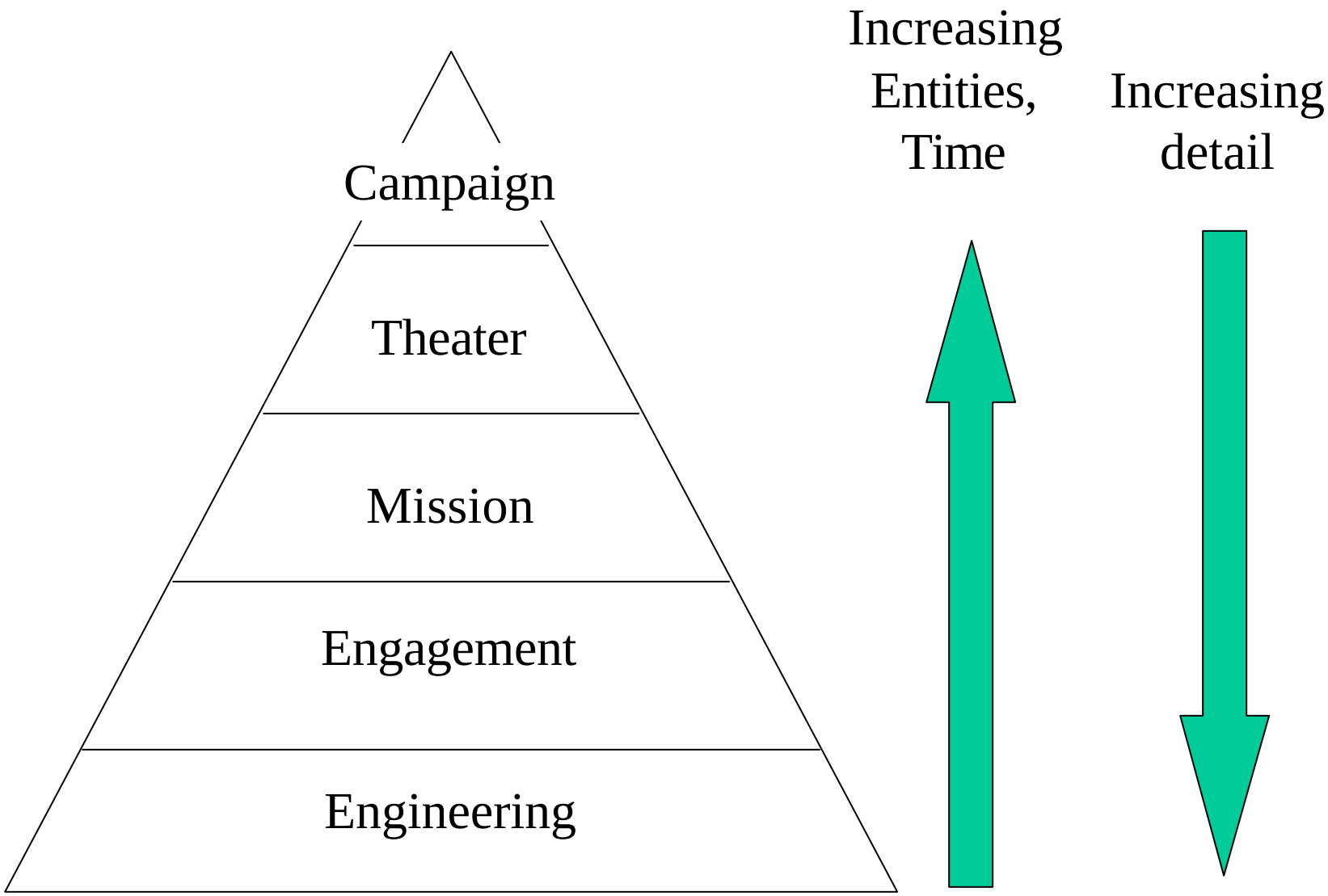
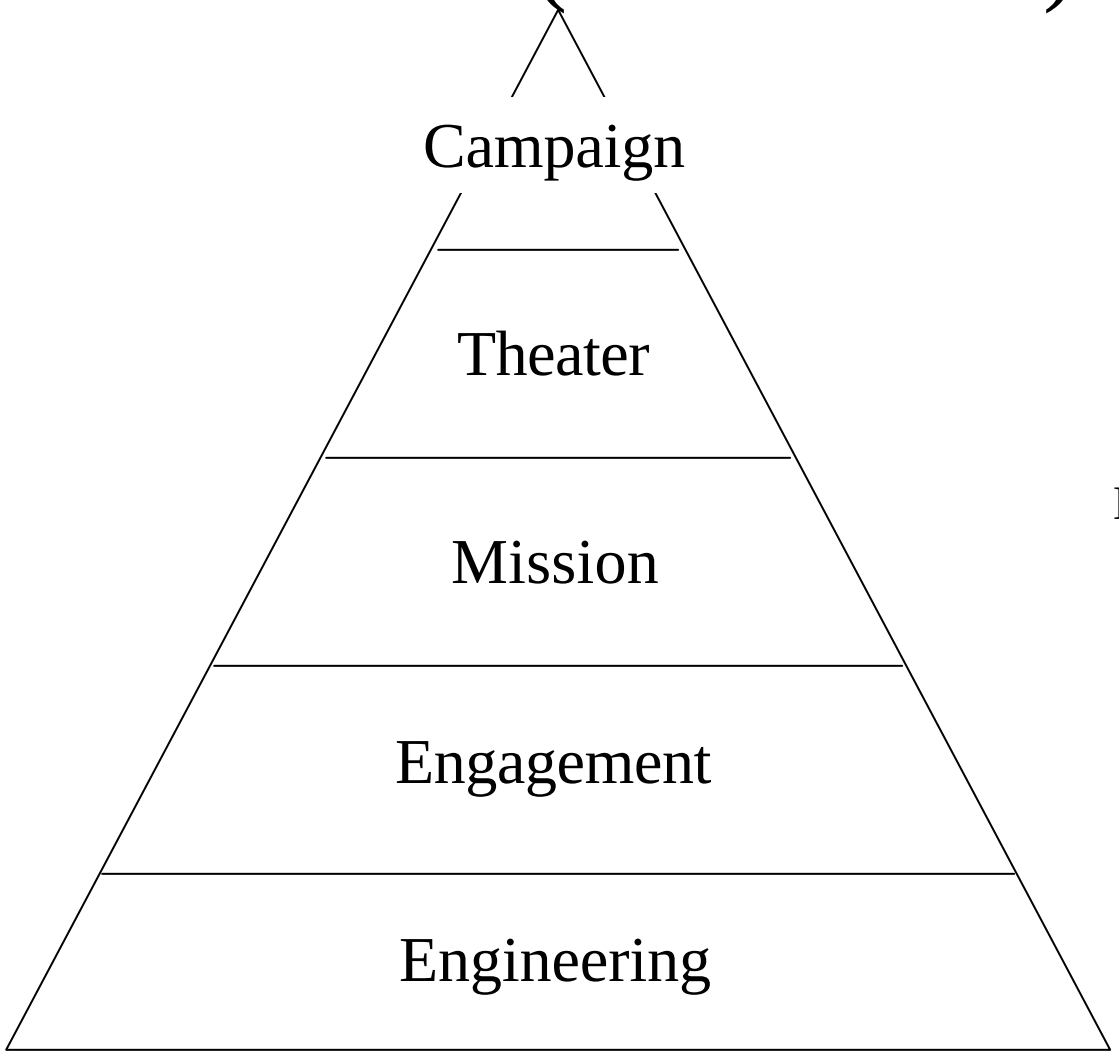
Section Outline Agenda

- A taxonomy of models pyramid
- Some key models/organizations/resources
- A little bit more on JWARS
- Some vocabulary
- Some important aspects of models

Hierarchy of Models



Types of studies in models (no absolutes)



Force Structure

Force Design

Doctrine, Mission planning, Force Employment, Force Modernization

Similar to mission (more detail)

Engineering Research/Development

Engineering models

- With the contractors
- Laboratories

Some Community Engagement models

- Air Force
  - TAC BRAWLER
- Joint: E-SAM (Evolutionary SAM simulation)

Some Community Mission-Level Models

- Army:
  - JANUS,
  - Modular Semi-Automated Forces (ModSAF)
  - Combined Arms and Support Task Force Evaluation Model (CASTFOREM)
- Air Force (Joint): Extended Air Defense SIMulation (EADSIM).
- Navy: Naval Simulation System (NSS), General Campaign Analysis Model (GCAM)

Theater Level Models

- Vector-in-Commander (Army)
  - **The Vector-In-Commander (VIC) model, developed by the TRADOC Analysis Center (TRAC) in 1982, is the Army's principle Corps-level simulation. While traditionally developed to study Army issues, VIC represents a variety of joint operations. The VIC model is a variable resolution, two-sided, deterministic, discrete event simulation. It portrays non-linear warfare in a combined arms environment representing land and air forces at the US ARMY Corps level with a commensurate enemy force in a mid-intensity battle.**
- GCAM (Navy)

Community Campaign Models

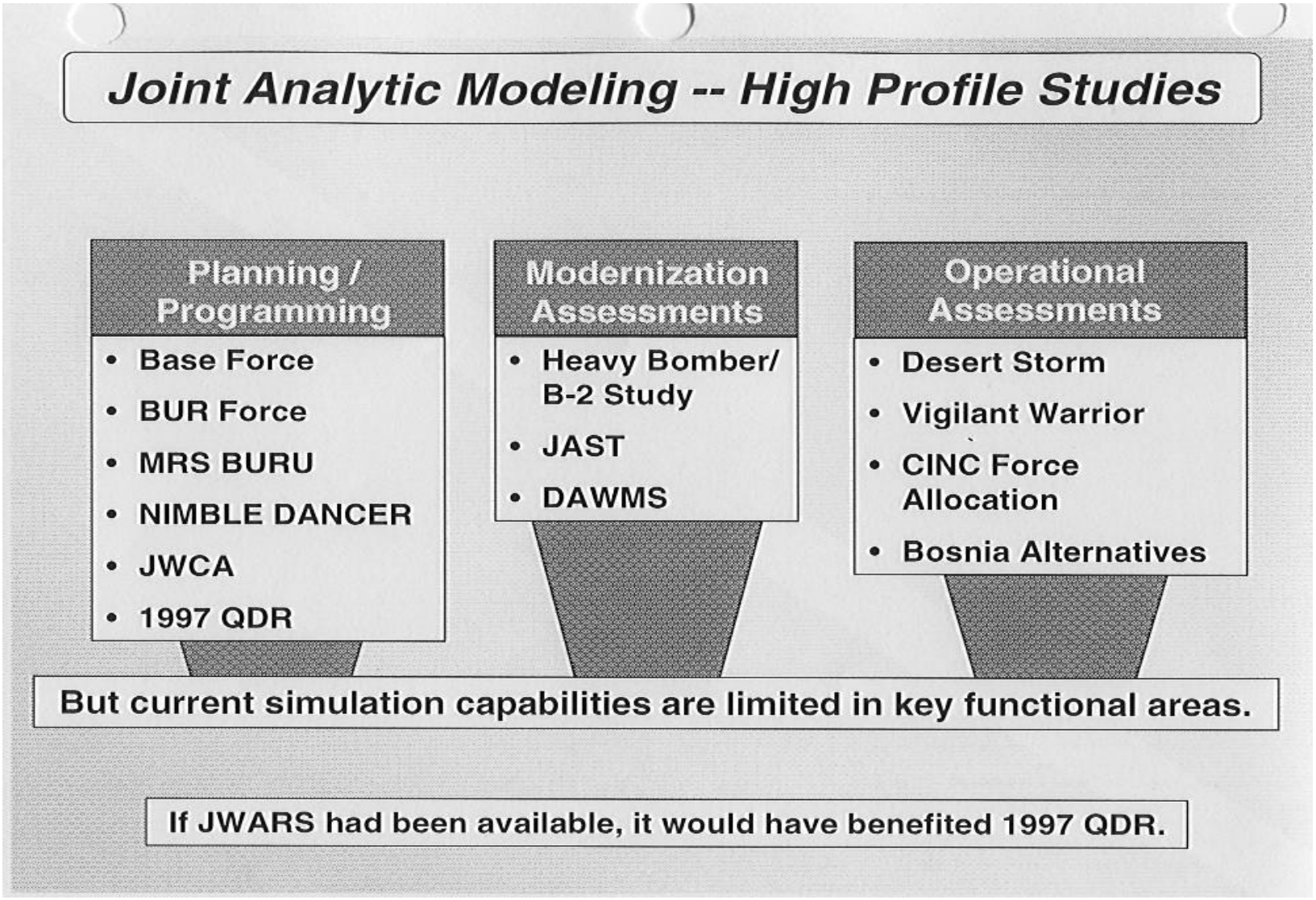
- Army: Concepts Evaluation Model (CEM)
  - Roots trace to ‘68
- Navy: Integrated Theater Engagement Model (ITEM)/ GCAM
- Air Force: THUNDER
- RAND: Joint Integrated Combat Model (JICM)
- Joint: TACtical WARfare (**TACWAR**)
  - 40 year lineage
  - TACWAR is a completely automated, deterministic, theater level simulation model. It can be used to assess the interaction of conventional forces, as well as, chemical weapons in a variety of combat engagements.

The Future?

- Analysis
  - Joint Warfare System (JWARS)
    - Link=https://www.jointmodels.army.mil/JWARS/
    - Emphasis on C4ISR
  - Being Designed/developed since 1995
- Training
  - Joint Simulation System (JSIMS)
- All services are also developing their own models
  - Most of the above have follow-on efforts

A Bit More on JWARS
(Official Slides)

Some Important Uses of Joint Campaign Modeling

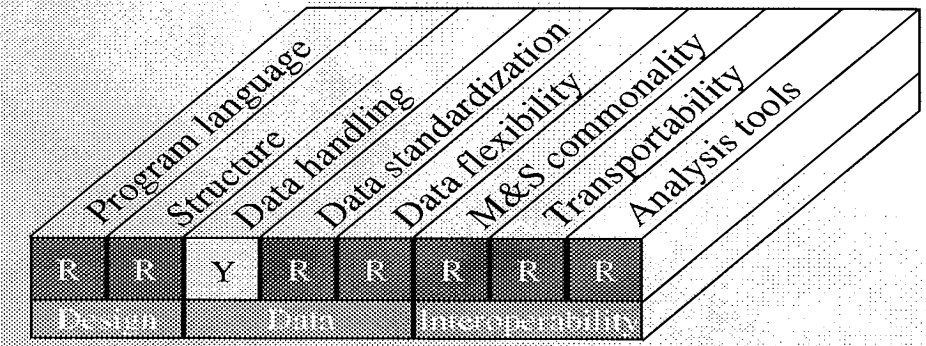


Assessment of Existing Campaign Models

Inventory of Current Models Used to Support Joint Analysis

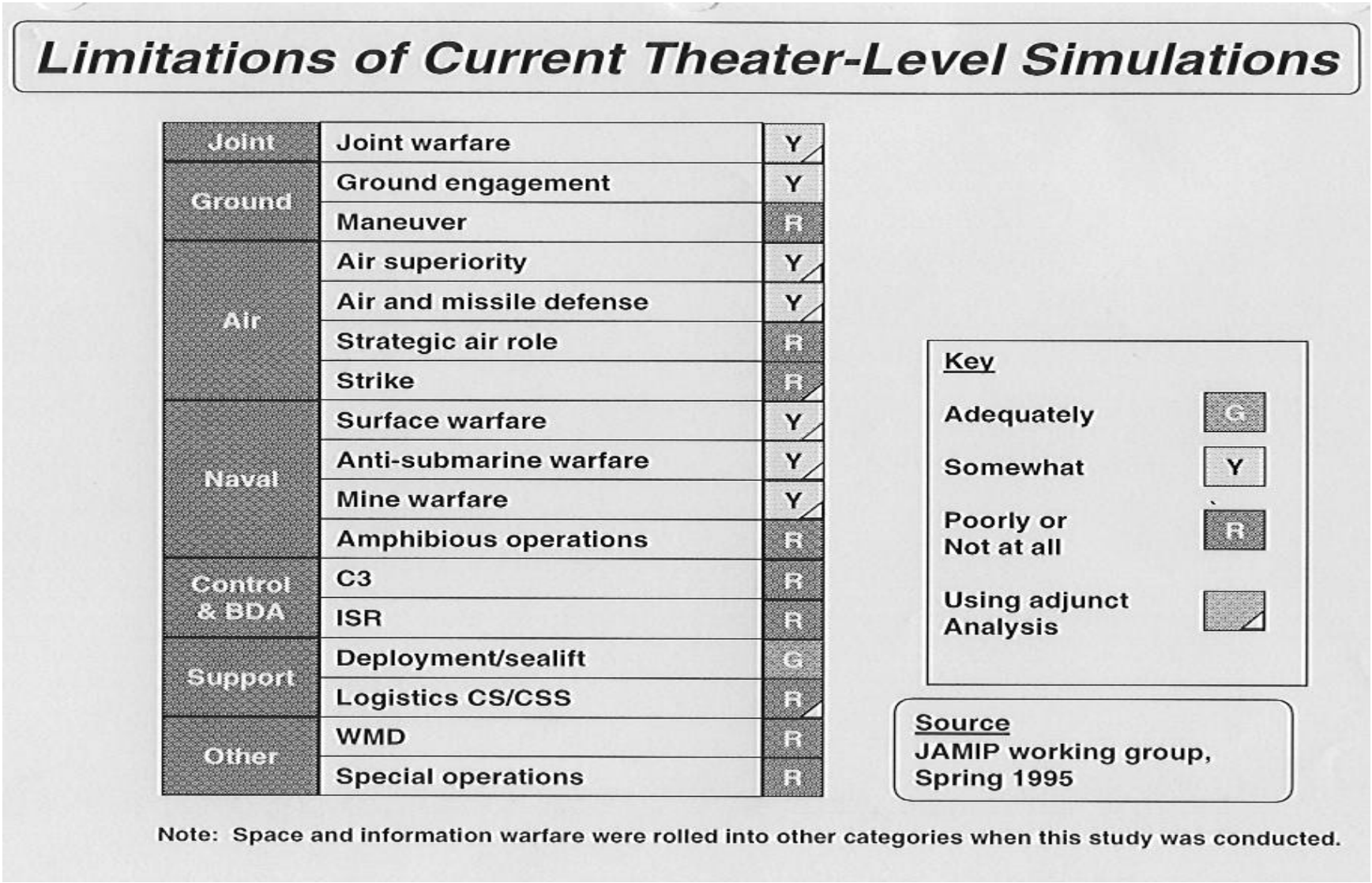
Model Name	Vintage	Users	Land	Air	Naval
TACWAR Base Force ** BUR ** MRS BURU Nimble Dancer (ND) ** Desert Storm	1960s	CINCs Joint Staff OSD/PA&E	✓	✓	
THUNDER USAF Analyses ** Nimble Dancer ** JAST	1980s	Air Force	✓	✓	
CEM Army Analyses ** TAA	1960s	Army	✓	✓	
ITEM Navy Analyses ** ND ** Invest Balance Review	1980s	Navy		✓	✓

Many weaknesses are caused by limitations in technical capabilities



✓ denotes emphasis

Limitations of Current Models



The Proposed Solution

Solution

Feb 95 - DepSecDef directed the Director, PA&E, with participation from the Assistant Secretary of Defense (Strategy and Requirements) and the Joint Staff, to

- Initiate a phased program to upgrade existing joint analytic models and simulations (near term) and develop a set of next generation models (longer term).
- Identify an approach and management structure.

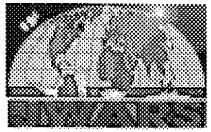
May 95 - DepSecDef approved the Joint Analytic Model Improvement Program (JAMIP) and directed PA&E in cooperation with the Joint Staff to

- Set up the Joint Warfare System (JWARS) Office.
- Establish manpower and support for the JWARS Office with assistance from the Services.
- Develop a funding plan.

Nov 95 - DepSecDef formally established JWARS Office.

Jun 96 - DepSecDef designated OSD/PA&E (Joint Data Support) as primary data support agency for JAMIP.

JWARS Mission Statement



Mission

Mission: Develop a state-of-the-art, constructive simulation that will:

- **Provide a multi-sided and balanced representation of joint theater warfare**
- **Be able to assess current and future operational concepts to include JV 2010's:**
  - **Dominant Maneuver, Precision Engagement, Focused Logistics, and Full-Dimension Protection**
- **Use C4 and ISR as the foundation for how entities perceive and interact with one another**

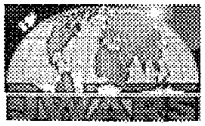
Users

- **Joint Staff**
- **Services**
- **CINCs**
- **OSD**
- **Joint Task Forces**
- **Other DoD org's**
- **Industry**

Applications

1. **Force assessment**
2. **Planning and execution**
   - **Deliberate planning**
   - **Crisis action planning**
3. **System effectiveness and trade off analysis**
4. **Concept and doctrine development and assessment**

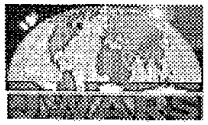
JWARS Key Performance Parameters



Key Performance Parameters (KPPs)

- **Traceability**
  - Cause and effect relationships
  - Tracking of data sources
- **Verification and validation (V&V)**
  - Correct representation of doctrine, performance, and environment
  - Balance across joint warfare functions
- **Utility**
  - Study execution
    - ⇨ Includes *warfare functionality*
  - Deterministic and stochastic modes
  - Multiple levels of resolution
  - Execution speed

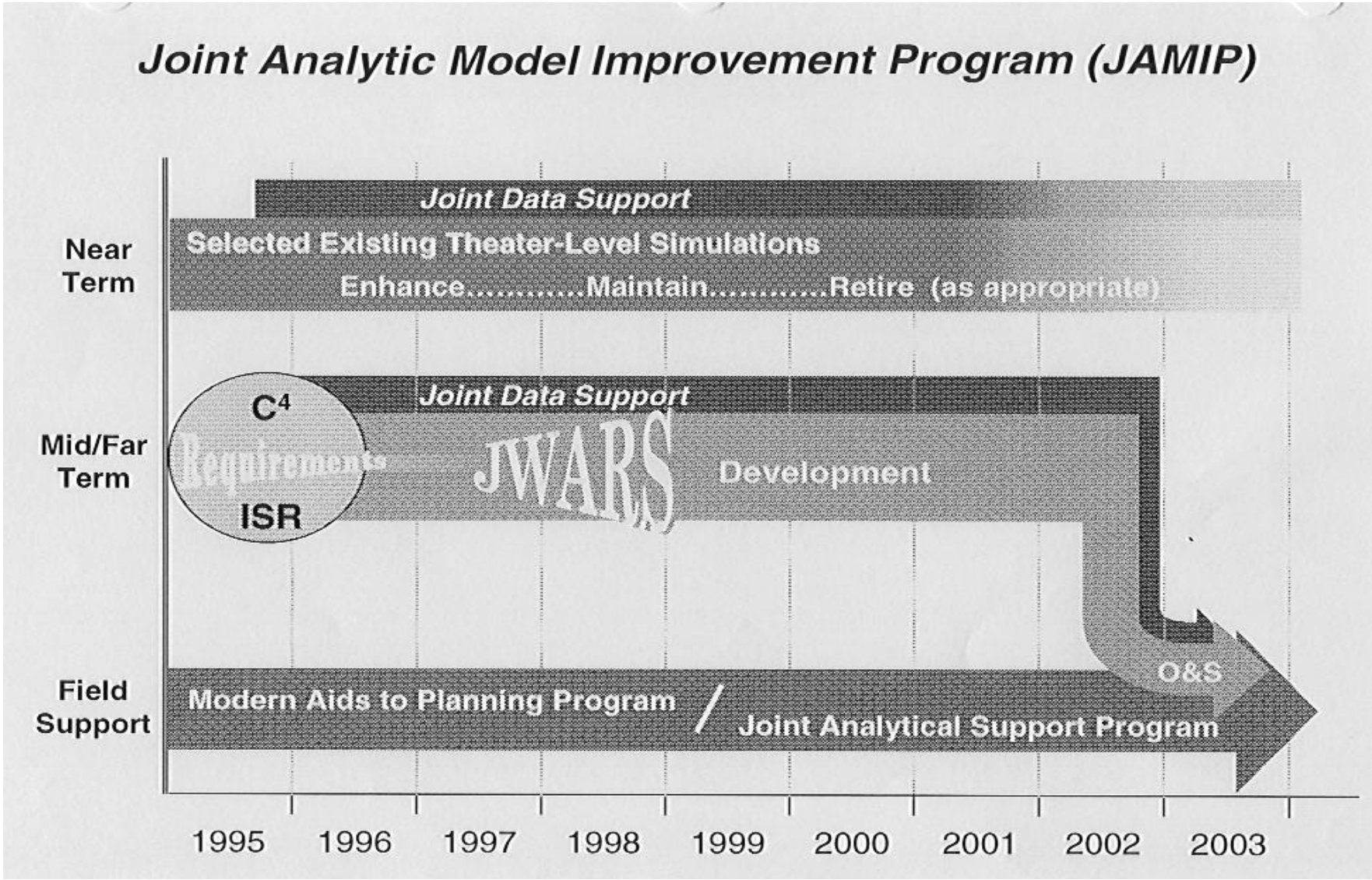
JWARS Execution Speed



Execution Speed

- Interpretation: ratio of simulation speed to clock speed for a deterministic use or one replication of a stochastic use
- Threshold for Releases 1 and 2 — 1,000:1
- Threshold for Release 3
  1. Planning and execution — 1,000:1
  2. Force assessment — 1,000:1
  3. System effectiveness and trade off analysis — 500:1
  4. Concept and doctrine development and assessment — 500:1

Joint Modeling Improvement Plan



Some Important Resources and Analysis Organizations

- **Some key organizations (resources for you)**
  - **DMSO; http://www.dmso.mil/**
    - **http://www.msrr.dmso.mil/**
- **- AMSO; http://www.amso.army.mil/**
  > pioneers in standards (my first choice)
  - **NMSO; http://navmsmo.hq.navy.mil/ (Note: 900+ models in the catalogue)**
  - **(SURVIAC) http://iac.dtic.mil/surviac/**
- **Some of the key <u>analysis</u> organizations**
  - **Army**
    - **- TRAC (Leavenworth, WSMR, MTRY)**
      - CAA
      - STRICOM--/*leaders in training and virtual simulation */-
  - **Air Force**
    - **AFSAA, RAND's Project Airforce**
  - **Navy**
    - **N81, CNA**
  - **Marines**
    - **MCCDC studies and analysis**
  - **DoD/Joint**
    - **J-8**

Some important aspects of models (Time advance mechanism)

- Time Step
- Event Driven
- Real-Time

Some important aspects of models (Verification/Validation/Accreditation)

- **Verification:** "Is your model coded correctly"

- **Validation**: "How accurate is the model to the real world from the perspective of the intended use"

- **Accreditation**: "Official certification that a model or simulation is acceptable for a specific purpose."

Some important aspects of models (Live/Virtual/Constructive)

- **Live**: real people and equipment
- **Virtual**: Real people, simulated equipment (e.g., tank and aircraft simulators)
- **Constructive**: computer based simulation
  - Open: people do tactics and strategy
  - Closed: push button and go

Analytical Properties

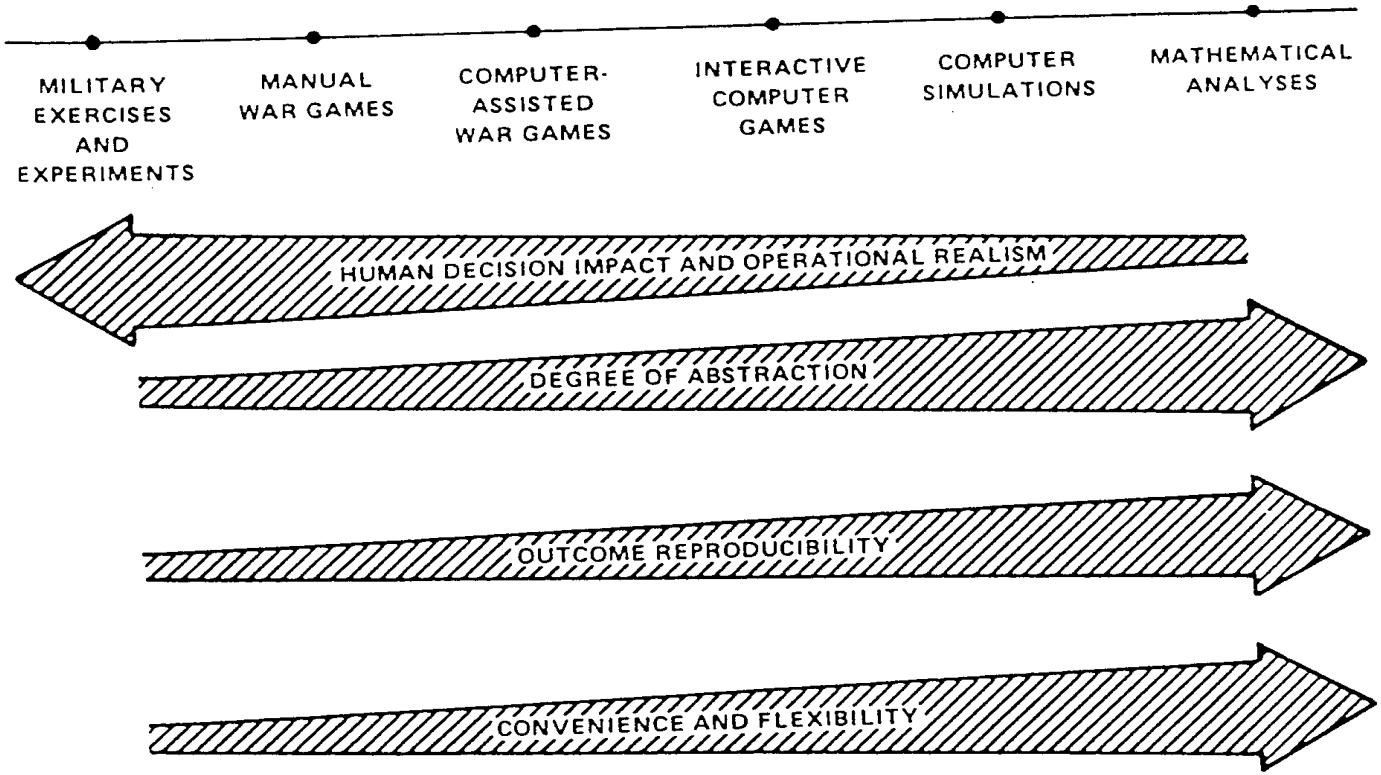


Figure 3. The Model Spectrum and Characteristic Trends

Anything other than war is a simulation…

Some important aspects of models (Deterministic versus Stochastic)

- Deterministic models, with the same input, always give the same answer (very common with campaign models)
- Stochastic models, with varying seeds, give a distribution of outcomes.
- Human-in-the-loop models are?

Some important aspects of models (Entity Decisionmaking)

- How is it made?
  - Script?
  - Rule based? Expert based? Doctrine based?
  - Human-in-the-loop?
  - Optimal algorithm?
  - Heuristic?
- What entities make it?
  - Only command elements? At what levels?
  - All entities?

Some important aspects of models (Uncertainty and Perceptions)

- How do entities acquire their knowledge?
  - By sensors?
  - By communication?
- Are perceptions based on ground truth?
  - Tracking errors,
  - ID errors (is fratricide played?),
  - Data fusion errors,
  - Time delays

Some important aspects of models (Levels of Aggregation)

- Related to model resolution=detail, granularity in the model
- Can aggregate across: entities (e.g., platoon versus battalion), attributes of entities, algorithms, processes, space, and time
- Big issues:
  - Variable or multi resolution models
  - Aggregation/disaggregation

Note: Resolution does not necessarily equal fidelity (often misconstrued)

Interoperability/Distributed Simulation

- Advanced Distributed Simulation (ADS), From Sikora, J., and Coose, P., "What in the World is ADS?," *Phalanx*, vol. 28, no. 2, June 1995. The technology area that provides a time-coherent, interactive synthetic environment through geographically distributed and potentially dissimilar simulations is called, reasonably enough, Advanced Distributed Simulation (ADS). The distributed simulations can be any combination of real people, real equipment, or computer programs which simulate people, equipment, and their interactions.
  - ALSP
  - **DIS**: Another, older, term for these technologies and vision is **Distributed Interactive Simulation** (DIS). ...a synthetic environment within which humans may interact through simulation(s) and/or simulators at multiple networked sites using compliant architecture, modeling, protocols, standards, and data bases.
    - Say something on SIMNET
  - HLA: The High Level Architecture (HLA) is defined by a set of rules, an interface specification, and an object model template (OMT). ... The overall objective of the DoD common technical framework, which includes the HLA, is to support interoperability and reuse.

At the highest level (from DMSO)

- Model. A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process.
  - – Can be analytical relationship, regression fit, physical model, computer simulation, etc.
    - » "Today it is NOT the word 'truth' but the word 'model' that continually decorates the pages of scientific journals"--Owen Gingerich (1982)
    - » "All models are wrong but some are useful"--George Box (1979)
    - » "Models are for Thinking"--Maurice Kendall
- Most DoD models are simulations
- Simulation. A method for implementing a model over time.
  - – "Anything but war is a simulation"--some 4 star

We will concentrate on simulations

- Think of simulations as a collection of objects that interact
  - You specify the objects and how they interact
- An important part of building a simulation and designing runs is defining the objects, events, processes, and data for the simulation.
  - Object: A fundamental element of a representation of an element in the simulation. For any given value of time, the state of an object is defined as the enumeration of all its attribute values /* and subobjects */.
  - Event: A change of object attribute value, an interaction between objects, an instantiation of a new object, or a deletion of an existing object.
  - Process: From Webster: (1) An orderly or established series of steps or operations towards a desired result or product. (2) A natural action or function marked by the gradual change from 1 state to another. From DMSO: Processes. Processes affect entities.
  - Data: A representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means.

Objects, events, processes, and data

- If you understand these you understand the simulation
- How we define these depends on the level of details (resolution) we need.
- Often the feasible objects and allowable events are constrained by the model you use.
- Getting data is a big problem
  - JWARS will have (at least 43 feeder sources)
  - Often have official sources
    - » DIA
    - » AMSAA

What do objects in Combat models do (Very broad)

- Move
- Sense (see, listen, etc.)
- Think (notice, build perceptions (digest/fuse information, decide)
- Talk (Communicate)
- Shoot/attrit (may create new objects)
- Degrade (suffer attrition / get killed)

- A good part of the course will be different approaches to doing these

Two different approaches to adjudicating events (Very broad)

- Data driven events
  - Supplied by theory, real data, training and testing, or *more detailed models*
- Physics based events
  - Simplified models based on the physics of the event being model
- Two discussion examples
  - Detecting (or engaging) an incoming missile
  - Adjudicating 3 F-14s engaging 4 Su-27s in a battle for air-supremacy (in EADSIM)
- We will see this idea again and again and again...

Strengths and weaknesses of the basic approaches

- Data driven events
  - primary strengths
    - » events can be based on real data or engineering level models
    - » quick run times (table look-ups)
    - » can be easy to do exploratory analysis
  - primary weaknesses
    - » combinatorics--too many factors require too many tables
    - » data may not exist (e.g., future systems)
    - » heavy reliance on other sources for data (e.g., JWARS)
- Physics based events
  - primary strengths
    - » self contained, the event depends on the model/scenario specifics
    - » usually easy to do hypothetical systems and unanticipated conditions
  - primary weaknesses
    - » complexity of events--very difficult to do well
    - » can increase model run-time significantly