solve the smallest overall value difference between
        %alternatives i and j:
        [~, minVdif] = linprog(f,A,b,Aeq,beq,LB,UB,options);
        %Solve the smallest overall value difference between
        %alternatives i and j:
        [~, maxVdif] = linprog(-1*f,A,b,Aeq,beq,LB,UB,options);
        maxVdif=-1*maxVdif;
        if (minVdif >= 0 && maxVdif > 0)
            %If the smallest possible overall value difference is
            %non-negative and the largest possible overall value difference
            %is positive, alternative i dominates alternative j:
            DD1(ii,j)=1;
        elseif (minVdif < 0 && maxVdif <= 0)
            %If the smallest possible overall value difference is
            %negative and the largest possible overall value
            %difference is non-positive, alternative j dominates
            %alternative i:
            DD2(j,ii)=1;
        end
    end
```

References

- **H. Mansikka, K. Virtanen and M. Kankaisto (forthcoming)** Chinese Whispers in Air Combat: Multi-Criteria Decision Analysis Framework for Converting Commander's Intent into Air Combat Course of Action. *Manuscript.*
- **A. Salo and R.P. Hämäläinen (2010)** Preference Programming – Multicriteria Weighting Models under Incomplete Information. *Handbook of Multicriteria Decision Analysis, Springer, New York.*
- **J. Mustajoki and R.P. Hämäläinen (2005)** Decision Support by Interval SMART/SWING - Incorporating Imprecision in the SMART and SWING Methods. *Decision Sciences, Vol. 36, No. 2, 317-339.*
- **M. Weber (1987)** Decision Making with Incomplete Information. *European Journal of Operational Research, 28, 44-57.*

Schedule

- Study the literature 06/2021
- Develop the model 06-07/2021
- Write the thesis 07-08/2021
- Finalize code (and implement GUI) 08/2021
- Finish the thesis 09/2021