DEFENSE THREAT REDUCTION AGENCY

Combined Defense

Science and Technology for Chem-Bio Information Systems

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Combined Defense

- The combined defense of a fixed-installation involves the combination of many different assets to be effective.
- The decision maker may choose to substitute one type of defensive measure for another (*e.g.* guards instead of fences).
- Analysis of this problem should take the form of a portfolio analysis- minimizing risk while conforming to a certain level of investment.
- The underlying requirements for this approach are that each element has a particular cost and associated value (based on expected return or effectiveness). Preliminary results are **value** only.

Logical Decisions Combined Defense Model

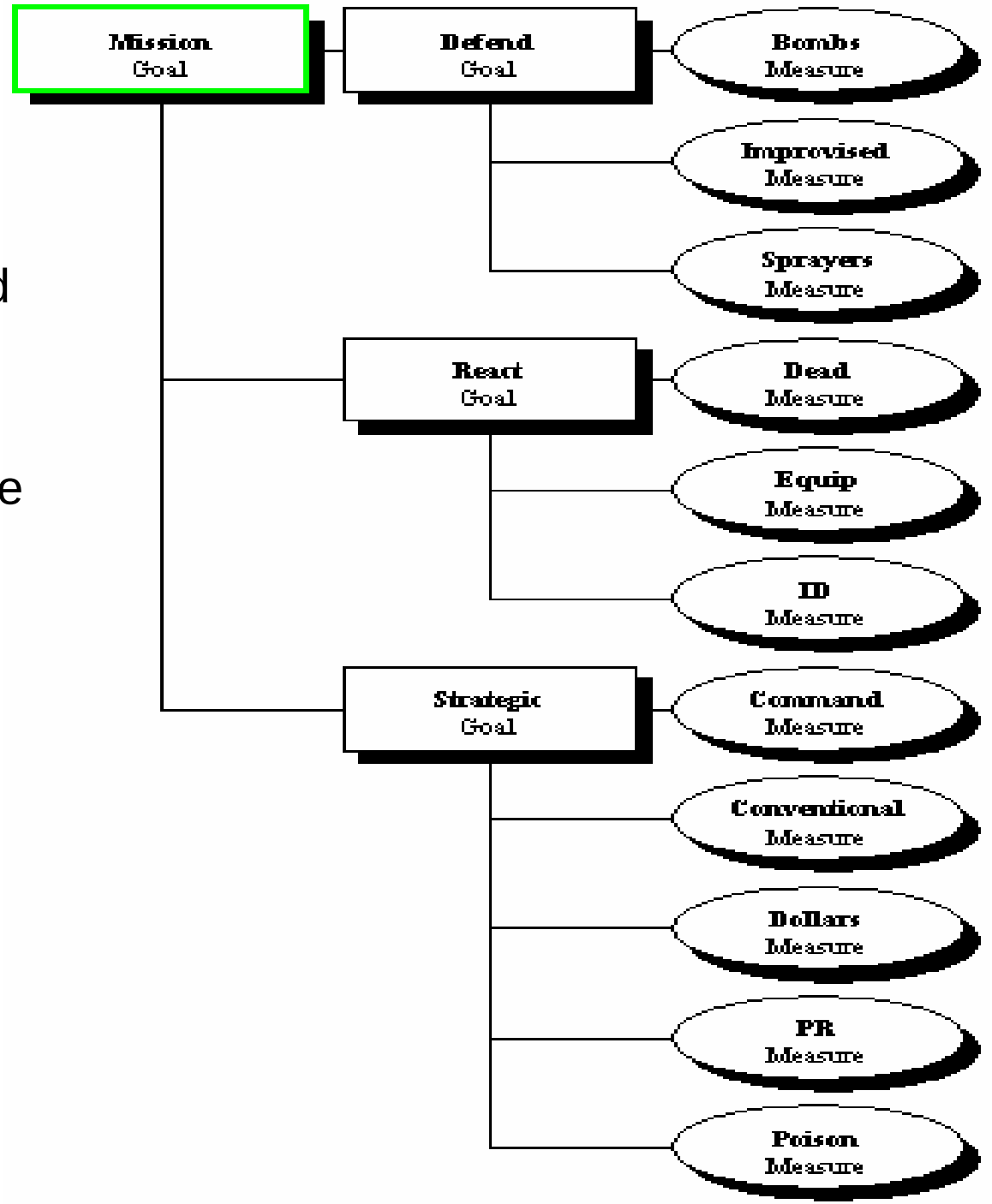
- A file was created in the LDW program by the DTRA OR cell which includes the defensive measures a base can take, the types of attacks it may need to defend against, and the goals it may need to achieve.
- Experts provided input values for the effectiveness of every action in relation to every attack or goal of the mission.
- This program can be used by a decision maker to find which actions should be taken in order to best achieve the overall goal.
- The decision maker can alter the inputs to reflect his changing concerns and objectives by altering the weights held by the many actions, values and goals.

Procedure for Decision Analysis

- Brainstorming to enhance the universe of possibilities for variables and alternatives which may be considered in the model
- Consolidation of the variables into an exhaustive and exclusive list of the pertinent variables
- Construction of the relationships between the variables and outcomes
- Gathering of data for the measures involving the mix of expert opinion, research and experimentation to gather inputs for the model
- Assignment of relative weights for the overall goals (mission, deaths, cost)
- Sensitivity analysis to determine tipping points (solution changes based on weight) for borderline evaluations
- Final determination of relative values of the inputs
- Normalization to reflect physical results

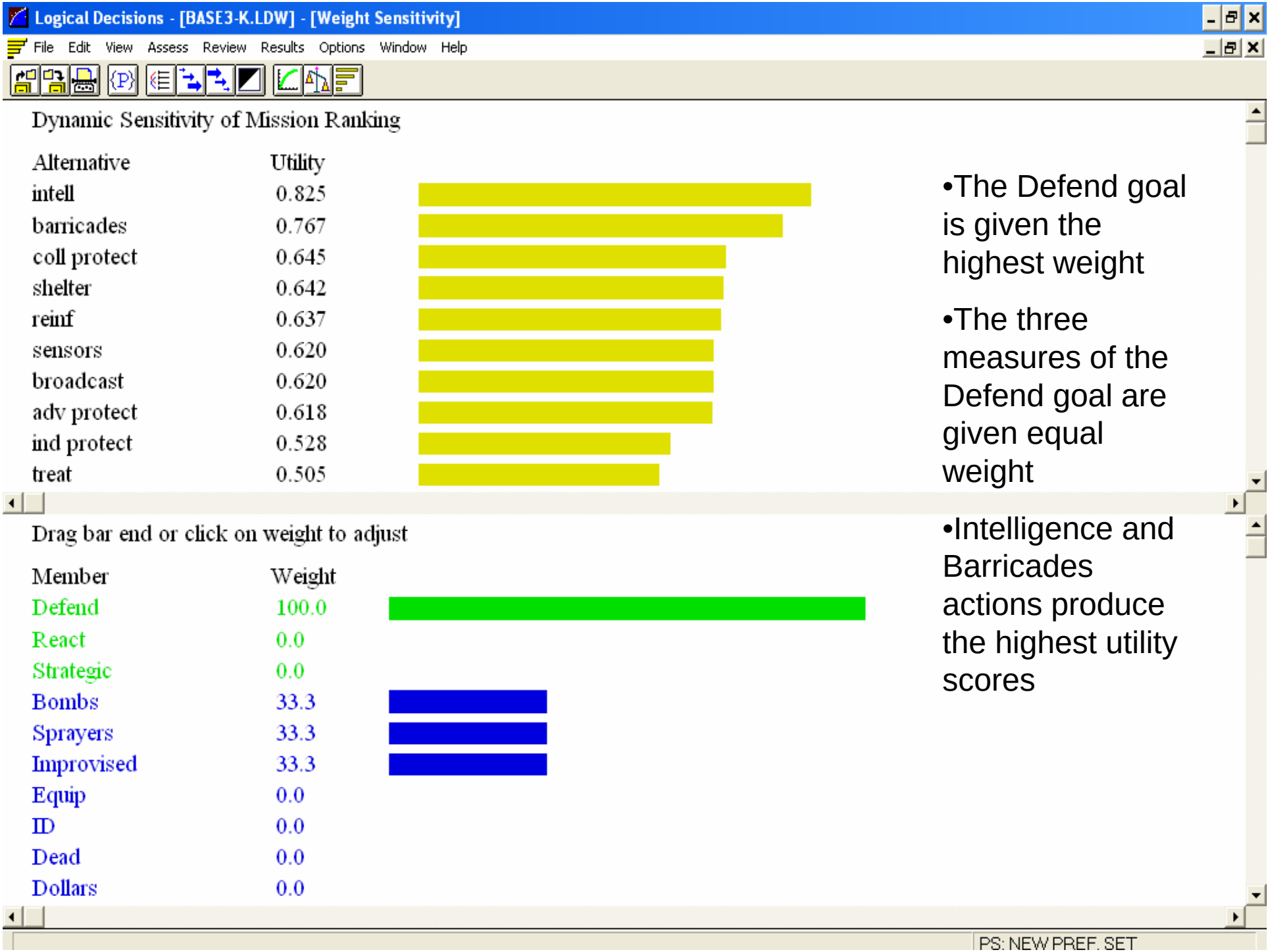
Goals Hierarchy

- The measures are categorized into three goals: defend, react, and strategic
- These three goals are all aimed at achieving the overall goal of the mission
- It is assumed that the mission is the absolute objective, and that sacrifices of personnel and equipment will be made in order to preserve and continue the mission

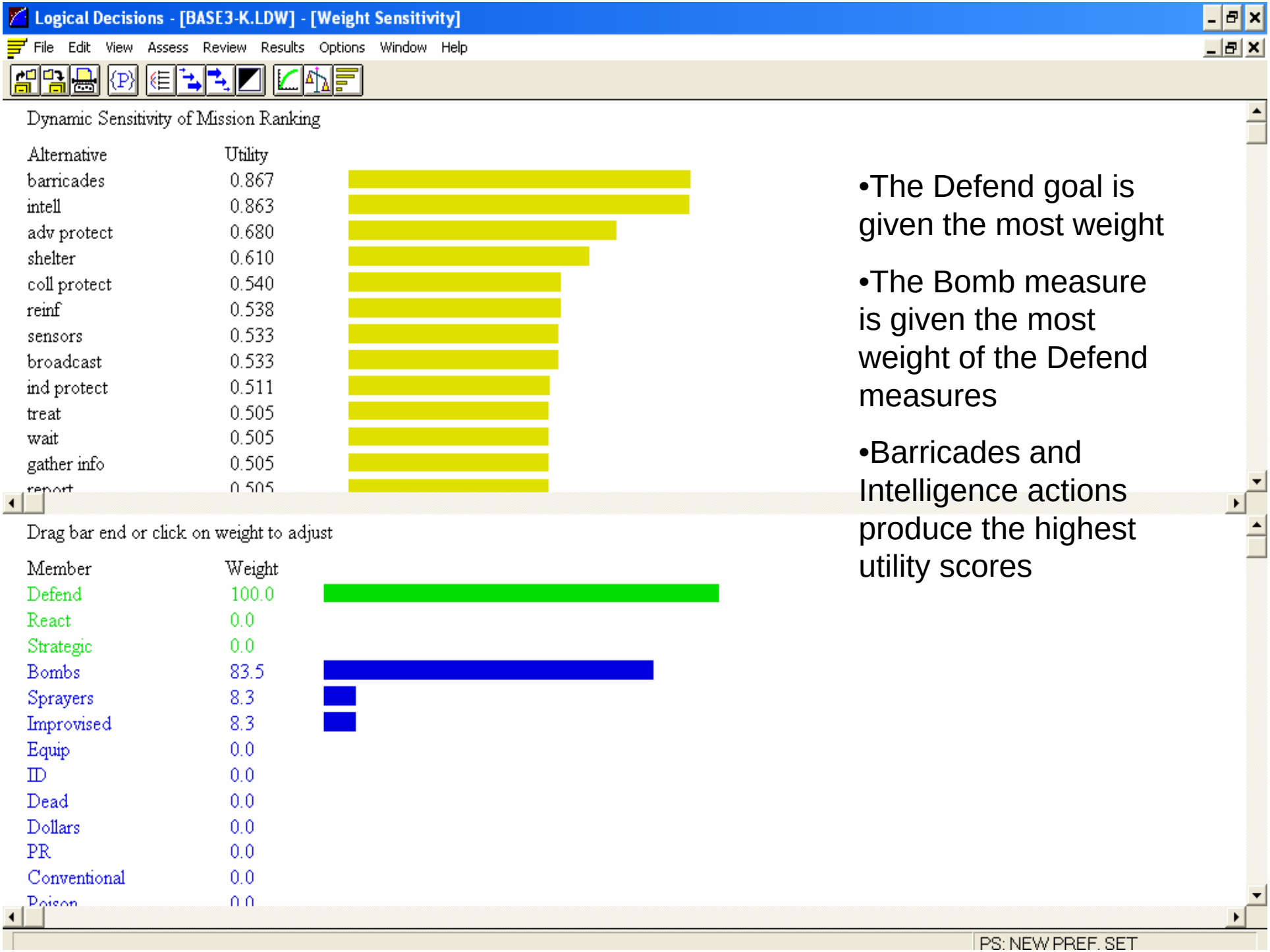


Matrix of Inputs

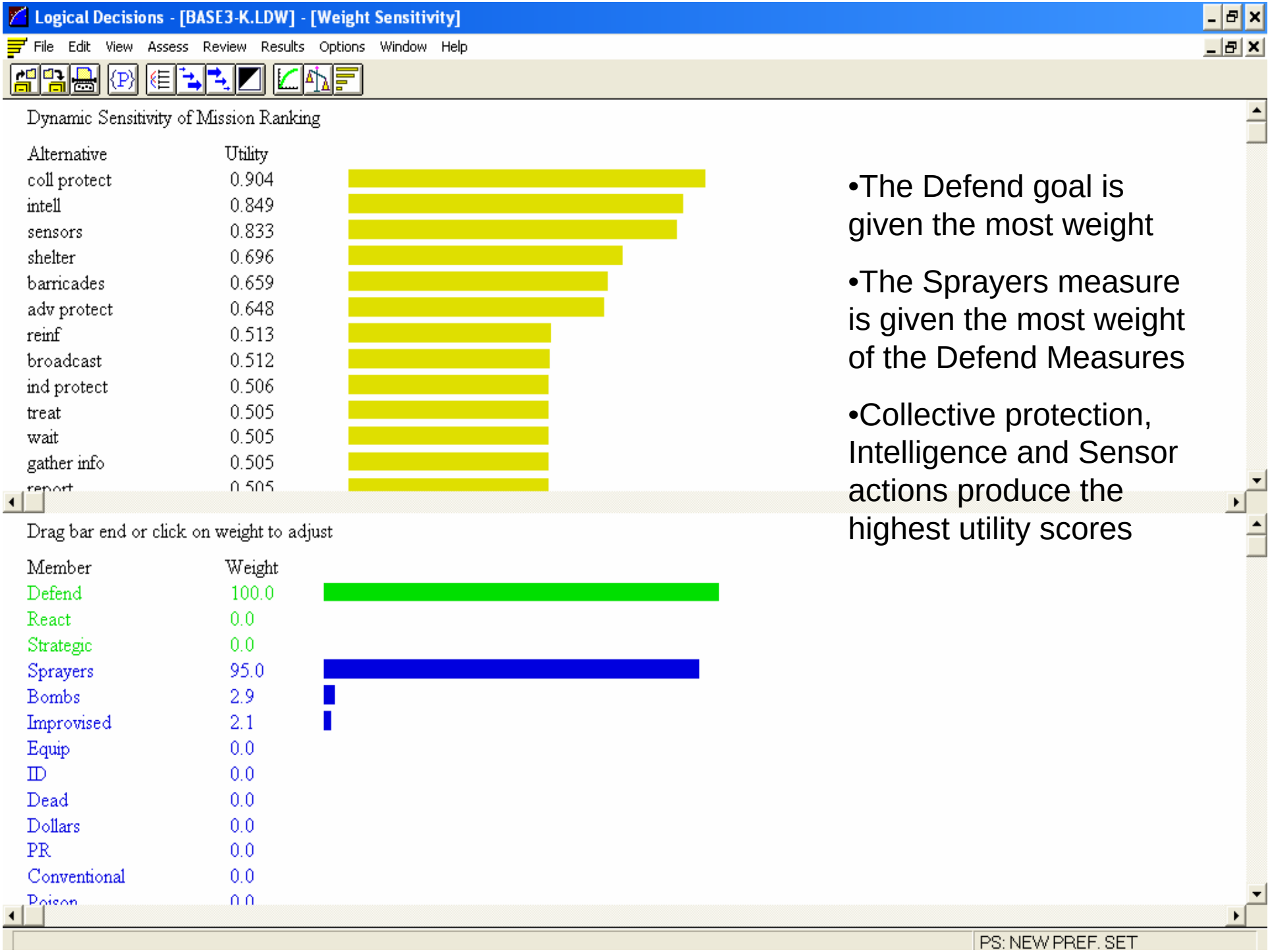
	Bombs	Command	Conventional	Dead	Dollars	Equip	ID	Improvised	Poison	PR	Sprayers
sensors	70	1	90	1	1	1	1	5.5	45	1	100
gather info	75	1	1	70	70	40	80	70	82.5	55	1
report	20	20	1	20	90	12.5	75	97.5	75	1	1
coll protect	75	82	1	85	90	80	1	70	5.5	-60	1
broadcast	82.5	40	1	65	85	-60	25	70	70	20	1
ind protect	80	20	1	85	65	1	-35	40	25.5	-5	1
reinf	50	30	1	1	50	-50	30	65	60	10	1
treat	62.5	45	1	85	-85	60	25	72.5	82.5	-95	1
shelter	10.5	50	1	70	90	20	-40	25	10.5	-15	1
deCon	1	10	1	50	60	85	1	25.5	20.5	-25	1
Intell	75	1	95	1	1	1	1	65	40	1	1
evac	-35	-50	1	80	-30	-83.5	-65	15	85	-50	40
barricades	80	1	35	1	1	1	1	1	30	1	1
adv protect	35	1	50	1	1	1	1	1	22.5	1	1
wait	1	1	1	-80	90	-80	27.5	1	5.5	-5	1
dispose	1	-5	1	35	-90	-72.5	1	1	1	-15	1



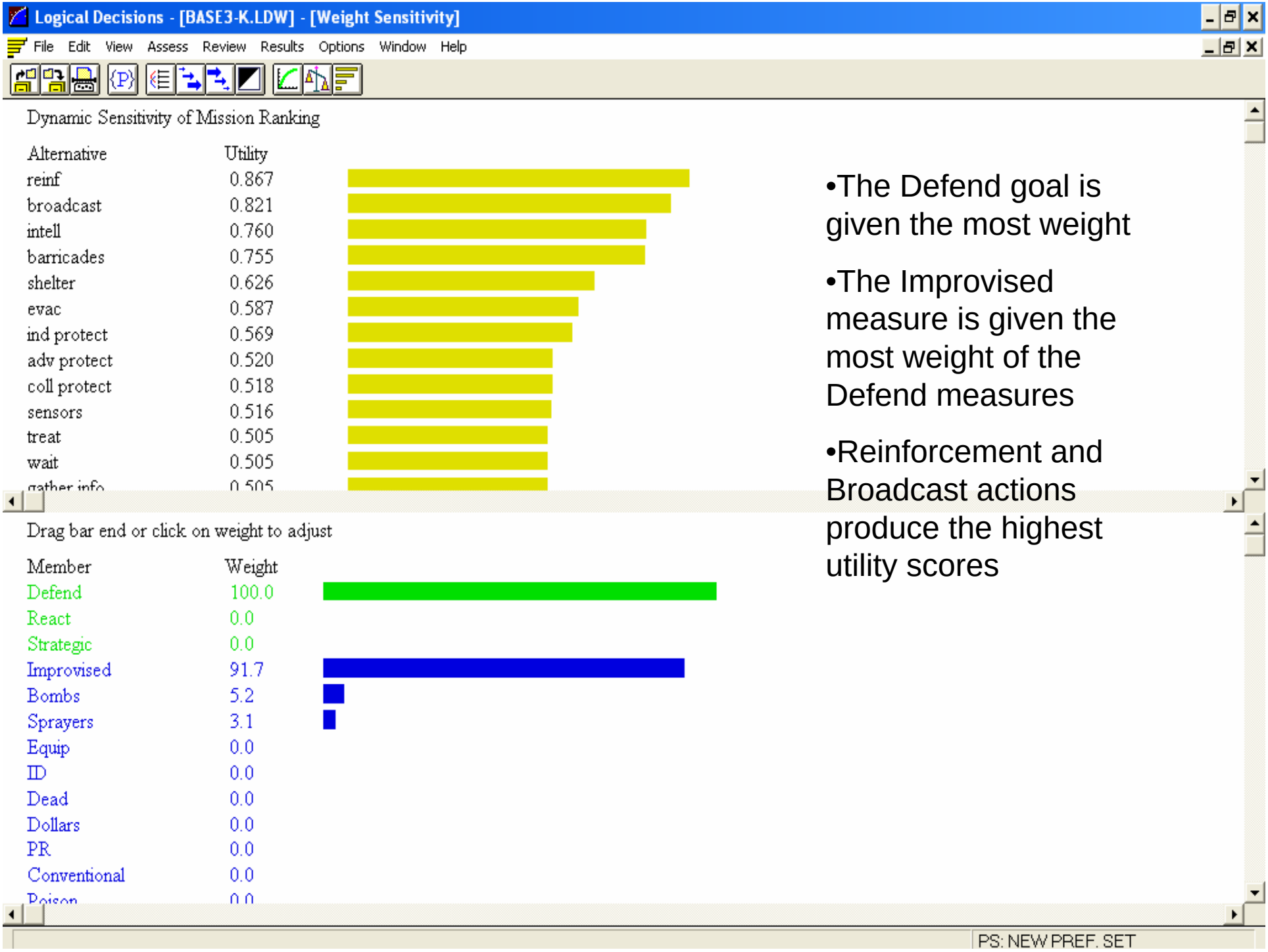
- The Defend goal is given the highest weight
- The three measures of the Defend goal are given equal weight
- Intelligence and Barricades actions produce the highest utility scores



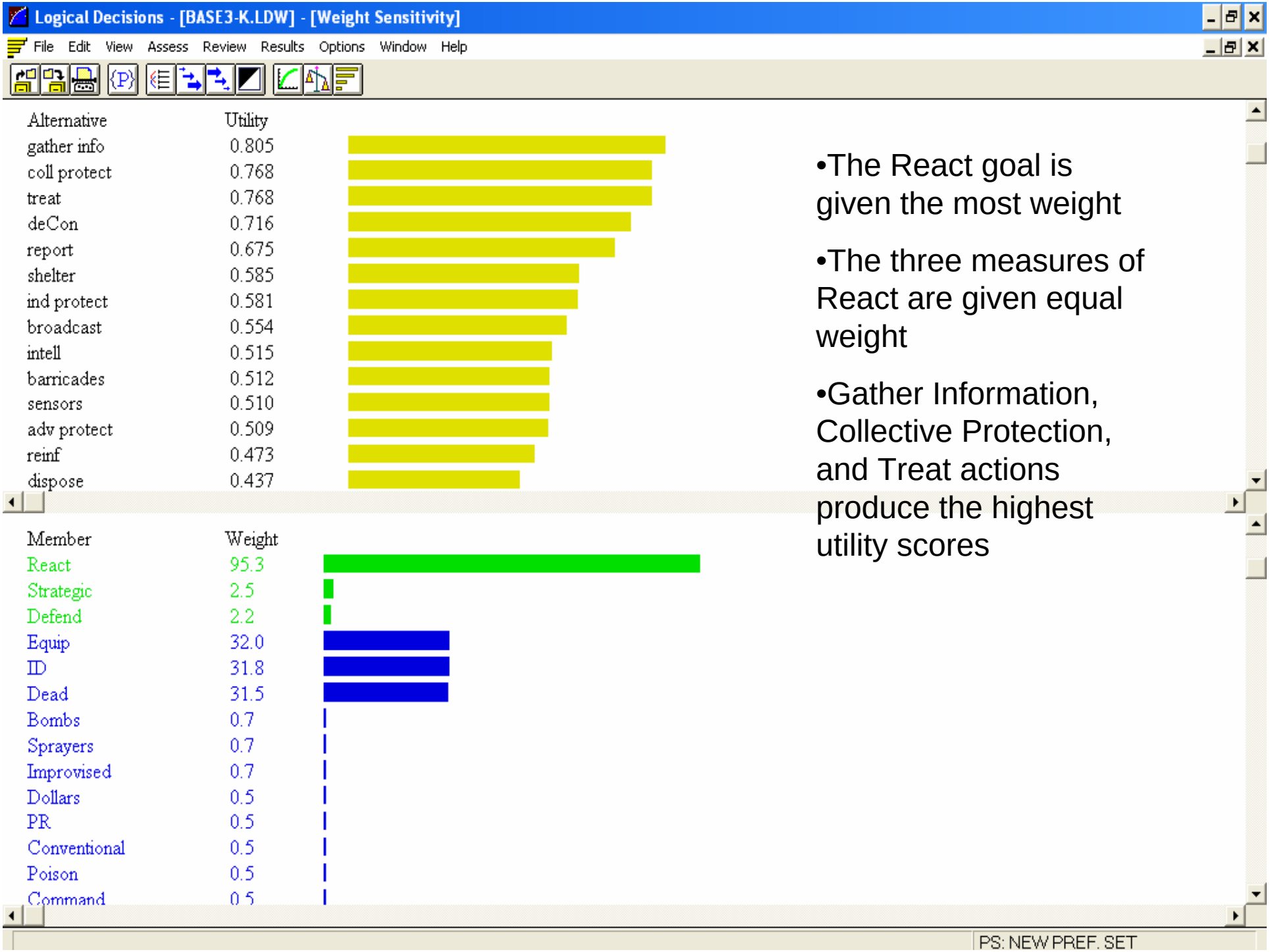
- The Defend goal is given the most weight
- The Bomb measure is given the most weight of the Defend measures
- Barricades and Intelligence actions produce the highest utility scores



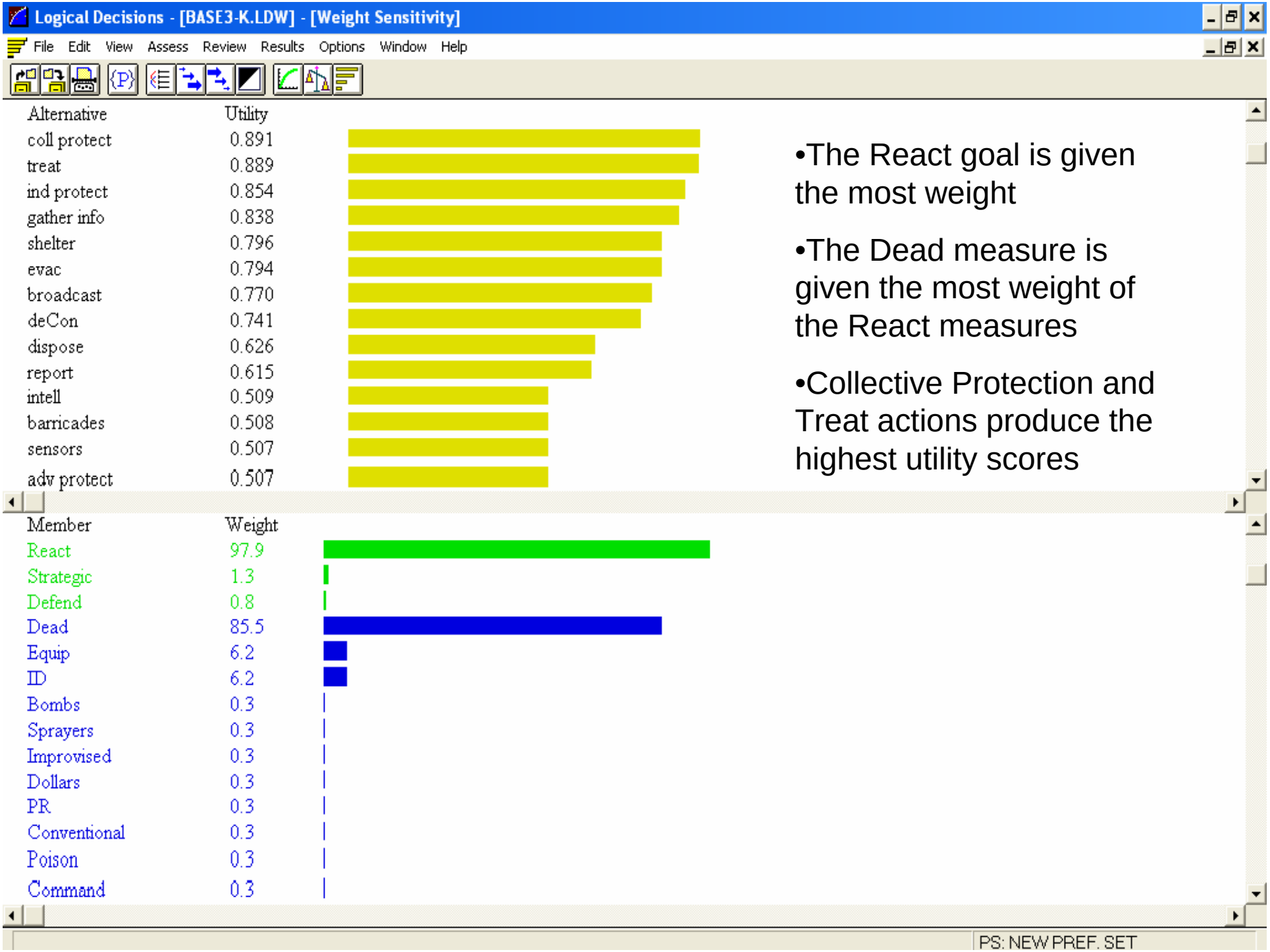
- The Defend goal is given the most weight
- The Sprayers measure is given the most weight of the Defend Measures
- Collective protection, Intelligence and Sensor actions produce the highest utility scores



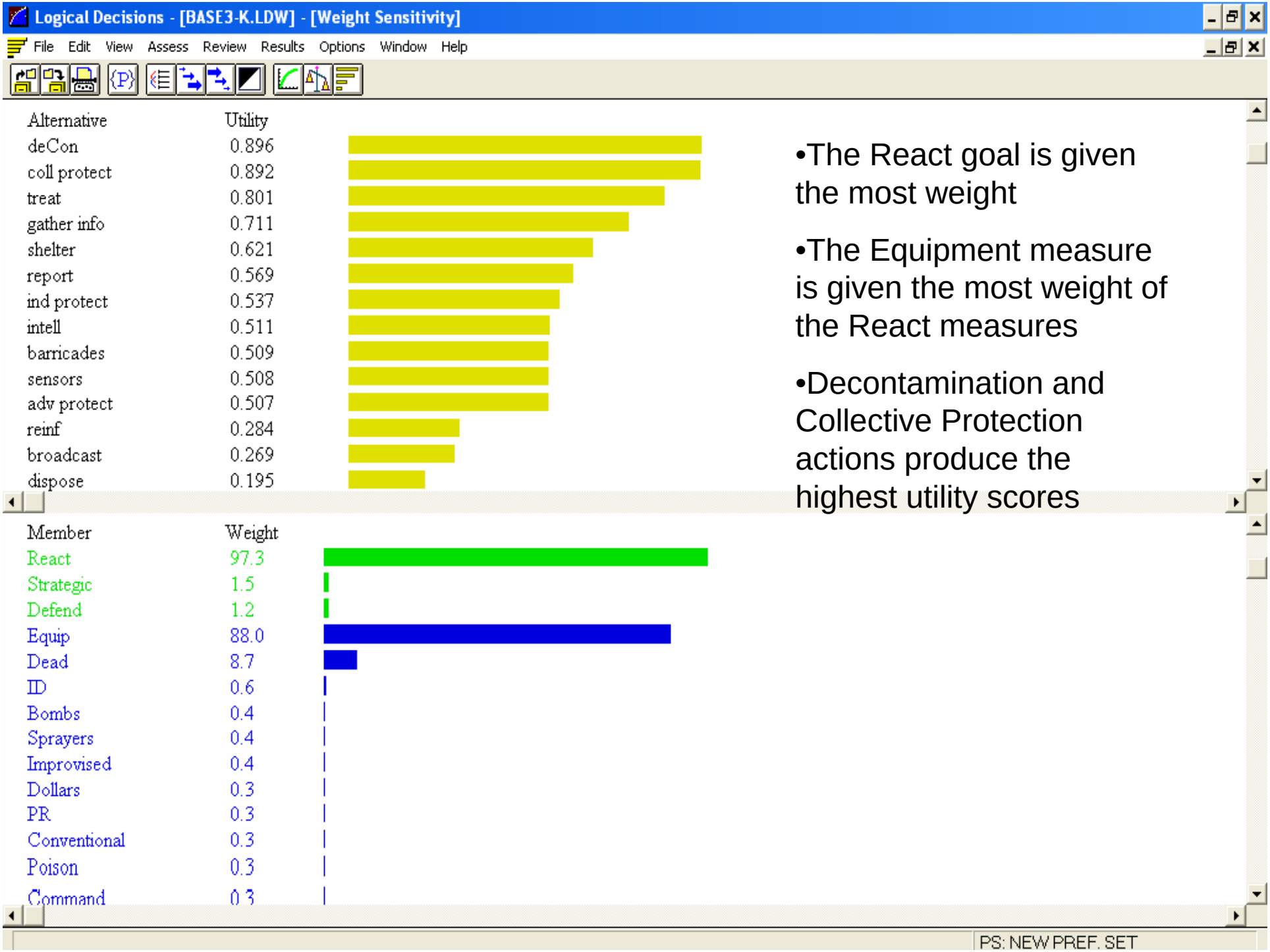
- The Defend goal is given the most weight
- The Improvised measure is given the most weight of the Defend measures
- Reinforcement and Broadcast actions produce the highest utility scores



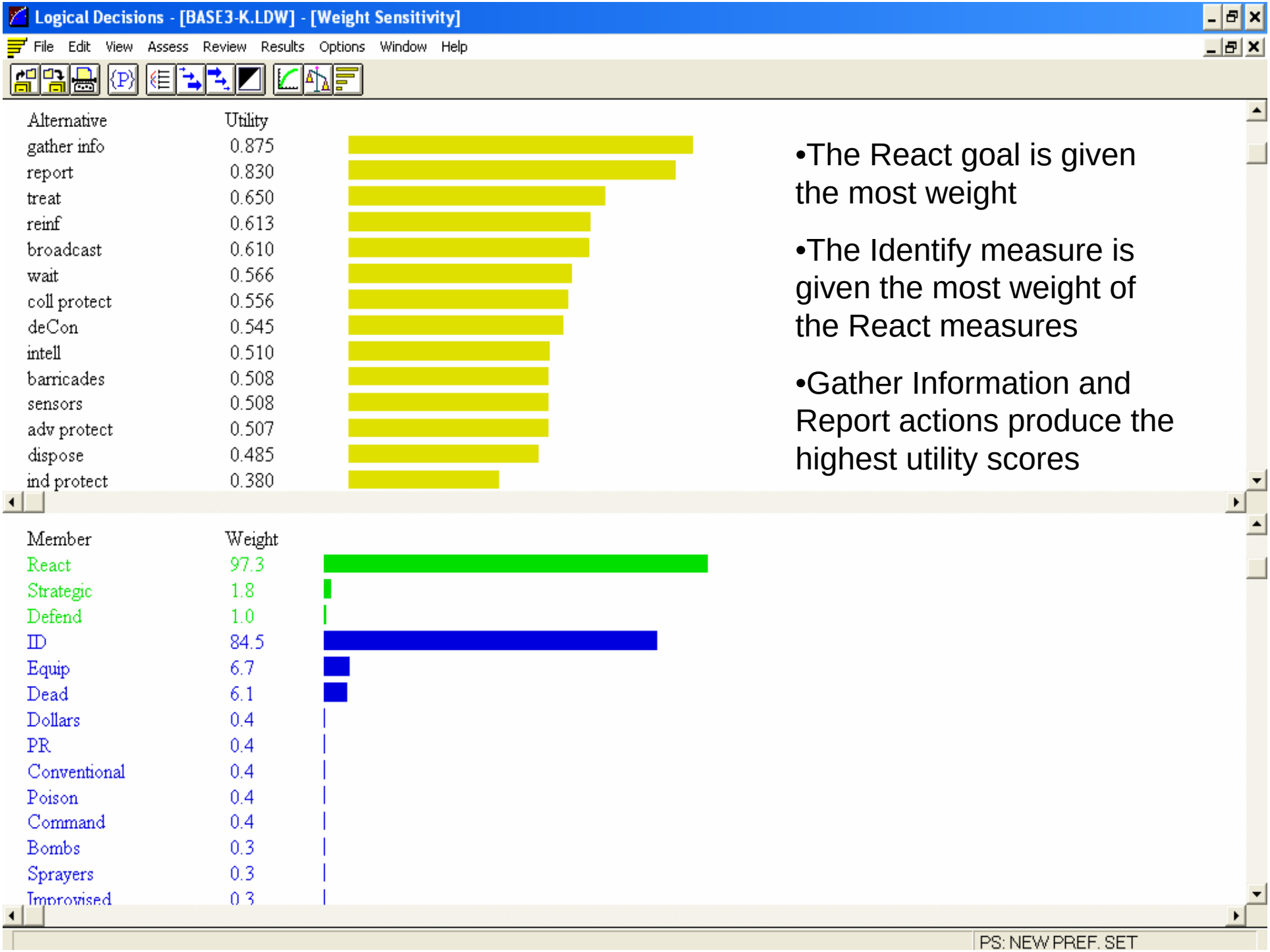
- The React goal is given the most weight
- The three measures of React are given equal weight
- Gather Information, Collective Protection, and Treat actions produce the highest utility scores



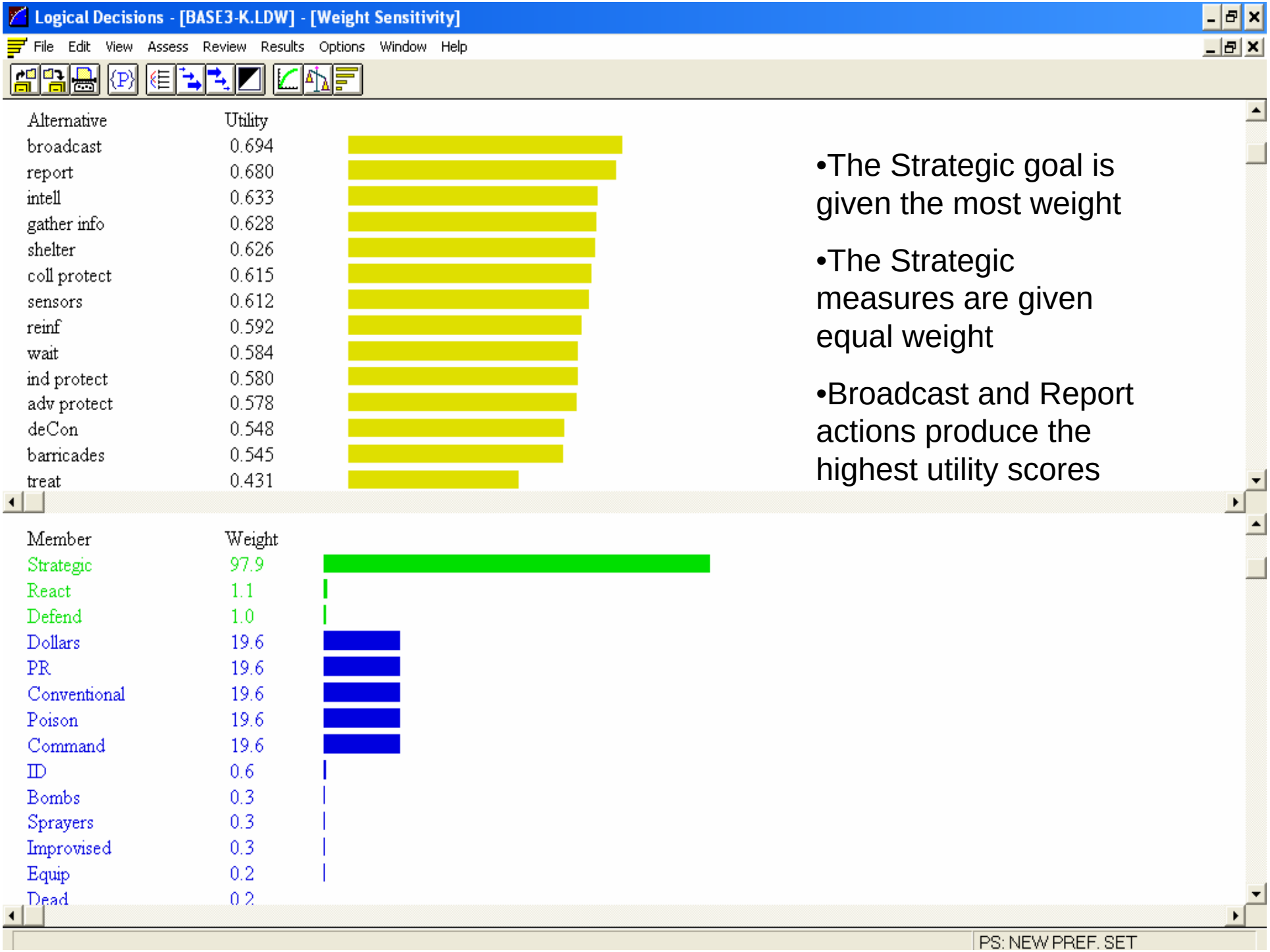
- The React goal is given the most weight
- The Dead measure is given the most weight of the React measures
- Collective Protection and Treat actions produce the highest utility scores



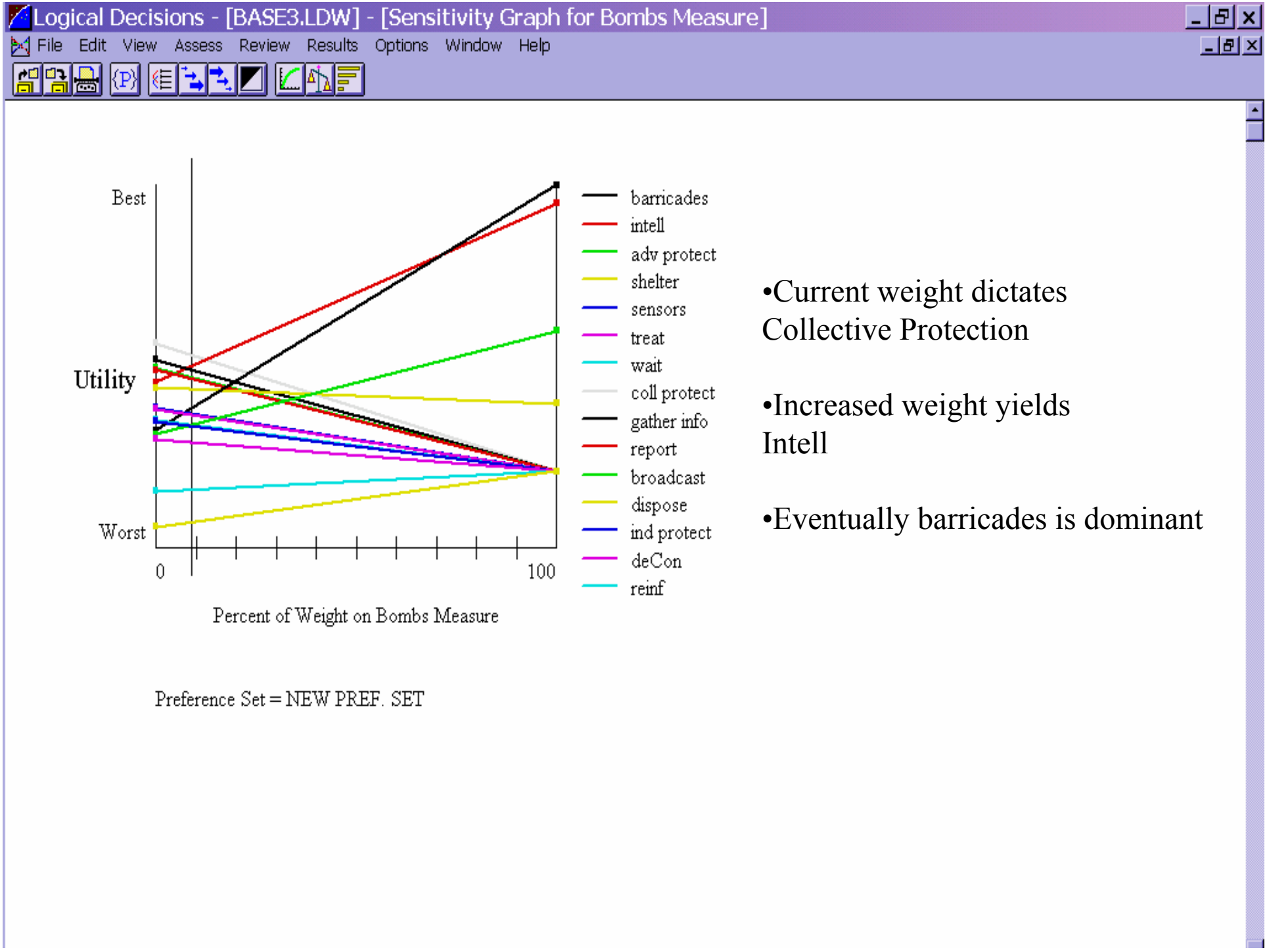
- The React goal is given the most weight
- The Equipment measure is given the most weight of the React measures
- Decontamination and Collective Protection actions produce the highest utility scores



- The React goal is given the most weight
- The Identify measure is given the most weight of the React measures
- Gather Information and Report actions produce the highest utility scores



- The Strategic goal is given the most weight
- The Strategic measures are given equal weight
- Broadcast and Report actions produce the highest utility scores



- Current weight dictates Collective Protection
- Increased weight yields Intell
- Eventually barricades is dominant

Conclusions and Future Areas of Study

- The Combined Defense Model can be used to analyze defensive measures based on a base's individual threats and objectives
- The program operates on a user friendly interface that can be quickly learned and used
- Only preliminary inputs have been completed for the Combined Defense Program
- The relative values currently saved in the program will be analyzed for accuracy and ground truth values will be researched in order to integrate real world facts and values into the inputs for the model
- Sensitivity analysis must be performed to assure that the results are correct and unwavering

Future Steps

- Step 1: Replace relative input values with actual values
- Step 2: Allocate a portfolio which maximizes the ability to complete the mission, but is subject to a risk threshold

$$\text{minimize:} \quad Z = \sum_{i=1}^{n} \sum_{i=1}^{n} \sigma^2_{ij} x_i x_j = X^T C X$$

$$\text{subject to:} \quad x_1 + x_2 + \ldots + x_n = F\ (\$)$$

$$E_1 x_1 + E_2 x_2 + \ldots + E_n x_n \geq L$$

σ = covariance

E = individual return

C= $[\sigma^2_{ij}]$ covariance matrix

L= expected return