



2015 NATO OR&A Conference

# **Operations Research & Analysis 2025: What are the roots and where do we go next**

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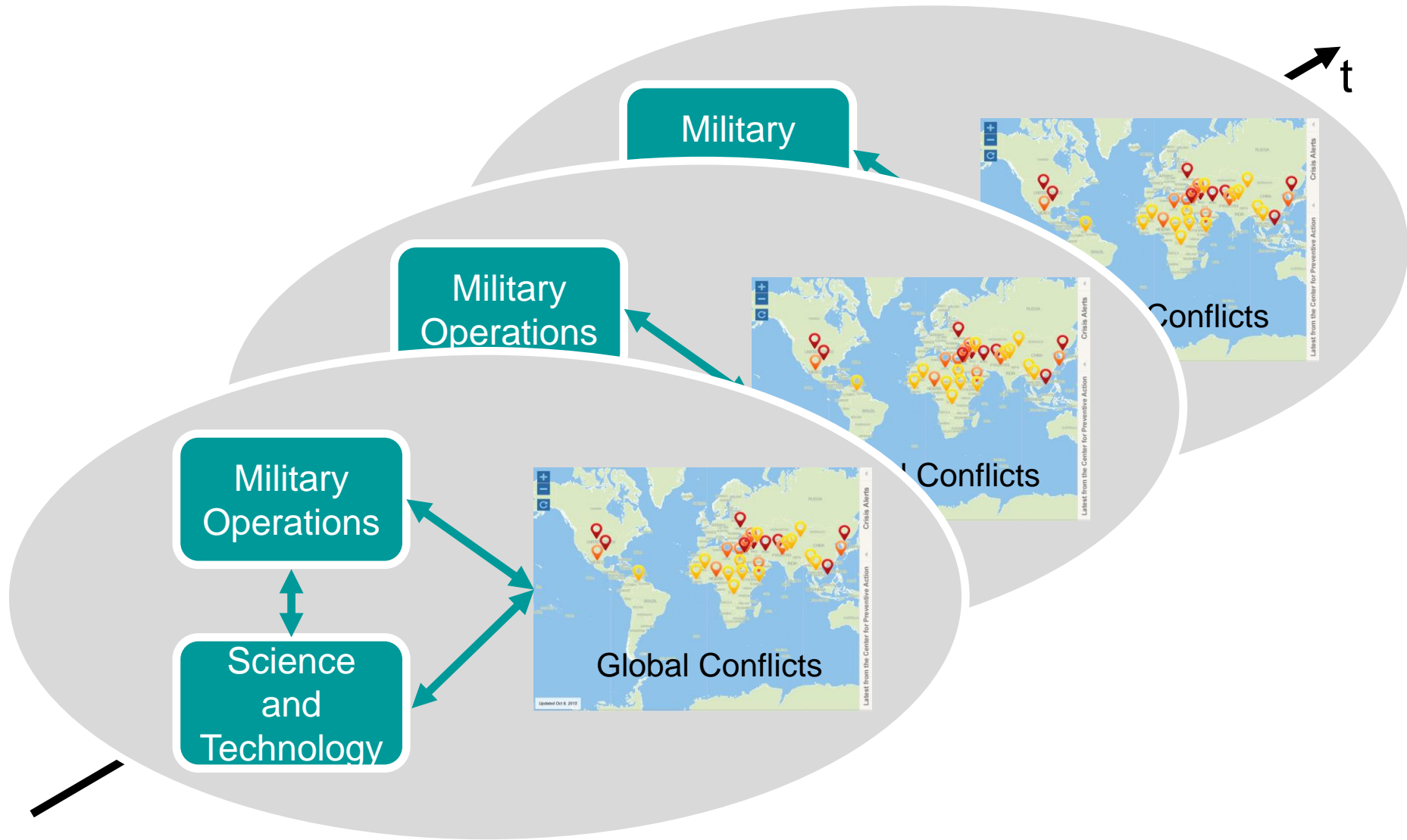
This presentation uses examples of OR&A based on the experience the author made working in the area of OR&A since 1979. It is not a history of OR&A.

The presentation follows the principles of a Long-Term Scientific Study (LTSS), but there is no “NATO LTSS on OR&A”.

The presentation is based on personal experience and doesn't represent any official position.

- LTSS Description
- OR&A Roots
- OR&A over time
  - 1979 – 1985 – 1992 – 2003 - 2015
- Where do we go next
  - Future OR&A science and technology developments/trends
  - Future operational military requirements
- Summary

- An LTSS assesses the **impact on military operations** that might be expected to come from **developments in science and technology** over both the medium and long term (typically 10-20 years).
- This would include how emerging technologies, systems and methods may affect tactical concepts and doctrines.
- Reciprocally, recommendations could be provided on how the evolution of the military doctrine should influence the Science and Technology priorities.



- Operational research is a discipline that deals with the **application of advanced analytical methods to help make better decisions.**
- Techniques from **mathematical sciences**, draws on **psychology** and **organization science.**

- Assignment problem
- Decision analysis
- Dynamic programming
- Inventory theory
- Linear programming
- Mathematical optimization
- Optimal maintenance
- Queueing theory
- Real options analysis
- Stochastic processes
- Systems analysis
- Systems thinking

- Behavioral operations research
- Big data
- Business engineering
- Business process management
- Database normalization
- Econometrics
- Geographic information system
- Industrial engineering
- Industrial organization
- Management engineering
- Managerial economics
- Military simulation
- Modeling and simulation
- Reliability engineering
- Scientific management
- Search-based software engineering
- Simulation
- System dynamics
- System safety
- Systems theory
- Wargaming



- Computing and information technologies
- Environment, energy, and natural resources
- Financial Engineering
- Manufacturing, service science, and supply chain management
- Marketing Science
- Optimization
- Policy modeling and public sector work
- Revenue management
- Simulation
- Stochastic models
- Transportation

- Analysis of Air Defence Systems  
(Part of my OR Master studies)
- Kalman Filter, Computer Simulation, Multi-criteria utility approach, lifetime cost analysis
- Cold war scenario

- Science and Technology
  - Simulation Systems would emerge in the following years allowing more complex scenarios
  - User interface would be much better
  - Computer power would allow more runs for analysis with better results
- Military
  - Design of integrated defence systems
  - Analysis of defence scenarios

- The NATO Defence Planning Process (NDPP) needs especially for a capability based approach a strong OR&A support in analysing options and giving decision support for different possible scenarios
- This is one of the roots of OR&A and should not be neglected

- Comparison of a conventional pre-compiler based approach for Human Behaviour Representation to support military planning with Expert Systems (Doctors degree)
- Formal Language, LISP, expert systems (KEE), planning of composite air operations (COMAO) and higher level planning (ATAF level)
- Cold war scenario

- Science and Technology
  - Expert Systems will be the ideal planning assistant in military operations
  - Personal Computer with intuitive user interfaces will support military staffs in planning and execution of missions
- Military
  - Science should spend more effort in computer hardware and intuitive user interfaces
  - Better understanding of military planning and implementation

- Slow down of "Star Wars" missile defense program – DARPA
- Artificial Intelligence (AI) Winter
- But after that new developments in the direction of intelligent systems

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**MLB WILD CARD**  
**Astros get in thanks to Rangers**  
Rivals beat Angels to give Houston a playoff berth.  
**IN SPORTS**

AP/WIDE WORLD

## Bernanke: More execs should have been jailed

Ex-Fed chief defends recession steps, won't second-guess Yellen



WASHINGTON This season, Ben Bernanke was able to sit through an entire National game. During the financial meltdown in 2008, the then-chairman of the Federal Reserve would buy a lens and head to his seats two rows back from the Washington Nationals dugout. But often he would find himself huddling in the quiet of the stadium's first-aid station or an empty stairwell for

**NOW SHOWING AT USATODAY.COM**  
Watch the full interview with Ben Bernanke.

consultations on his BlackBerry about whatever economic catastrophe was looming.

"I think there was a reasonable



WIDE WORLD USA TODAY BY STEVE GRANITZ  
Ex-Fed Chairman Ben Bernanke says some 2008 data in his 2014 memoirs is a lie.

ization of the financial system, that we could have gone into a 1930s-style depression," he says now in an interview with USA TODAY. "The panic that hit us was enormous — I think the worst in U.S. history."

With publication of his memoir, *The Courage to Act*, on Tuesday by W.W. Norton & Co., Bernanke has some thoughts about what went right and what went wrong.

For one thing, he says that more corporate executives should have gone to jail for their misdeeds. The Justice Department

and other law enforcement agencies focused on indicting or threatening to indict financial firms, he notes, "but it would have been my preference to have more investigation of individual action, since obviously everything that went wrong or was illegal was done by some individual, not by an abstract firm."

He also offers a stilled rebuttal to critics who argue the government could and should have done more to rescue Lehman Brothers from bankruptcy in the

► STORY CONTINUES ON 22

NEWSLINE

**IN NEWS**

**Supreme Court faces rulings on race, lab or again**  
Justices are likely to consider "contraceptive mandate" for second time in three years.

**Company warns against having sex with robots**  
Human aid machine designed to understand feelings, emotion.

## 1,000-YEAR STORM SLAMS S.C.



**'Mind-boggling rain' forces curfew and evacuations**

John Hancock  
USA TODAY

South Carolina's weather disaster intensified Sunday as "historic" rain fell up to 2 feet in some areas, combined with high winds to strand motorists and residents and force hundreds of evacuations and rescues.

The rain was forecast to continue down into Monday in some





- Autonomous robotic systems are further developed
- Man-Machine Teaming is a relevant issue
- Ethics is a main issue

- German Concept for CAX and LTSS on CAX bringing simulation in the operational command and control environment and tools for exercise preparation
- Multinational Working Group to combine simulations from different nations in a coalition using ALSP (precursor of HLA)
- Scenario change from cold war but still symmetric (Bosnia and Gulf War)

- CAX established in NATO and nations as own method besides OR&A (JWC and JFTC)
- Science and technology forecast and demands of the LTSS on CAX were very accurate (e.g. modular systems)

- NC3A Project Leader for OA Support to Operations Planning (from GOP to COPD)
- Change of a symmetric scenario (Atlantis) to asymmetric warfare (Zoran Sea Crisis)
- OA support with Transport Feasibility Estimation (TFE), Land, Air, Maritime Battle Assessment (LAMBDA/GAMMA) and Comprehensive (ZETA)
- OA Branch in Command Group with A5 Lead OA

- Science and Technology
  - System Dynamics offering new opportunities to model the comprehensive approach
  - Better optimization of the transport problem and other typical planning problems (e.g air to air tanker planning)
- Military
  - Comprehensive Approach
  - System Thinking

- SAS-089, SAS-098 and SAS-101 Study on OA to support NATO Operations
  - This study series tried to show the benefits OA could provide to military operations and how to establish an environment supporting it
  - No OA Courses at NATO School after prototype course
- With NATO reorganization of HQs changes to OA structure
  - OA from Command Group to Ops Assessment (JFC level)
  - Ops Assessment will change over time with new mission

If we would do an LTSS on OR&A now in 2015  
what would be the results?

- Big Data as next hype
  - Data is in general available in many different kinds and has to be analysed and evaluated for operational questions, but the relevance of the data is questionable
  - During operations data collection and evaluation is essential and has to be assured in the new environment
- Data Farming
  - Data farming based on simulation methods provides input for analysis of different fields like cyber defence, but is limited to what is covered in the underlying models



- Man-Machine-Teaming
  - In the future more autonomous robotic systems will be available
  - Interfaces between autonomous robotic systems and end users will be crucial
  - Training will be an important issue
- Ops Planning Support
  - Tools and technologies from commercial applications
- Comprehensive Approach
  - Better understanding of system relationships and modelling of the impact of actions

- Strategic level foresight and planning is essential in dealing with crises
  - Forecast of potential crises and possible reactions is essential
  - Risk assessment plays a major role in dealing with possible crises
- Overall force structuring to meet accepted levels of threat is crucial
  - Assessment based on the NATO level of ambition using OR&A tools

- Education and Training
  - Introduction into OR&A and training of staff how to use OR&A as a service done by practitioners with experience from missions
  - Courses on OR&A to military staff members with scientific background done by practitioners with experience from missions
- Integration of OR&A into HQ structure
  - OR&A should be integrated into operational planning and operations assessment

- Strengthen OR&A for the NATO Defence Planning Process (NDPP) especially in the area of the comprehensive approach
- Develop better support systems for classical applications of OR&A like air to air refuelling, transport feasibility estimation etc.
- Be careful with Big Data, Architectures and Data Farming, the commercial world is already rethinking its influence
- Accept that some OR&A application is now taken by staff officers and is not an OA function any more
- Do the training of staff officers in working with OR&A by practitioners and not by scientific personal who never has been in the field

# Questions?

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