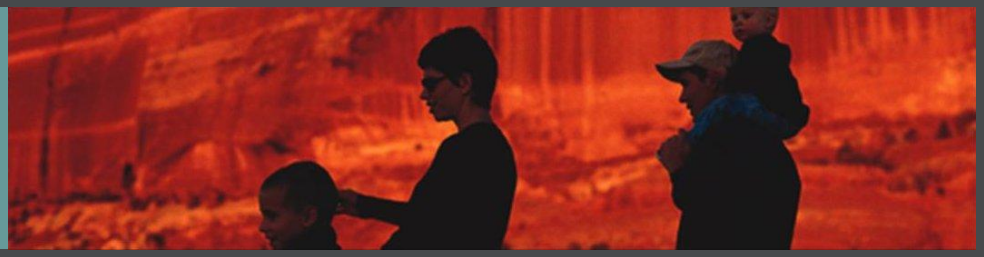
Investigating the Benefits of Information Management Systems for Hazard Management

Ian Griffiths, Martyn Bull, Ian Bush, Luke Carrivick, Richard Jones and Matthew Burns



Aims of CBRN IM

- To seamlessly acquire, process and deliver data, information and knowledge
- To provide best possible picture of CBRN situation now and into future
- To support the decision maker in making optimal decisions

Application

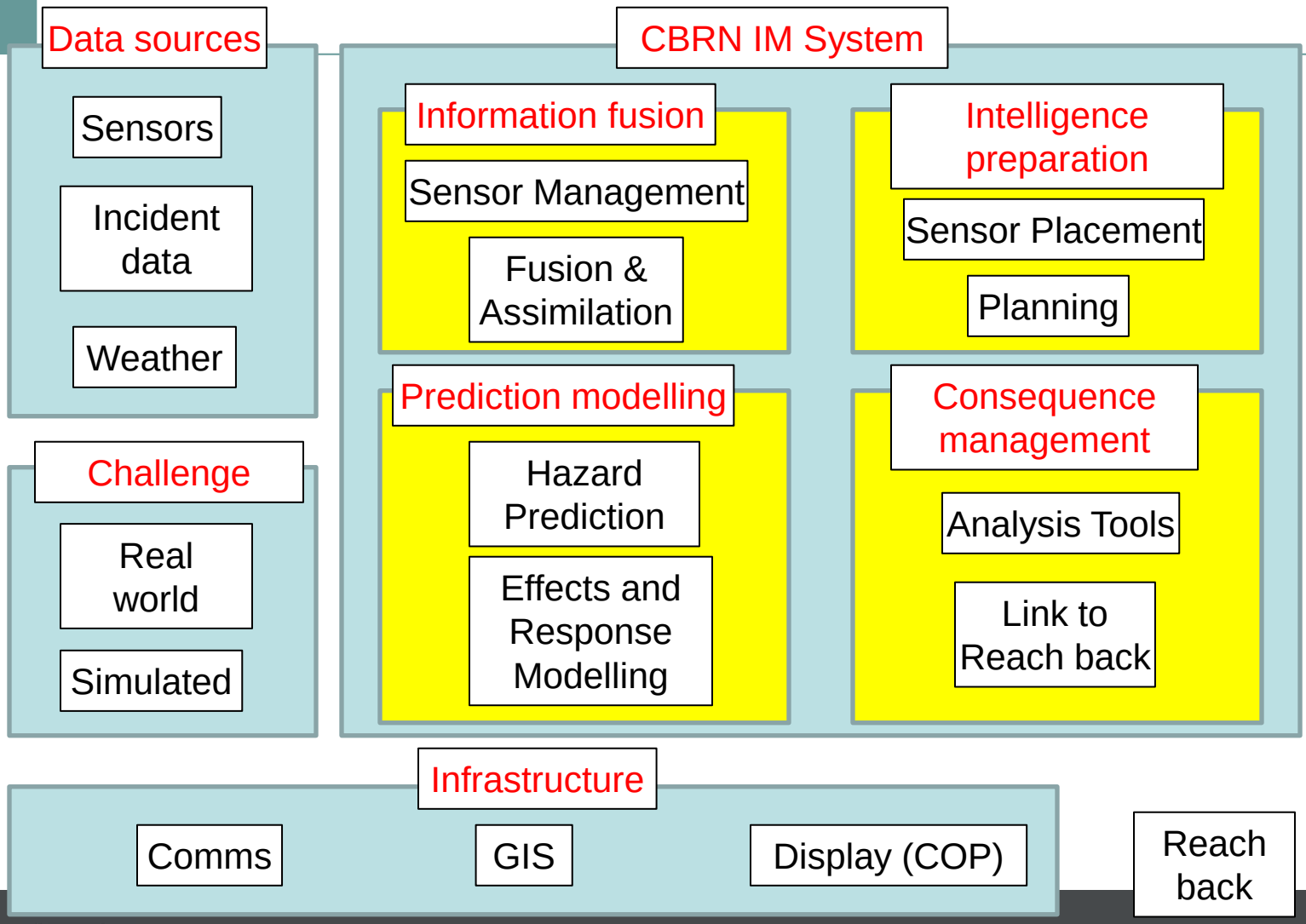
- Military
- Homeland security

Overview of CBRN IM Systems

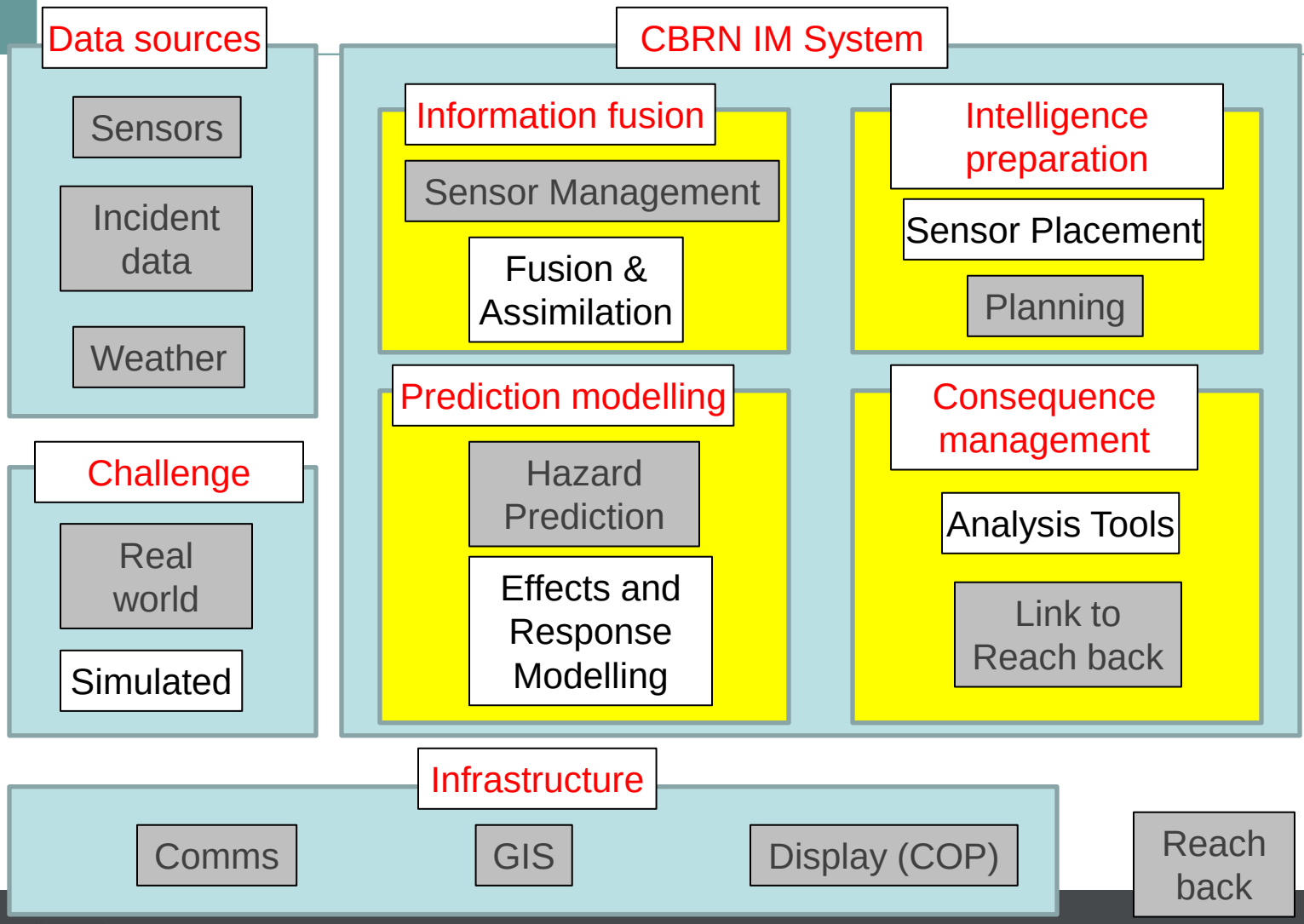
- Example operational systems
  - JEM/JWARN
    - US DOD
  - NARAC
    - US DOE
  - ARGOS
    - Multinational

- PRIME
  - Prototype Response and IM Engine
  - Prototype system developed by RiskAware to demonstrate, test and evaluate concepts and capabilities

Overview of CBRN IM Systems



Overview of CBRN IM/DS Systems



PRIME Demo

Sensor model

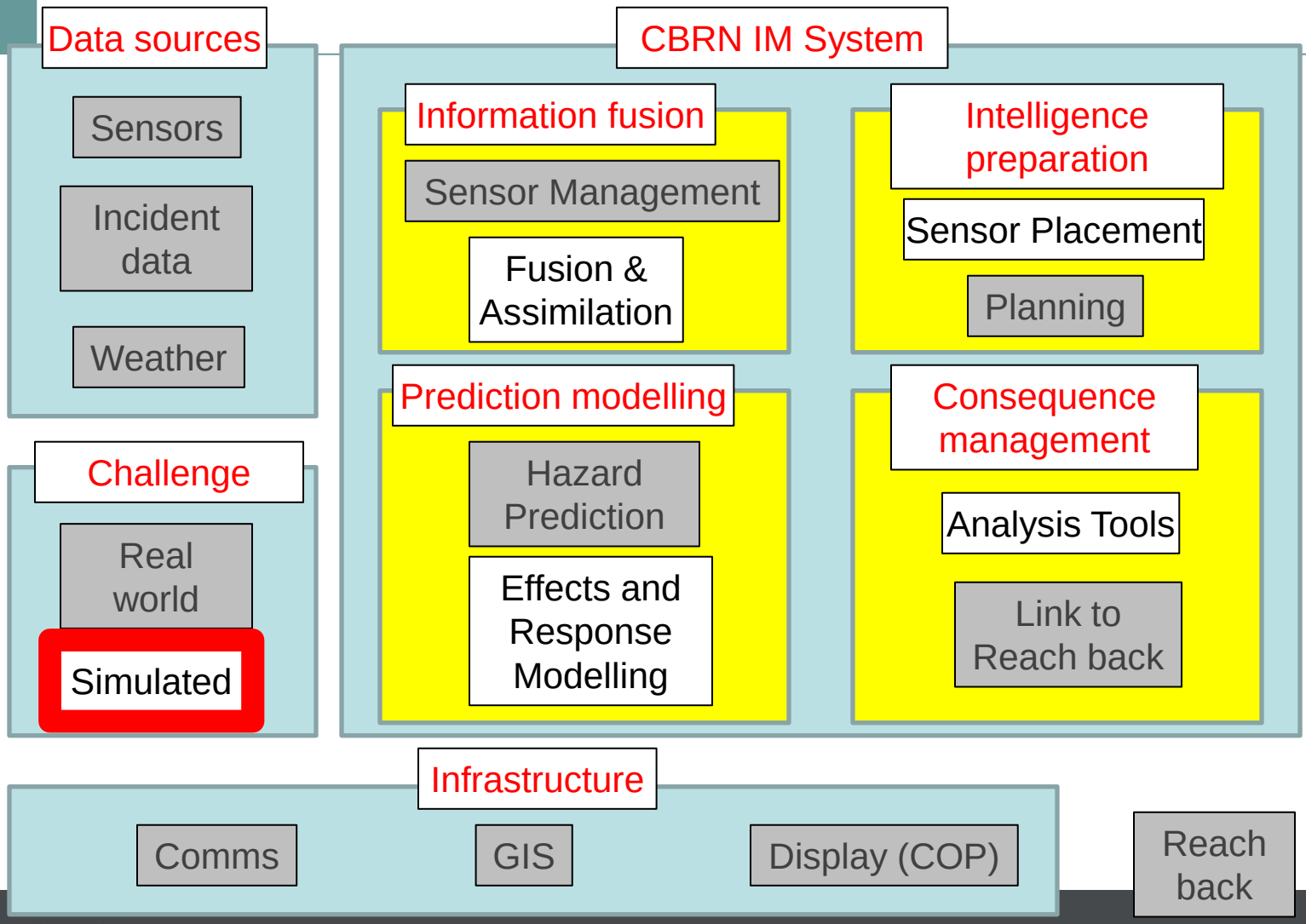
Fusion

Hazard

Response

Challenge

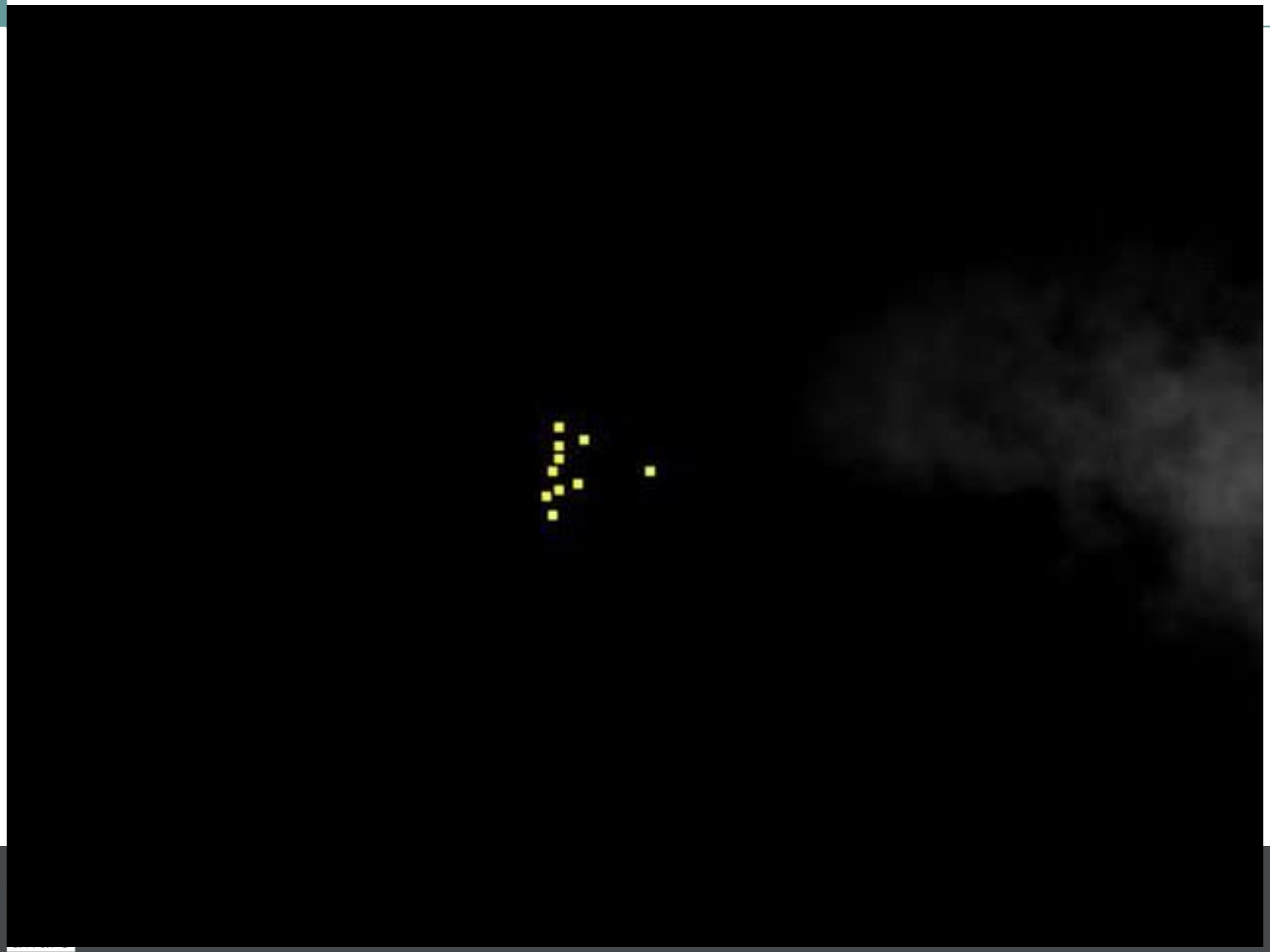
Overview of CBRN IM Systems



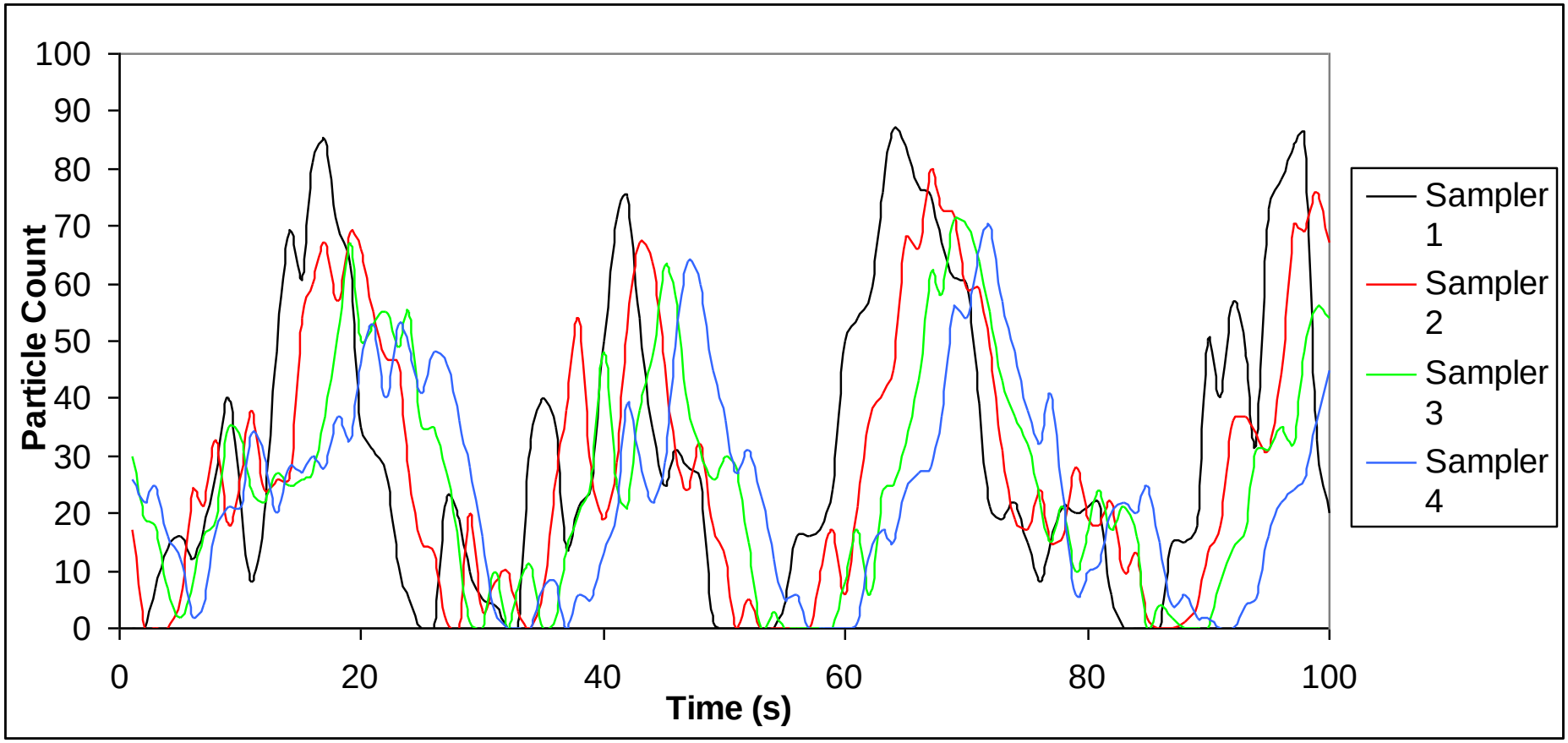
CB Challenge For Studies

- Standard evaluation
  - Use standard T&D model with sensors & effects
  - Monte Carlo sampling of inputs
- Advanced simulated challenges using CB Challenge Generator

Example Output

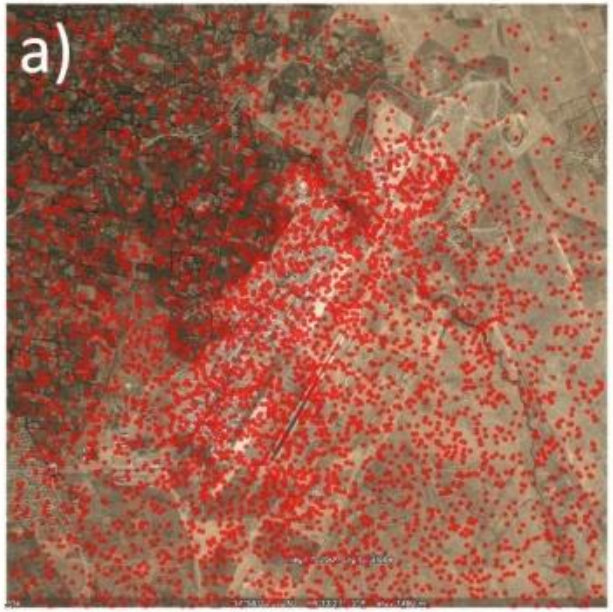


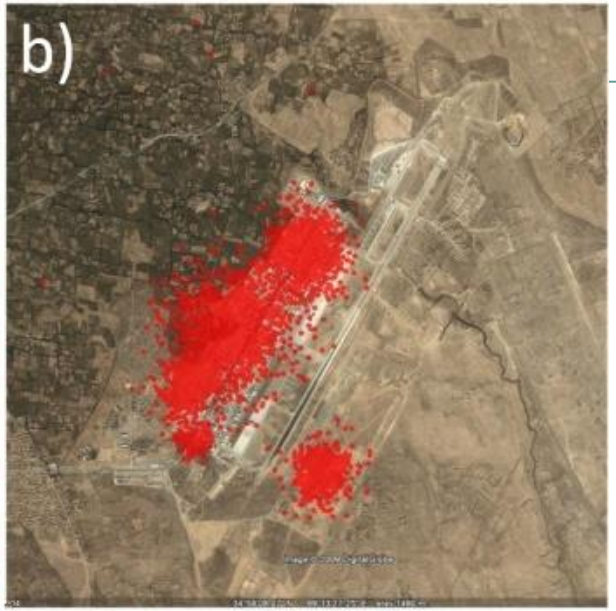
Sample Time Series Output



Cases Considered 1: Bagram

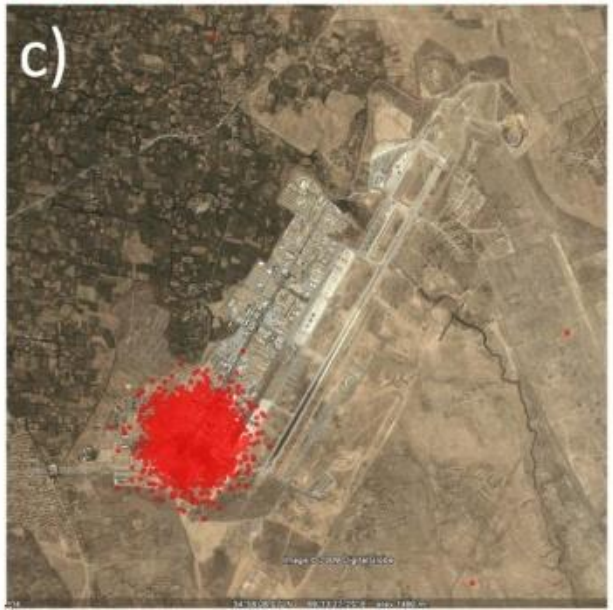
Long term placement – threat could be anywhere

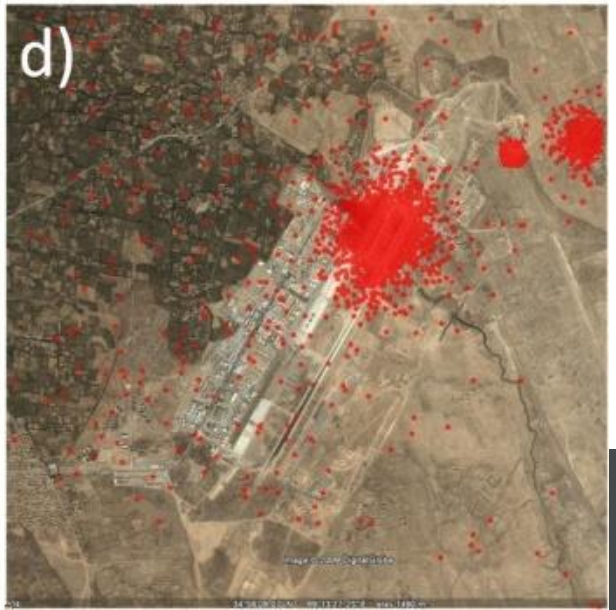




Placement for 3 months – believe base is targeted

Placement for 1 month – concern of release near base entrance



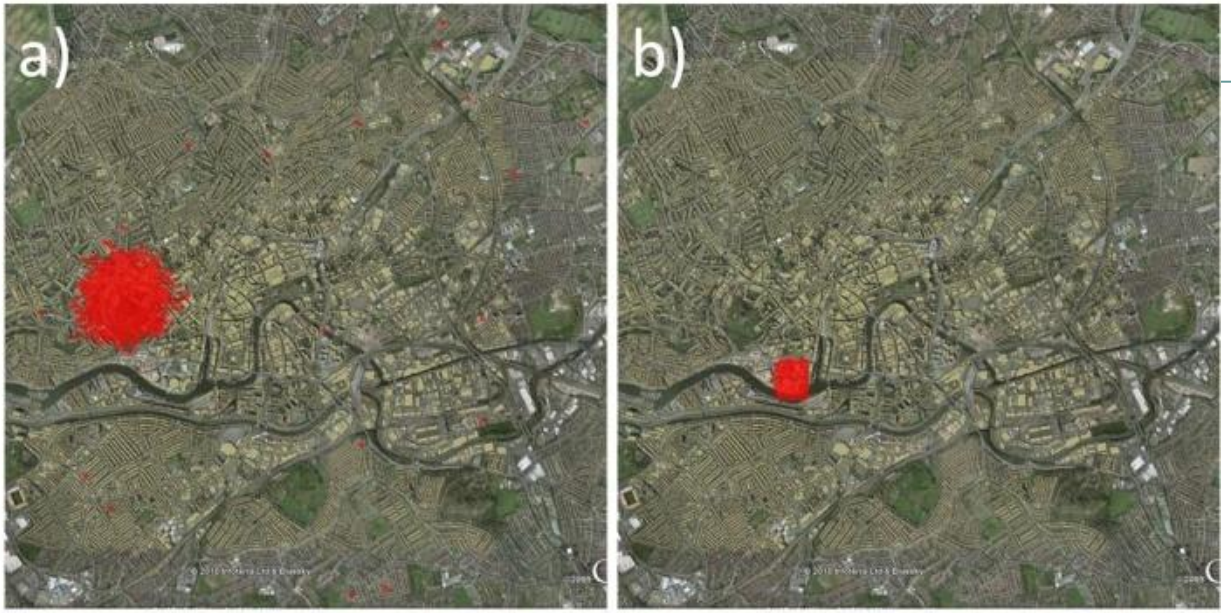


Placement for 1 week – intelligence of attack from insurgents NE of base

Risk aware

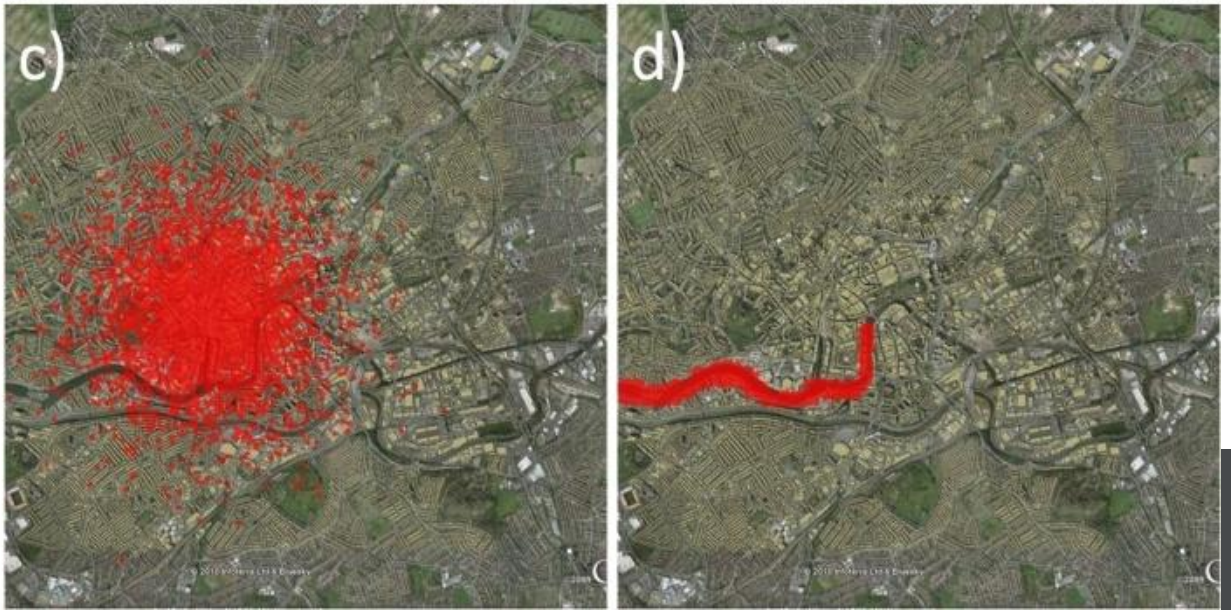
Cases Considered 2: Bristol

Threat to area surrounding key civic buildings



Town square surrounded by offices of telecoms company

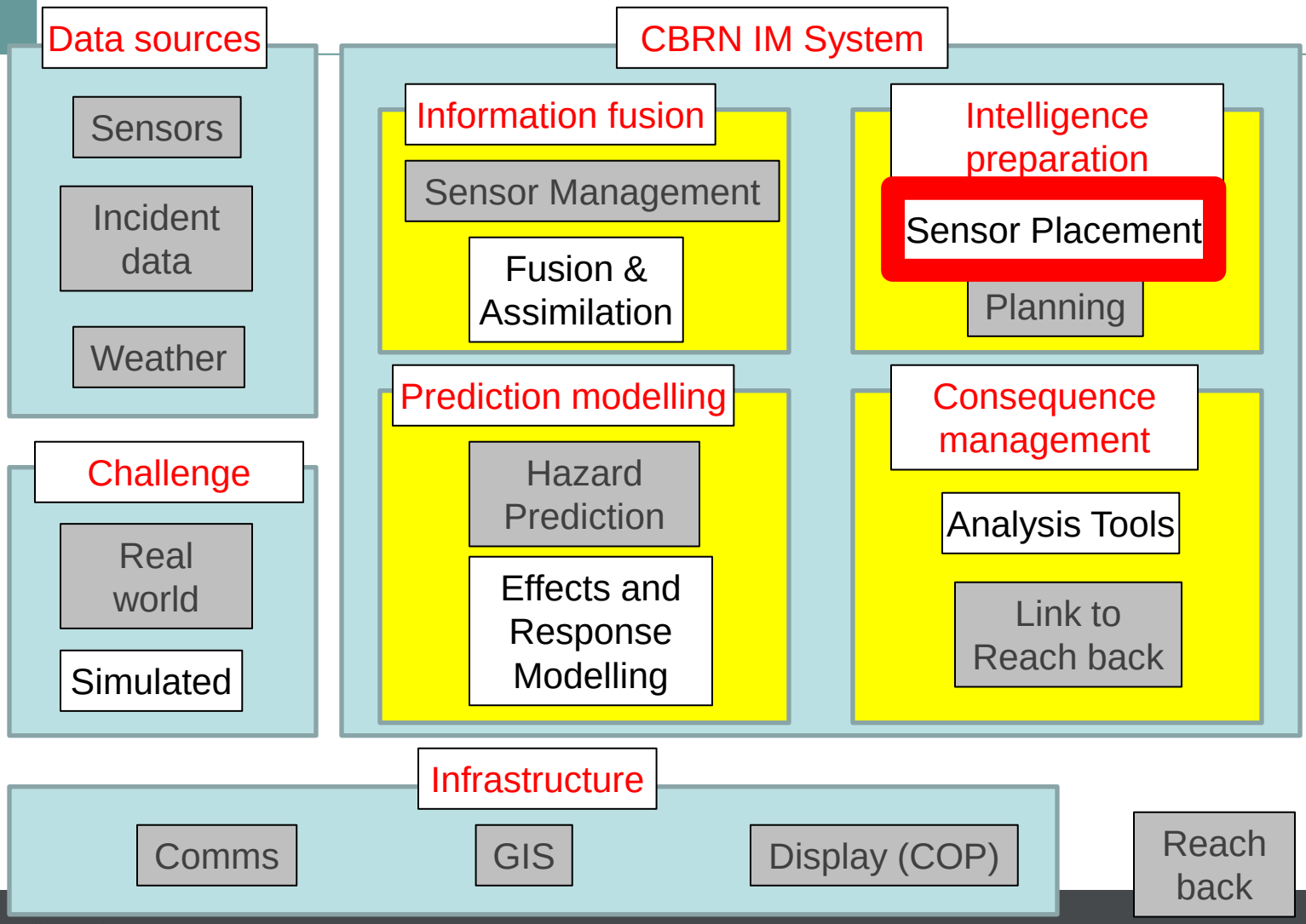
Vague intelligence of threat of release in Bristol



Intelligence report of release from boat on the river

Risk aware

Overview of CBRN IM Systems

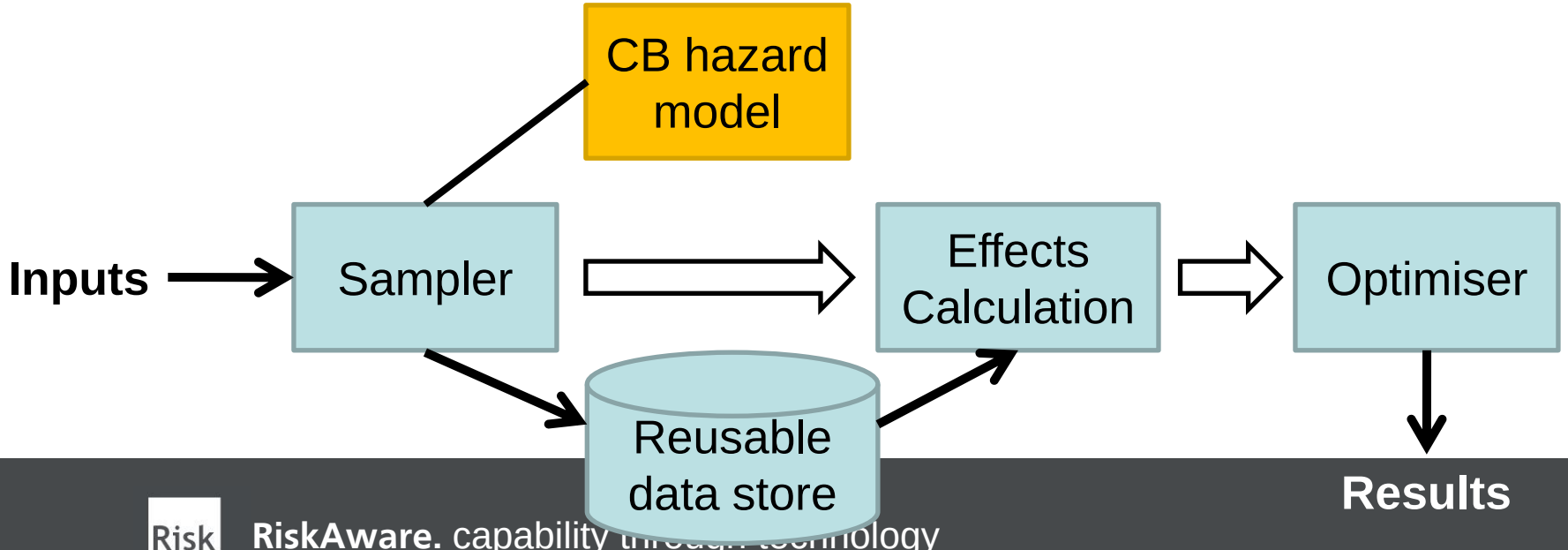


Sensor Placement Aims

- CBRN sensors limited resource & placement needs to provide maximum information for response & protection
- Approaches
  - Automated optimisation
  - Rules based

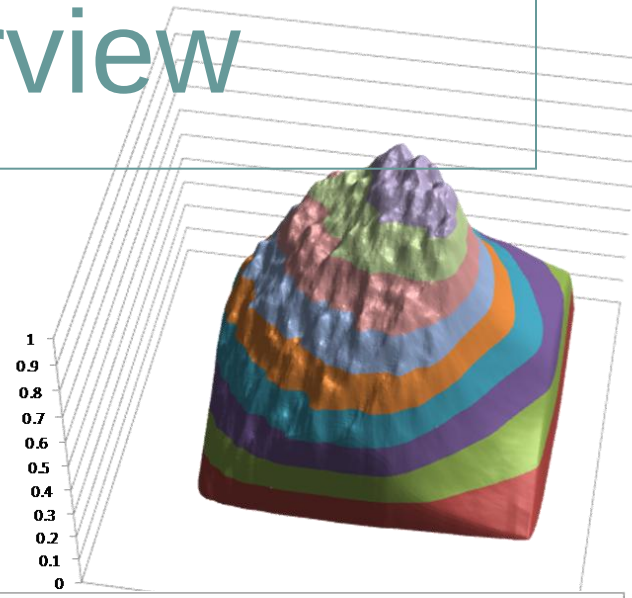
SPARTA Overview

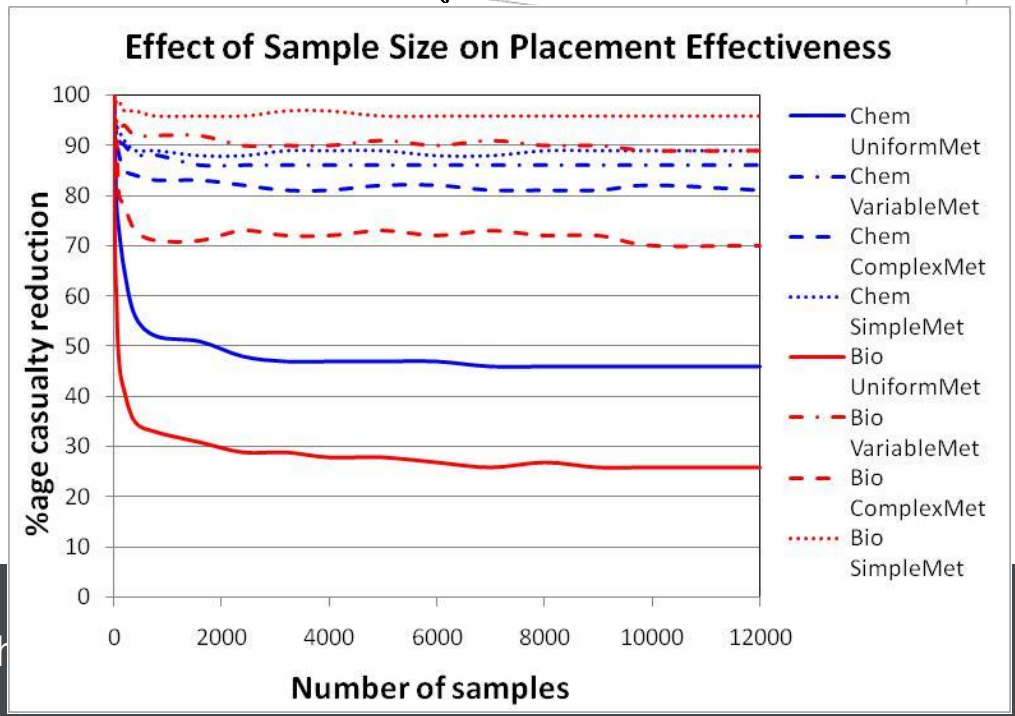
- SPARTA optimises placement to minimise the casualties for described threats
  - Multiple releases considered that match scenario
  - Placements that provide best overall reduction of casualties across all releases selected



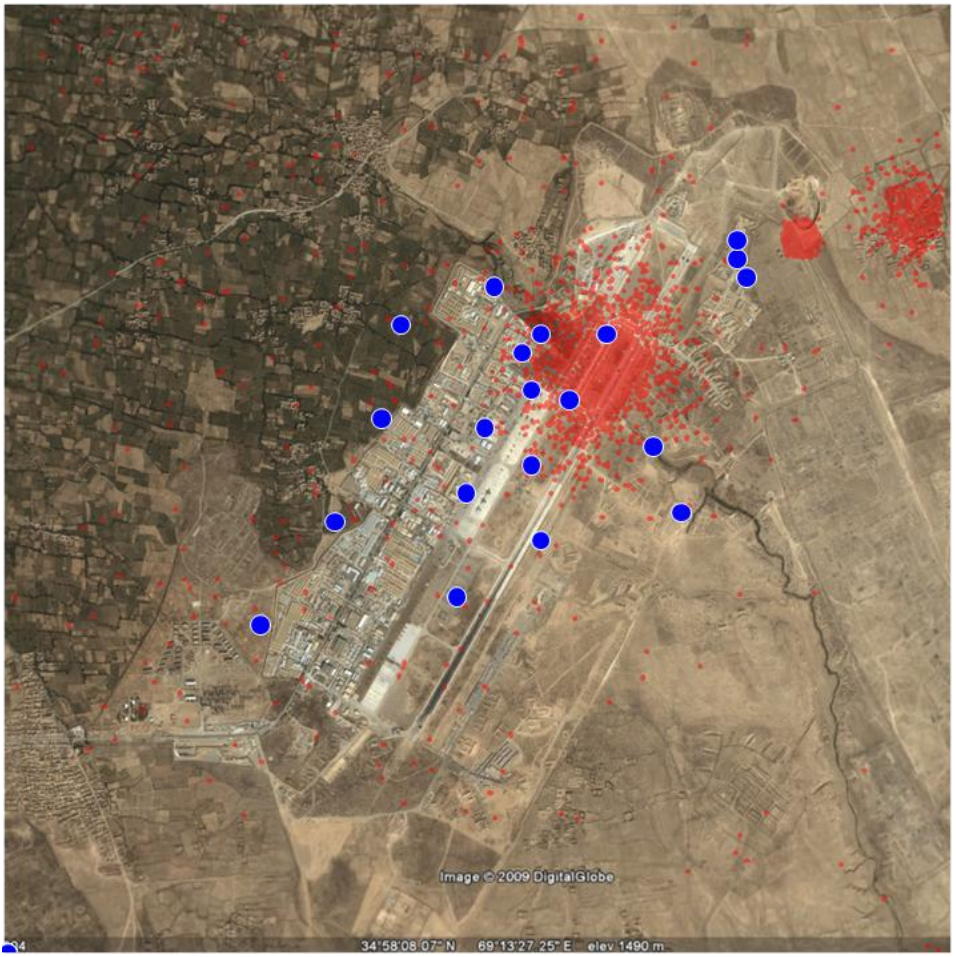
SPARTA Overview

- Analysis has shown
  - 1000 model runs required for simpler scenarios
  - Up to 5000 for complex scenarios
- SPARTA can provide optimal placement in ~10 mins for complex scenarios running on a standard laptop

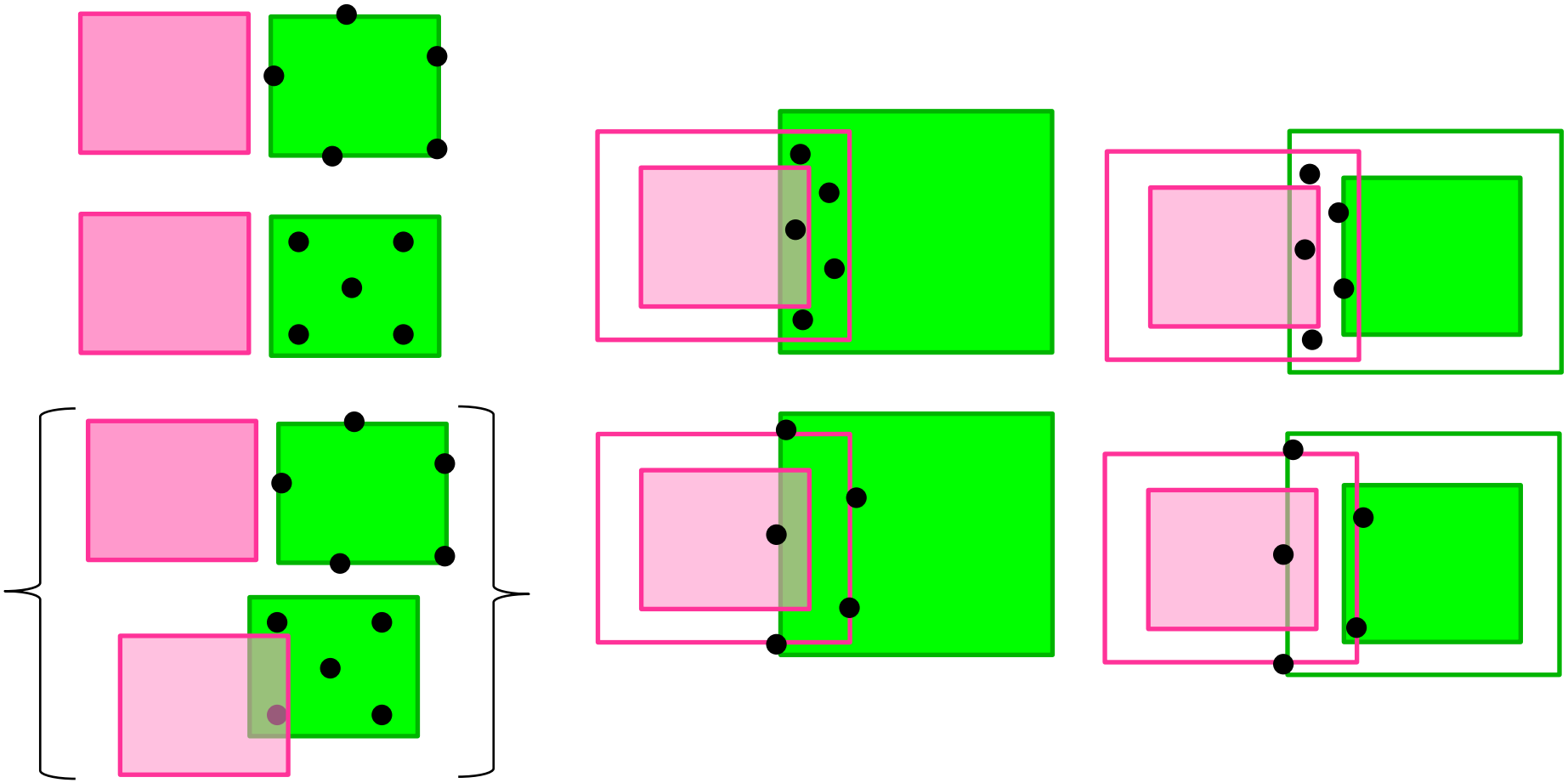




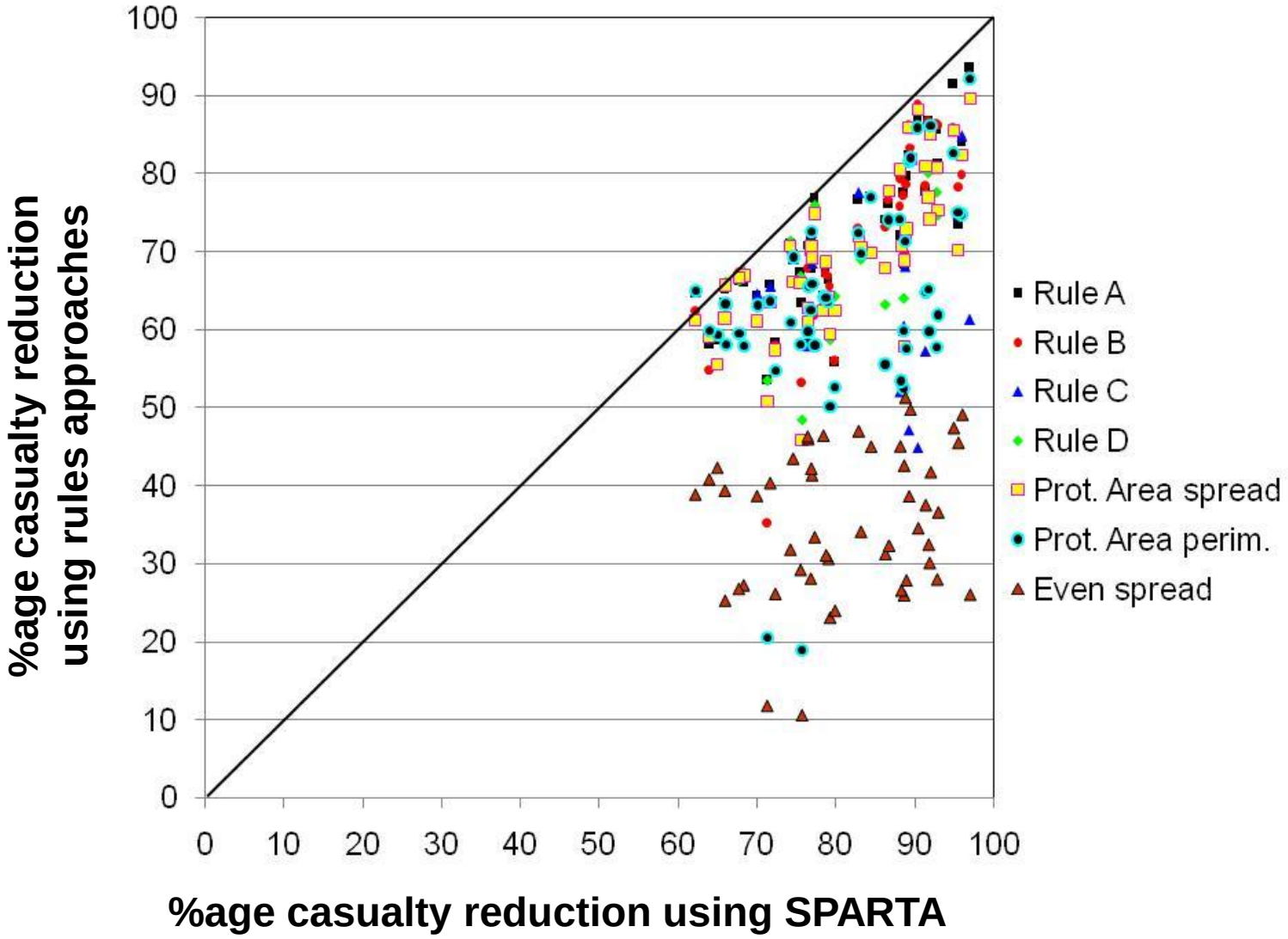
Example Placements



Rules Approaches

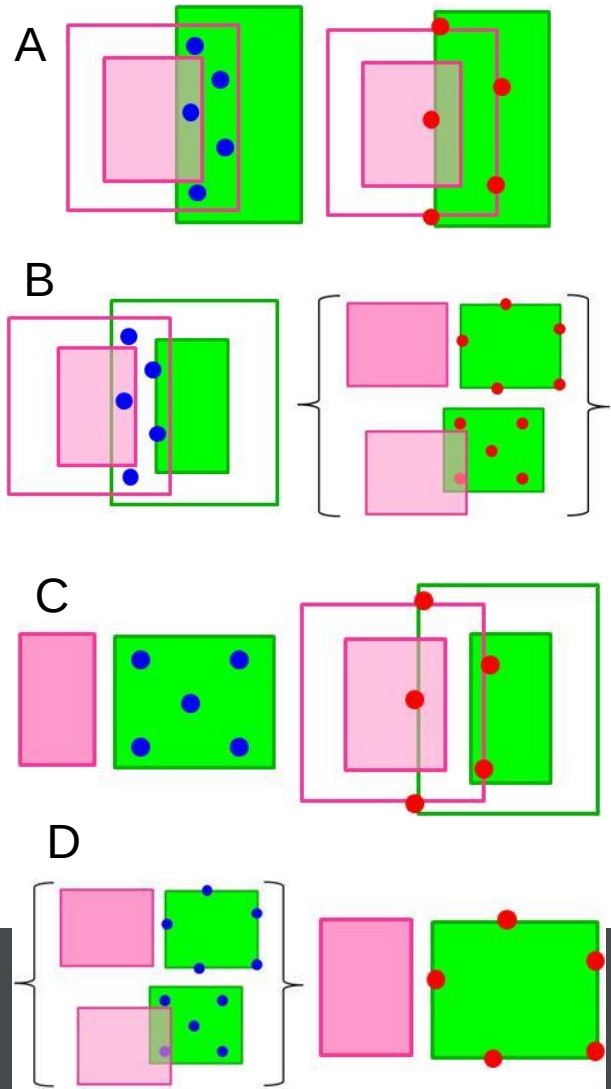


Results of Ensemble Model Challenges

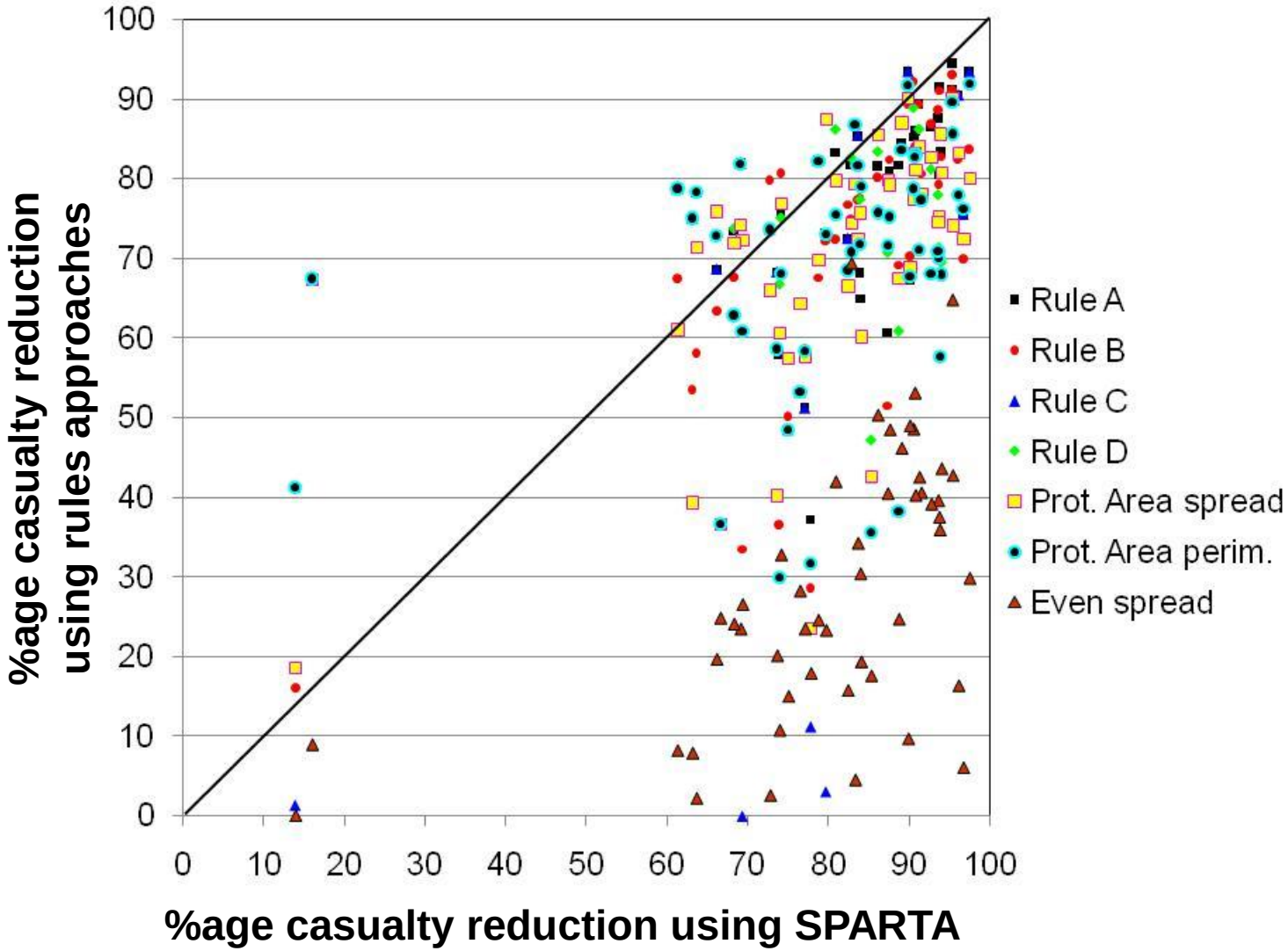


Results of Ensemble Model Challenges

Approach	Average rank for test cases	Total %age casualties saved
SPARTA	1.12	81
Rule A	3.58	72
Rule B	3.84	71
Rule C	3.98	70
Rule D	4.4	69
Spread in protection area	4.6	69
Place evenly around prot. area	5.48	65
Spread evenly across domain	8	36

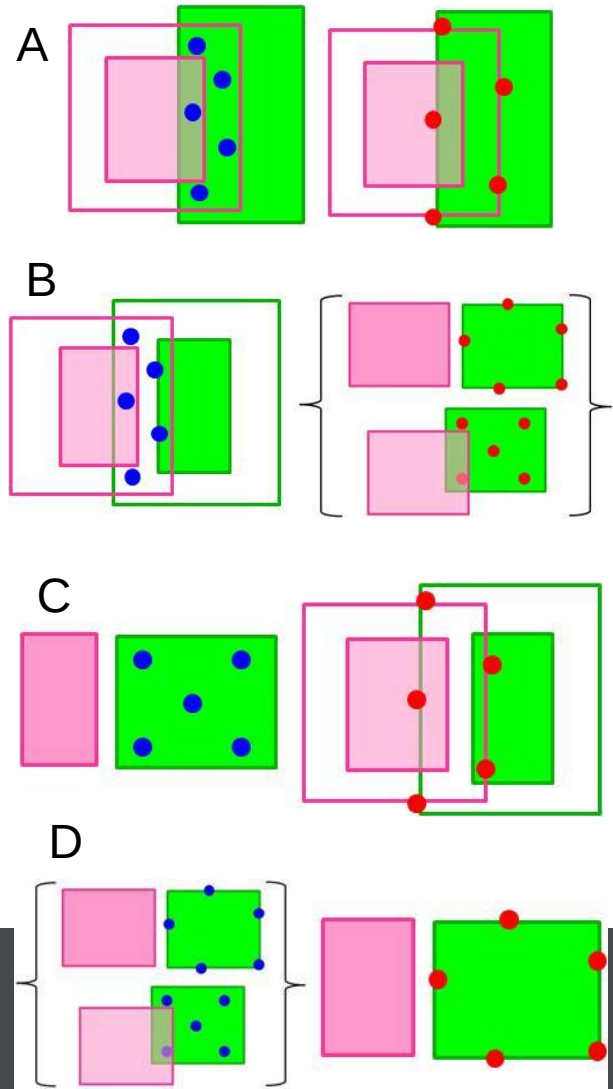


Results of Advanced Model Challenges



Results of Ensemble Model Challenges

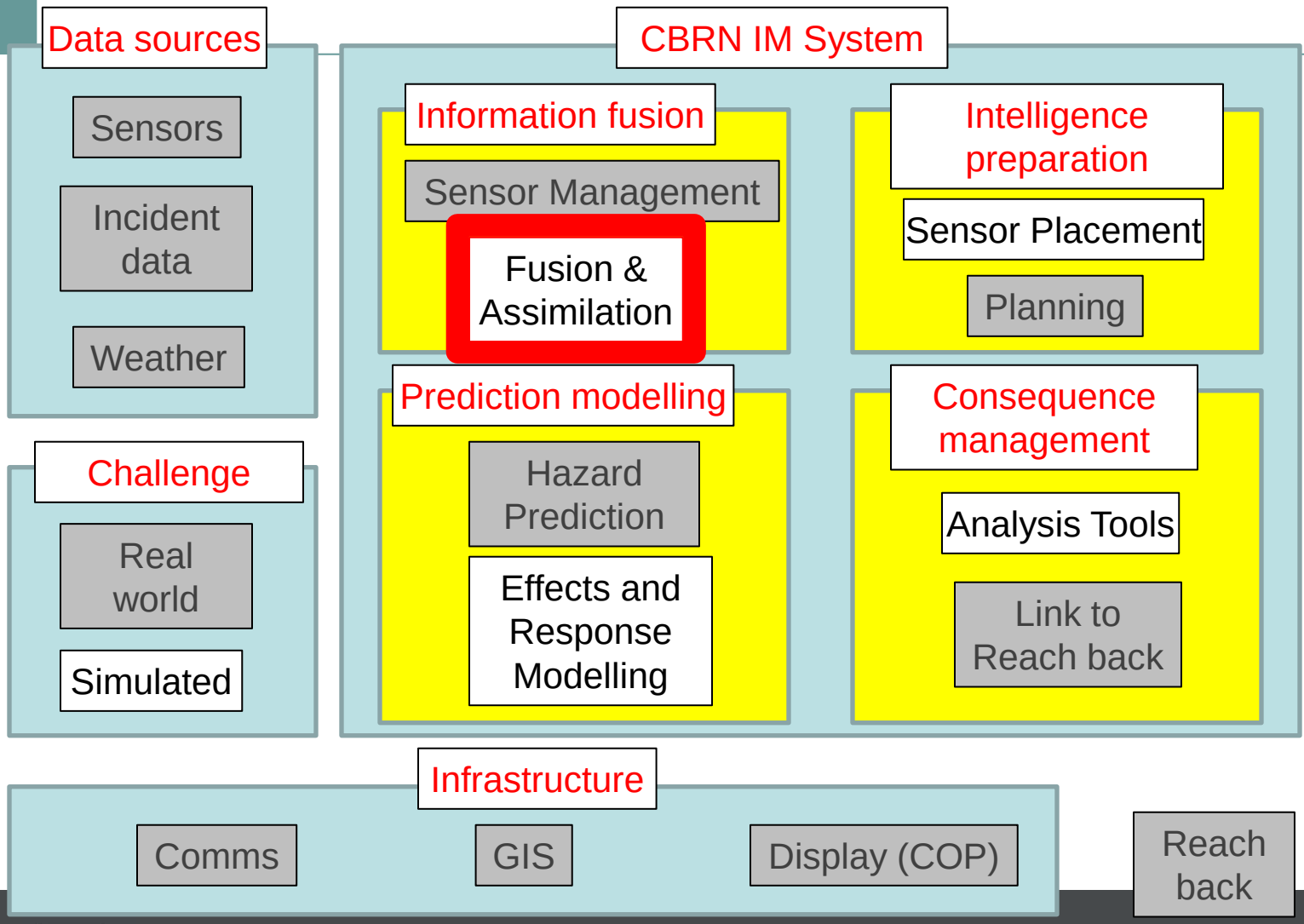
Approach	Average rank for test cases	Total %age casualties saved
SPARTA	2.42	86
Rule A	3.14	79
Rule B	3.98	78
Rule C	3.9	77
Rule D	3.6	77
Spread in protection area	4.52	76
Place evenly around prot. area	4.6	72
Spread evenly across domain	7.92	37



Sensor Placement Benefits

- Sensor placement strategies result in improved protection
  - Major casualty reduction over random placement – ~35% compared to 70%-80%
- Rules can be applied that provide good results
- Automated optimisation approaches provide best results
- Tools such as SPARTA can provide rapid optimal placement
- Decision aids for pre-event planning have merit

Overview of CBRN IM Systems

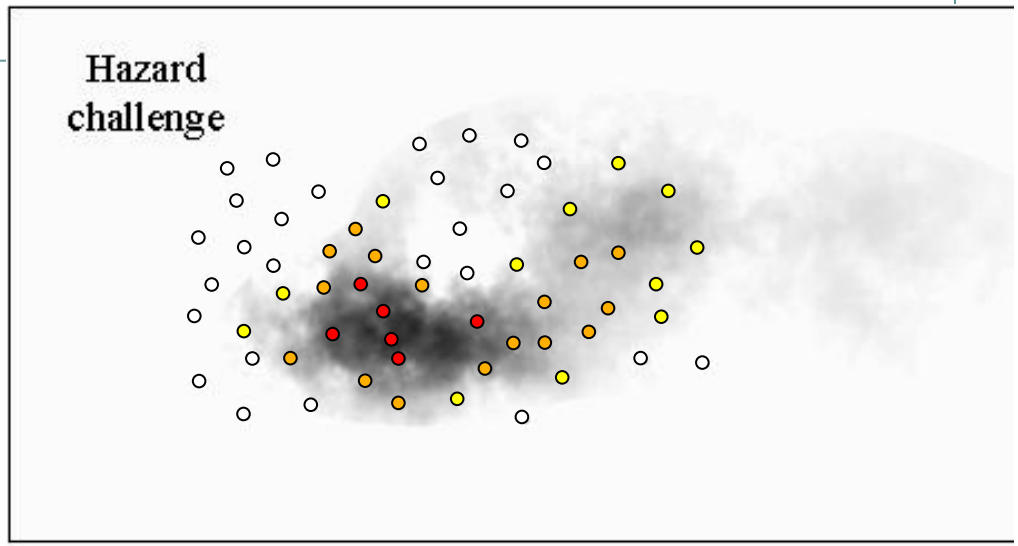


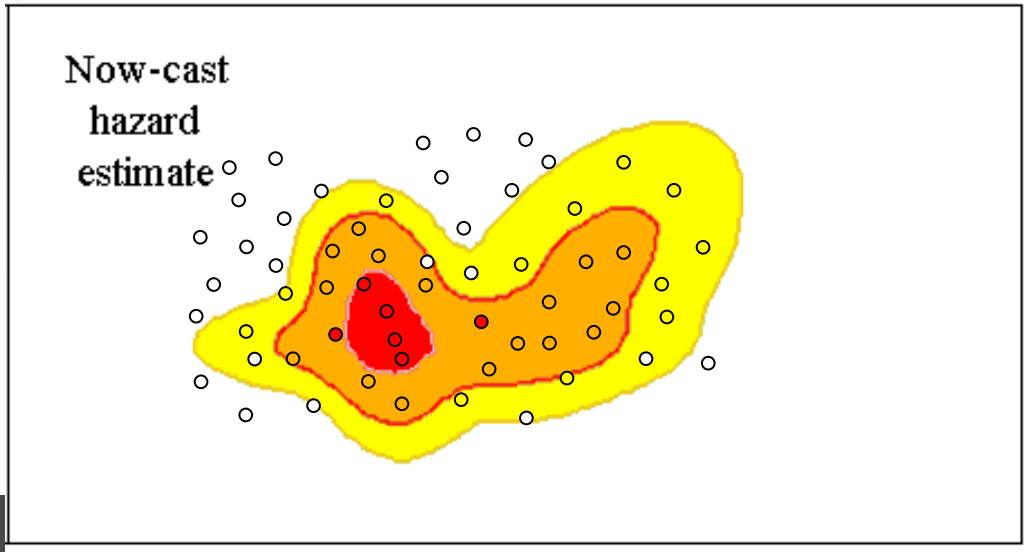
Fusion & Assimilation Aims

- Lack of information on source and met
- Need to exploit any information from deployed CB sensors
- Aim to provide best situation awareness through providing accurate inputs to hazard prediction

Nowcast Assimilation Prototype

- Developed hazard now-casting approach
  - Fits gaussian mixture model to observations using EM algorithm
  - Rapid
  - Dynamically updates
  - Compatible with operational hazard models

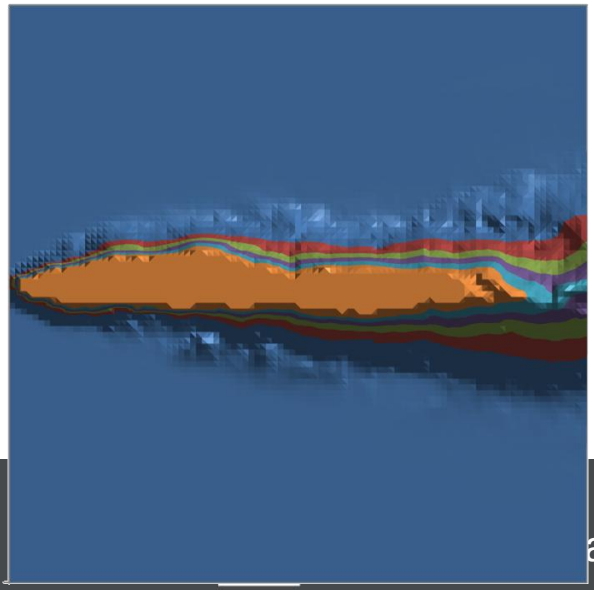




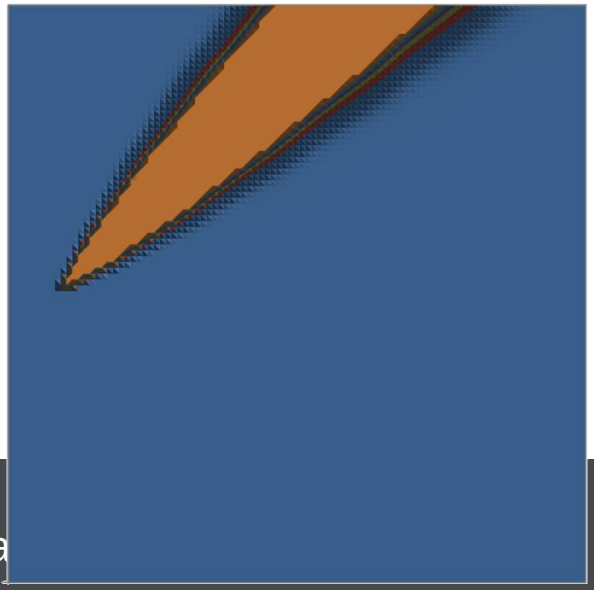
Nowcast Assimilation Prototype

- Estimates wind speed and direction
  - Robust to error in met input
  - Provides local met observation

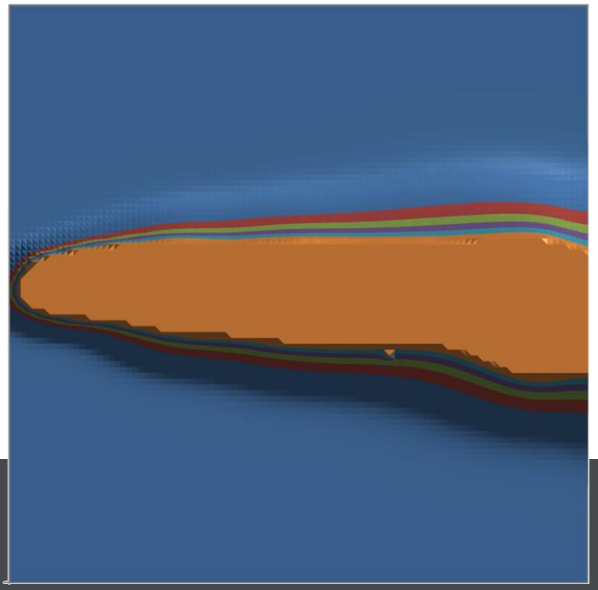
Challenge dosage



Standard modelling using erroneous met

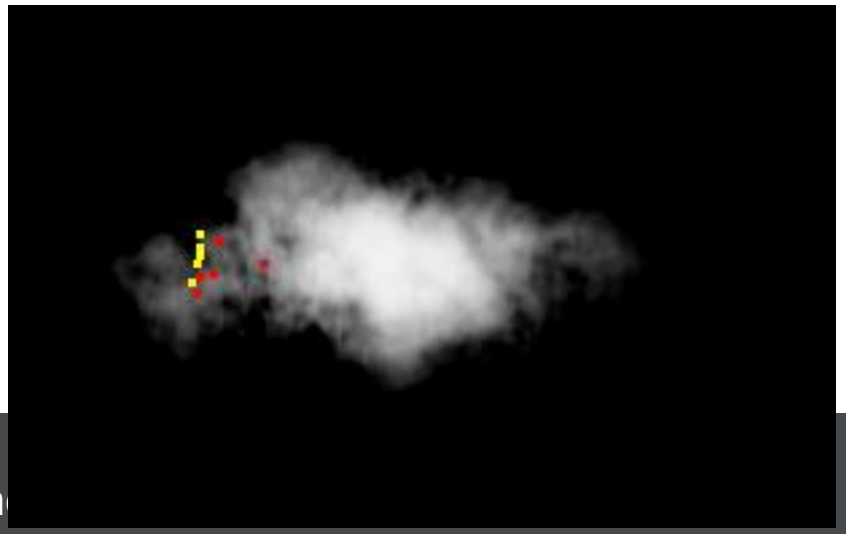


Nowcast total dosage with erroneous met



Evaluation

- Realistic scenarios using Bristol with vignettes sampled from 4 threats and 5 met conditions
- Used high resolution challenge data generated by Evaluation System
- Compared
  - True release
  - Standard doctrine
  - Nowcast

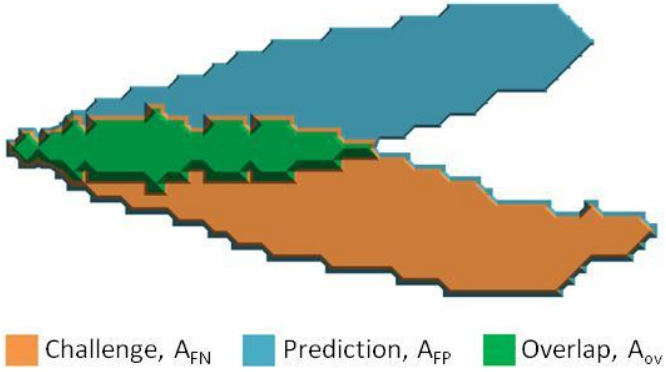


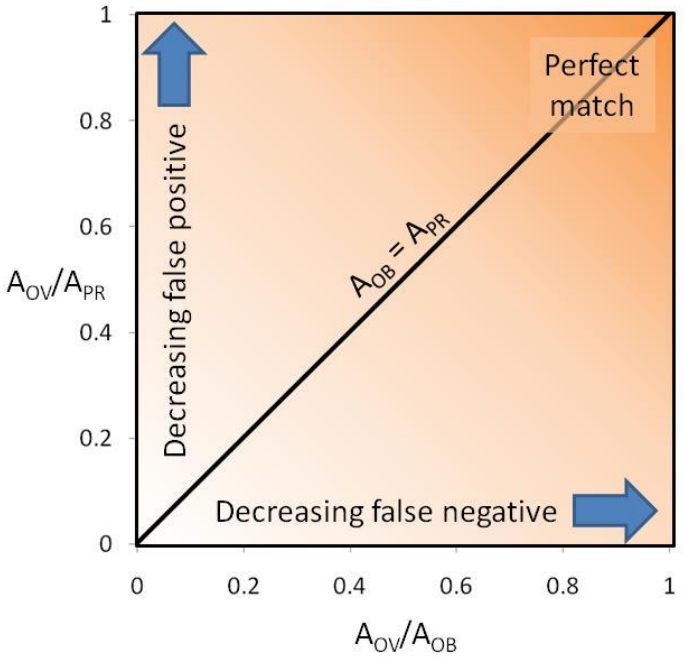
Evaluation

- Calculated dosage for each
- Used MOE metric

$$MOE = \left(\frac{A_{OV}}{A_{OB}}, \frac{A_{OV}}{A_{PR}} \right)$$

  - Ideal for comparing contour levels
  - Thresholded at LCt50

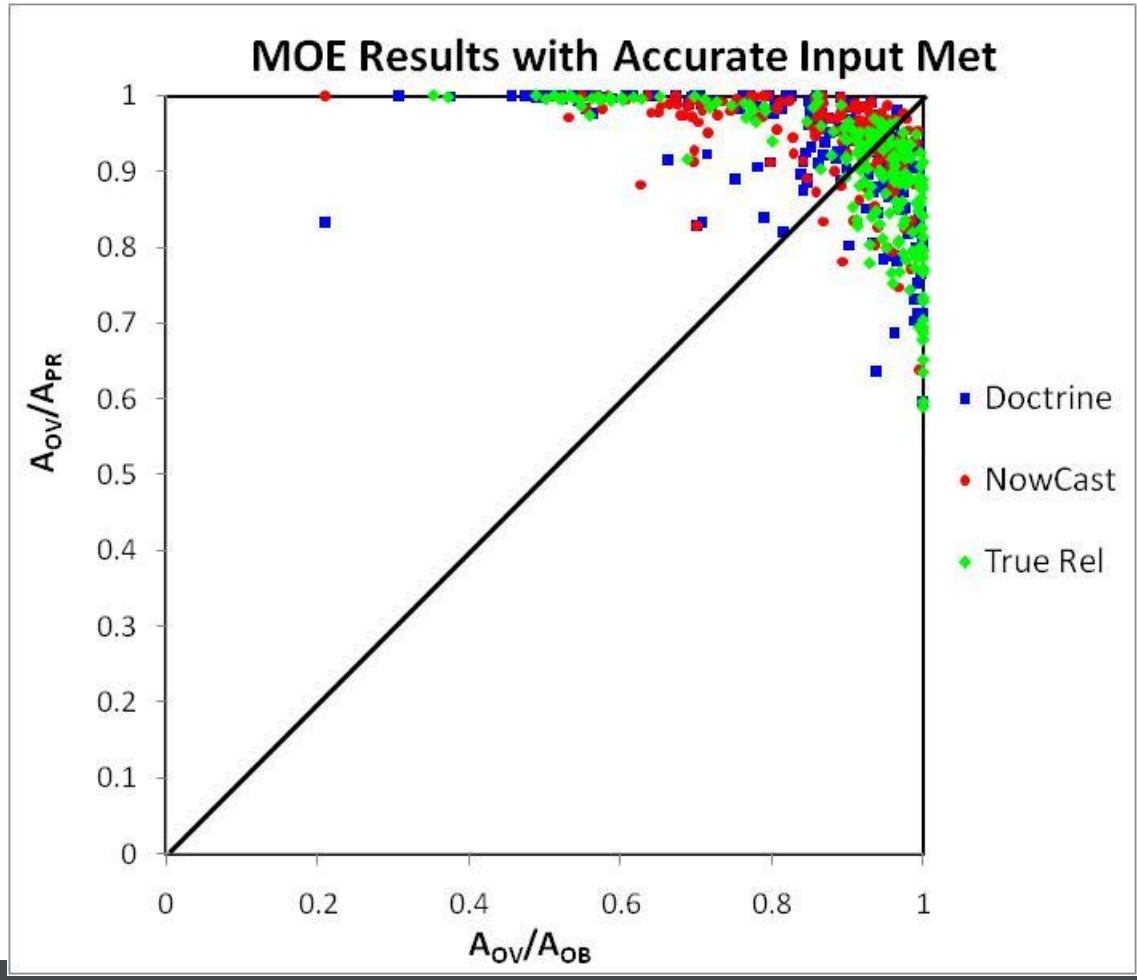




Evaluation Results

- Met provided to all models
- All performed well
  - Nowcast is best

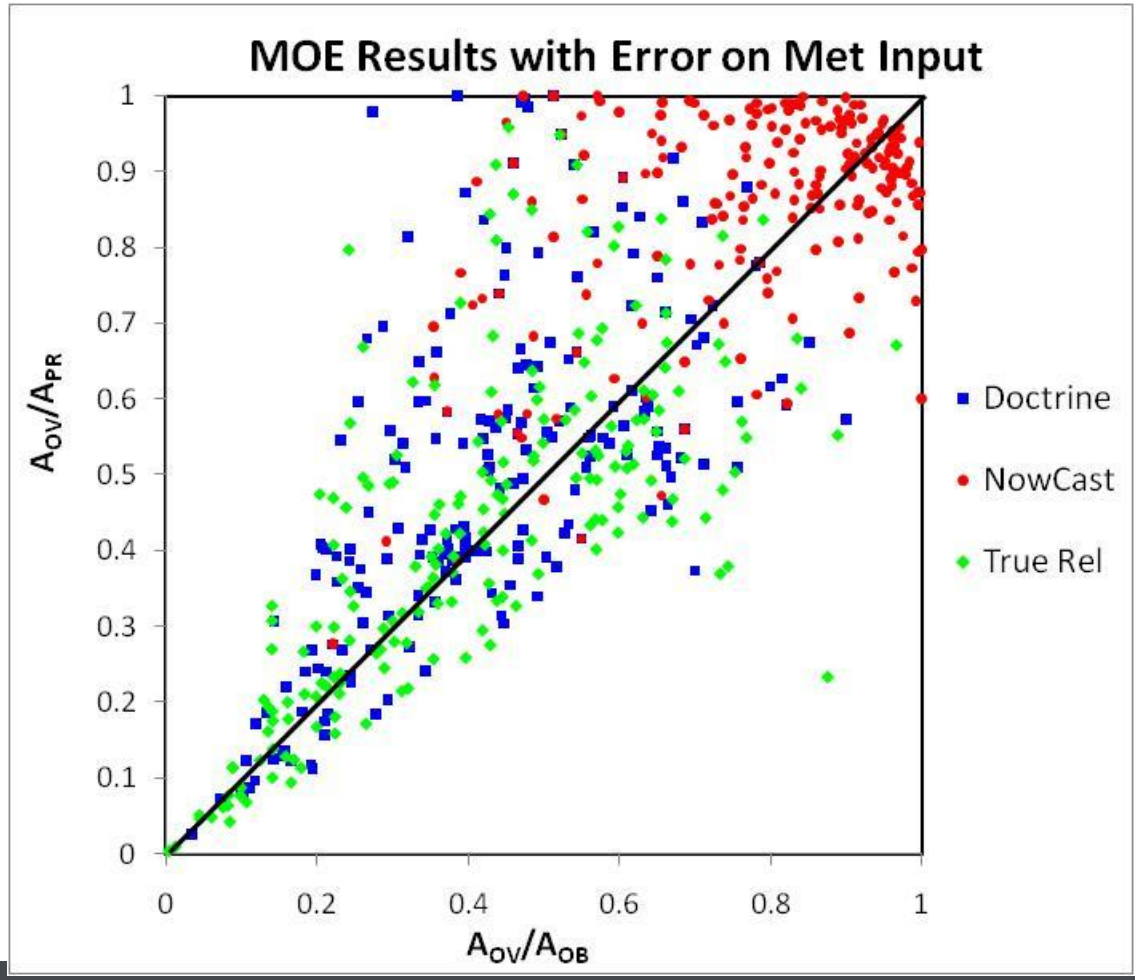
Approach	MOE dist
True Rel	0.196
Doctrine	0.216
Nowcast	0.166



Evaluation Results

- Met error included in input to models
  - 10^{o}-30^{o}
- Performance worse for all
- Nowcast significantly better
  - Handles incorrect met

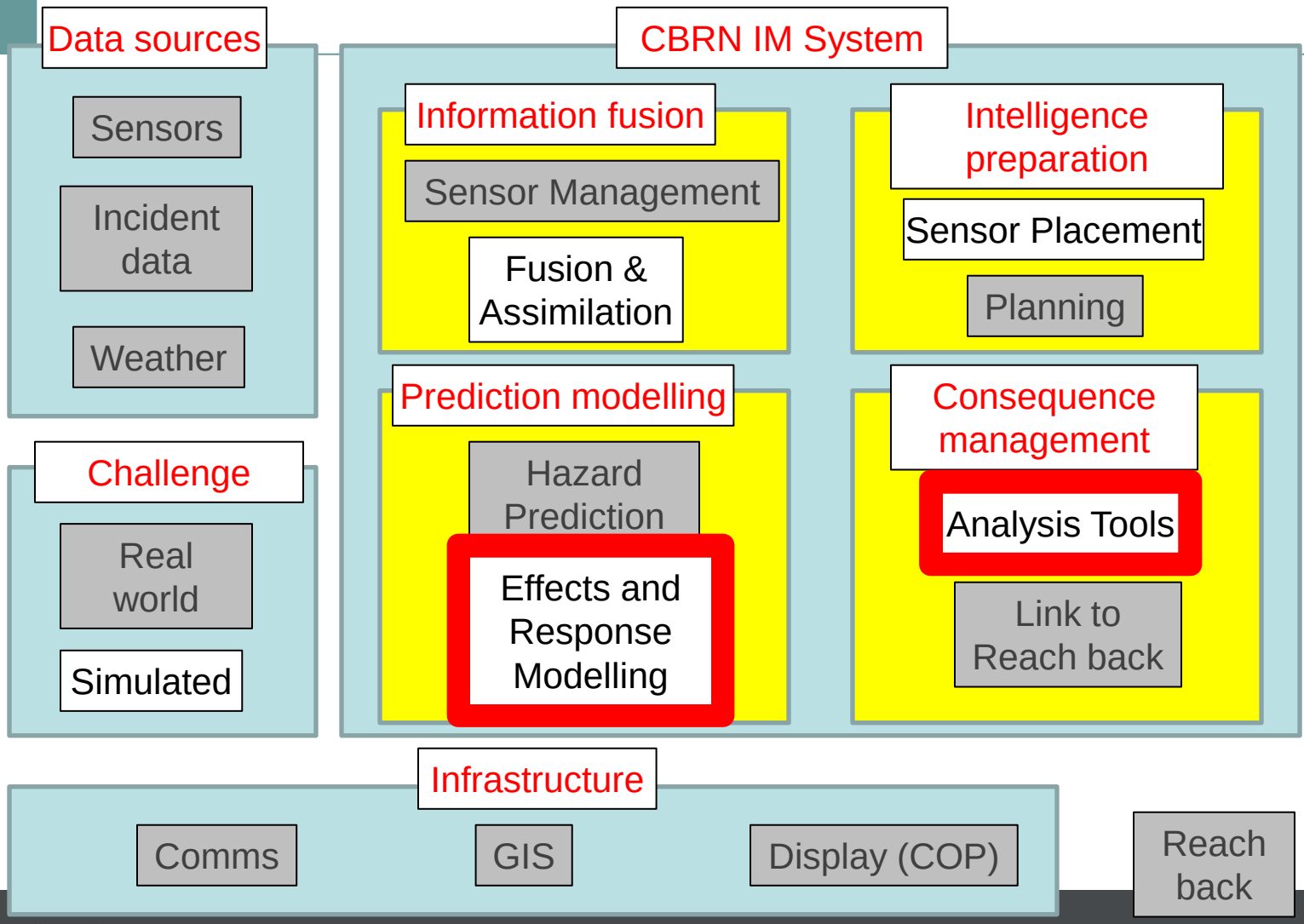
Approach	MOE dist
True Rel	0.831
Doctrine	0.771
Nowcast	0.278



Fusion & Assimilation Benefits

- Can lead to improved hazard prediction
  - Nowcast provides better situational awareness than doctrinal approach and even modelled releases from true source
- Can estimate other useful parameters such as meteorology

Overview of CBRN IM Systems



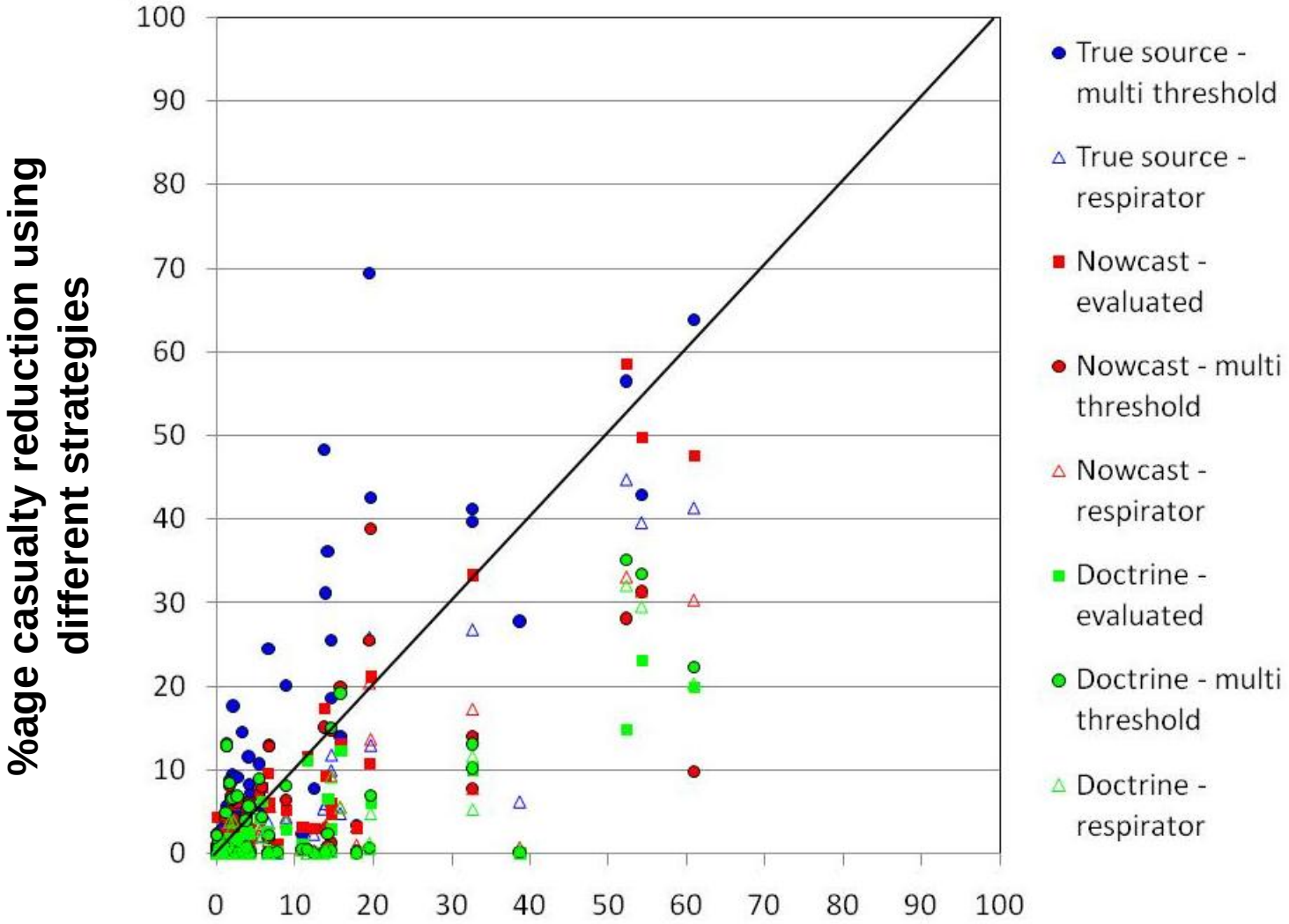
Aids for Response Decision Making

- What are the benefits of data assimilation and improved hazard prediction?
- Can we provide automated real-time tools to help decision making for the optimal response?

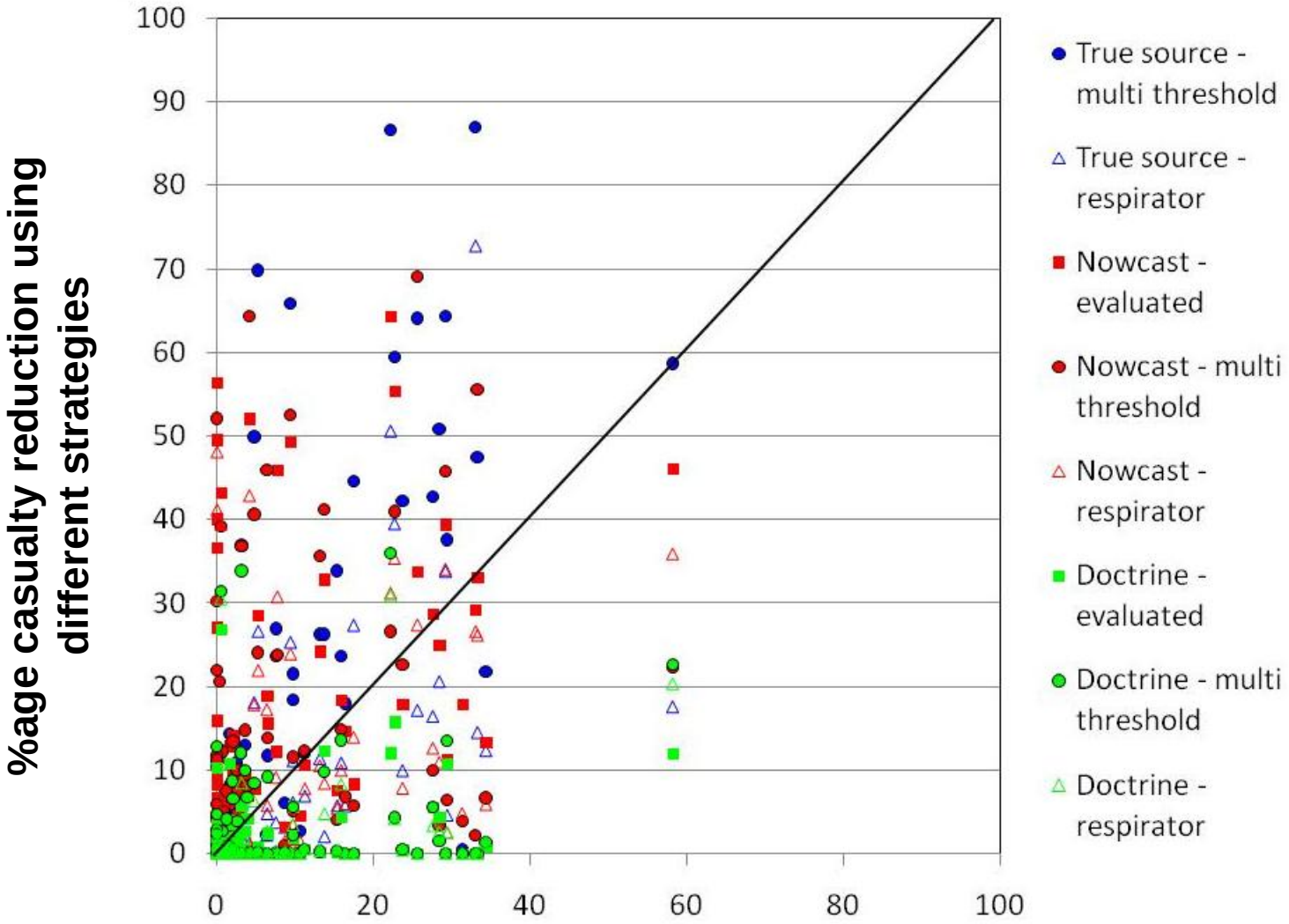
Aids for Response Decision Making

- Modelled effects of different response strategies
- Used Bagram scenario
- Compared
  - True source, doctrine, Nowcast
  - With and without input met error

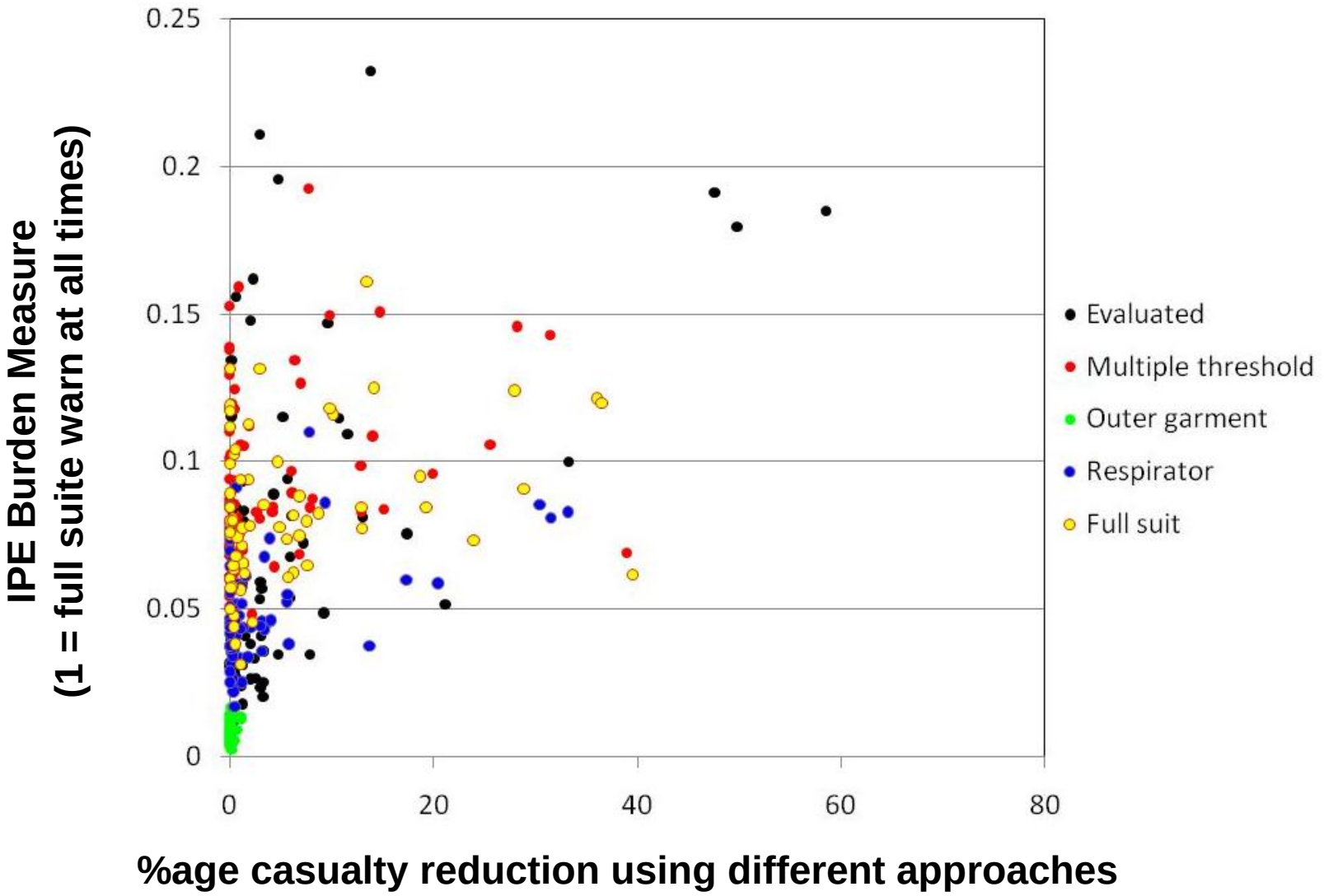
Comparison of Response Strategies – with Accurate Met Input



Comparison of Response Strategies – with Inaccurate Met Input



Comparison of Response Strategies and IPE burden for Nowcast



Comparison of Response Strategies and IPE burden for Nowcast

Strategy	Total Casualties Saved	Average IPE Burden Measure
Evaluated response	2335	0.073
Multiple threshold	1530	0.092
Outer garment	50	0.008
Respirator	1382	0.050
Full suit	2089	0.082

- In this case evaluated response performs the best

Aids for Response Decision Making Results

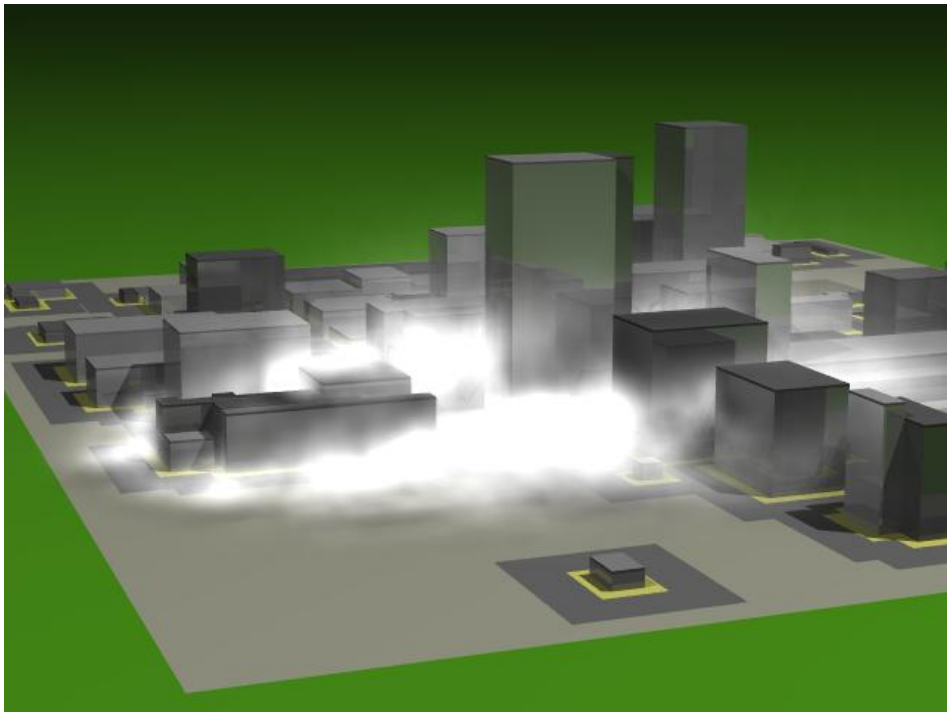
- Strategies applied can make a difference
  - Casualties sometimes reduced by >25%
- Only simple ones so far considered
- Automatic evaluation of different response can provide some benefit
- More work required

Summary

- Considered range of key elements in CB IM
- Implemented as prototypes within PRIME
- Evaluated using realistic challenge
- Decision aids considered show benefit
  - Casualty reduction
  - Potential to lead to improved operational performance
- Suggests CBRN IM can improve situational awareness and aid decision making
- Have demonstrated prototype capability for studying complex effects

Future Ideas

- Enhance and optimise components within PRIME
- Evaluate in more detail
- Consider interaction between them
- Further quantify benefits
- Extend to urban



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