

# KNOWLEDGE GLYPHS: VISUALIZATION THEORY DEVELOPMENT TO SUPPORT C2 PRACTICE

11<sup>th</sup> ICCRTS 2006

Topical Area: COGNITIVE AND SOCIAL DOMAIN ISSUES  
CONFERENCE PRESENTATION BY:  
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**NORTHROP GRUMMAN**  
*Information Technology*

## AUTHORS

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# OUTLINE



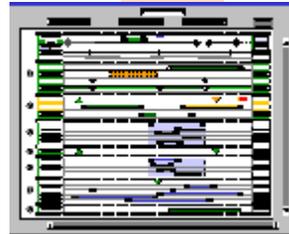
- **Background: Mutual influence of theory and practice in our work**
- **Research motivation: Opportunities for improving ‘best practice’**
- **Pre-theorization I: Envisioning next-generation practices**
- **Pre-theorization II: Criteria for theory development**
- **Theorization: A definitional model for knowledge glyphs**
- **Closing the loop: Projecting subsequent ‘best practice’**



# THEORY AND PRACTICE IN OUR WORK



## CONCEPTUAL DESIGN



- We perform research and design for advanced C2 systems concepts.
- Our focus is on facilitating human performance in complex decision making tasks.

## PROTOTYPE DEVELOPMENT



- Our approach is 'work-centered' (focused on the decision maker's 1st-person perspective and needs).
- Our objective is advancing the state of the art in C2 systems 'practice'.

## USER EVALUATION



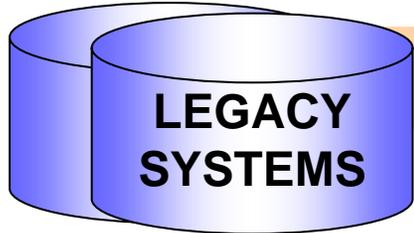
- Our results advance the state of the art in analysis and design 'practice'.
- These practical advances sometimes involve advancing the state of the art in analysis and design 'theory'.



# RELEVANCE OF OUR WORK-CENTERED INNOVATIONS

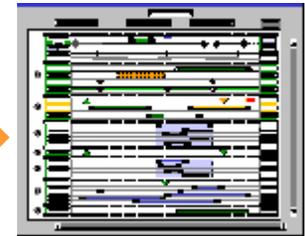


DATA REPOSITORIES CONFIGURED TO HOLD 'EVERYTHING WE GOT'



“FROM THE CENTER” - “TO THE EDGE”

INFORMATION SPACES ACCOMMODATING ALL ROLES WITH GENERAL PURPOSE ACCESSIBILITY



INFORMATION SPACES TAILORED TO SPECIFIC TASK REQUIREMENTS AND PARTICULAR DECISION APPLICATIONS

- Our work-centered support tools give individual decision makers subject matter visualization affording them:
  - The specific data relevant to decision task(s) at hand
  - A coherent presentation of the ‘state of the world’ (i.e., situation awareness)
  - Data presentation(s) framed in a manner consistent with their own perspective
  - Drilldown access to the full array of data resources underlying the display
- Integration of focused subject matter visualization with ‘what if’ simulation / modification allows for dynamic support and recording of potential solutions.
- Quantitative evaluations have demonstrated significant performance gains over existing legacy systems.
- We have repeatedly provided an EFFECTIVE OPERATING PICTURE for particular roles / decision makers.
- Sharing these tools among a team / unit affords a COMMON OPERATING PICTURE.



# THE WORK BEING REPORTED HERE



**TOPICAL AREA:** Advanced information visualization as a means for improving C2 decision making.

**MOTIVATION:** Recognition of a need to augment current 'best practices' in C2 symbology to better accommodate the complexities of modern warfare and the information domain within which commanders must operate.

**IT'S RELEVANT TO THE CONFERENCE THEME BECAUSE:** It can be seen as theorization in response to practices which themselves embody prior theorization.

**IT ILLUSTRATES:** The reciprocity between theory and practice at any given point as well as the manner in which these factors interact to guide progress over time.

**WHAT WE'VE DONE:** Established a framework for defining basic constructs and interrelating them with conventional interface or visualization concepts.

**WHERE WE'RE GOING:** Demonstration applications and experimental studies to be pursued in 2006.



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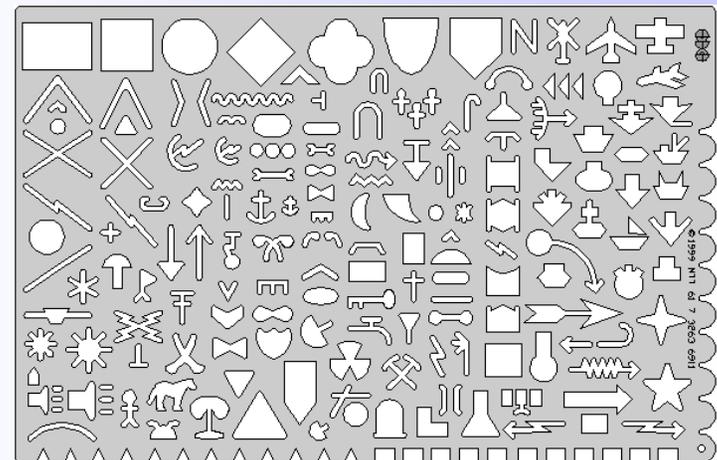
# STARTING POINT: MIL STD 2525 B



Enemy	Friendly	Unknown	Neutral

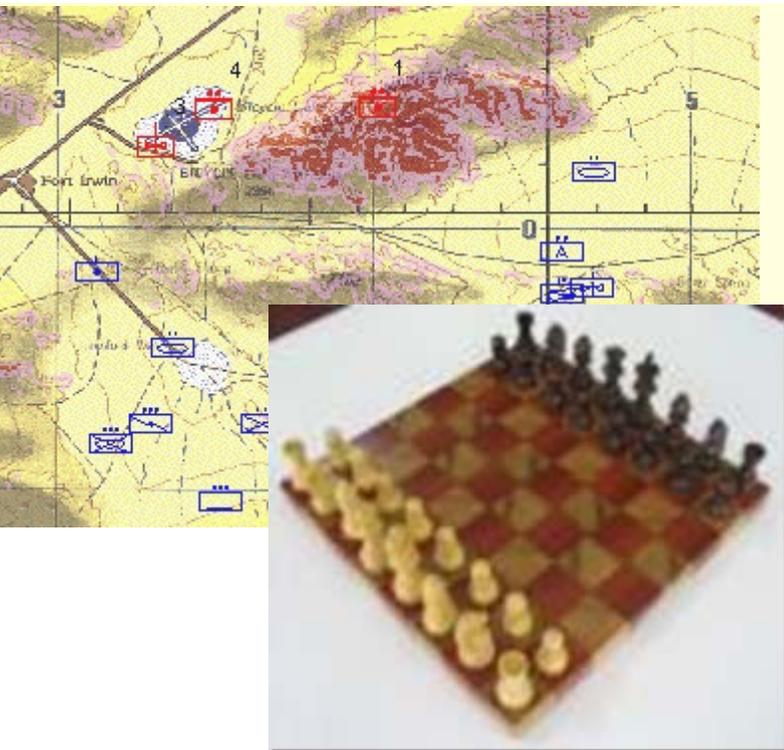
- Issued 1999, revised ('Change 1') July 2005.
- A structured specification for C2 battlespace symbology.
- Provides a modular 'toolkit' for symbolizing discrete battlespace entities.

- PRO: 'Regularized' enough to afford 'cookie cutter' or 'template-driven' implementation.
- PRO: Imposes consistency.
- CON: Rigid enough to make it difficult to portray things not accounted for in the spec.
- CON: Limited 'richness' in portraying battlespace entities.





# LIMITATIONS OF MIL STD 2525 B



- MIL STD 2525 B offers a 21st Century protocol for depicting entities on a battlespace map.
- The battlespace map, however, is a 19th Century C2 support artifact.
- Such a battlespace map only affords the commander a 'chessboard' analogous to what one player uses in playing a game against a remote adversary (e.g., by mail).

*MIL STD 2525 B is fine for what it is, but ...*



- It affords little capacity for more deeply inspecting and analyzing the 'pieces' (battlespace entities).

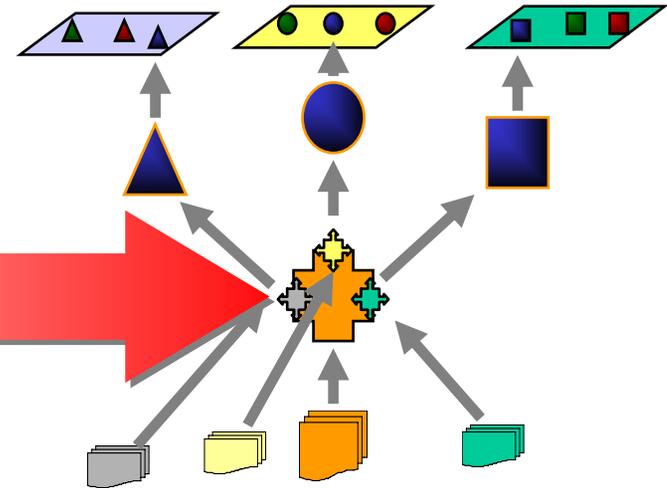
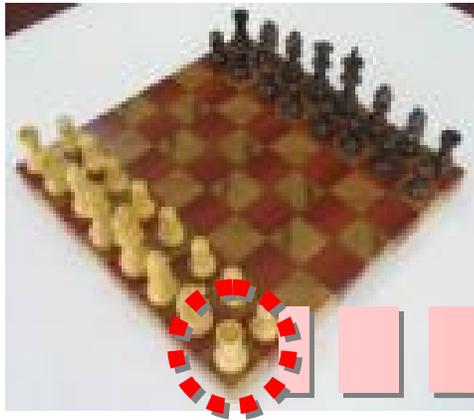


- It affords no support for analyzing uncertainty (about either the 'pieces' or battlespace states).

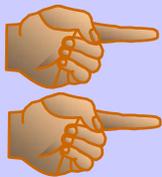
*We seek innovative ways of augmenting MIL STD 2525 B for richer C2 visualization...*



# OUR INTENT: AUGMENTING MIL STD 2525 B



We want to invent visualization innovations allowing:



- Exploitation of all data pertaining to a given battlespace entity
- Examination of a battlespace entity in terms of its role and implications across multiple referential contexts (not just geo-space)

Effective situation awareness  
+ Proactive problem identification

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Better / faster decisions / actions

*Why? ...*

*How? ...* KEEP THE USER FOCUSED ON THE OBJECT OF CONCERN



# THE GOALS WE SET OUT TO PURSUE...



-  • We seek to augment - not supplant - MIL STD 2525 B.
-  • We seek to provide means for usefully visualizing uncertainty with respect to battlespace entity features.
-  • We seek to provide means for usefully visualizing uncertainty with respect to the overall state of the battlespace.
-  • We seek to provide richer representations for the entities portrayed on the battlespace display.



# OUTLINE

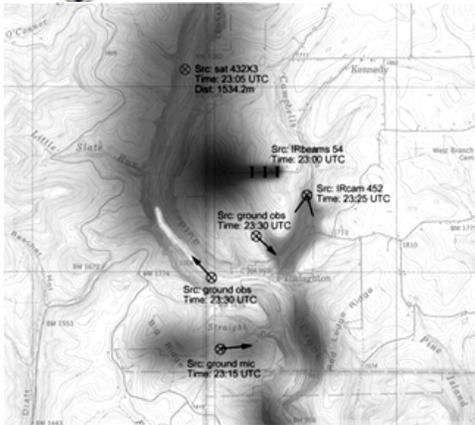


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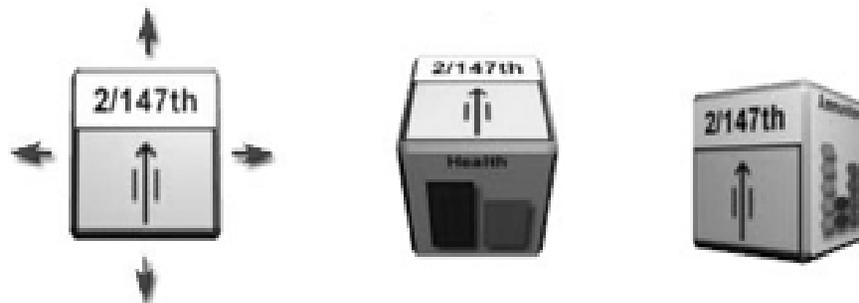
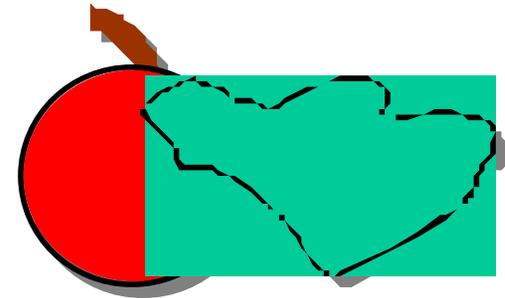


# EXAMPLE: NOVEL SYMBOLIZATIONS



Overlay 'blobs' to represent states (e.g., range of predicted movement for a given entity)

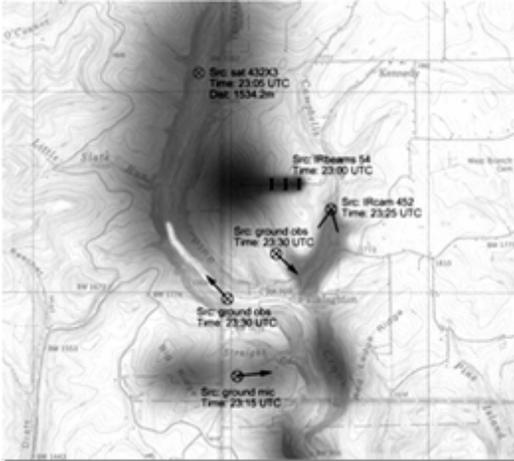
Composite iconography to permit richer, modular addition of value-adding representational features.



3-D iconography capable of 'rotation' to increase info presentation area without increasing visual 'footprint'.

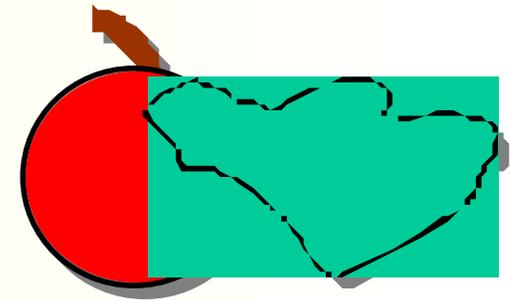


# EXAMPLE: VISUALIZING PROBABILISTIC DATA



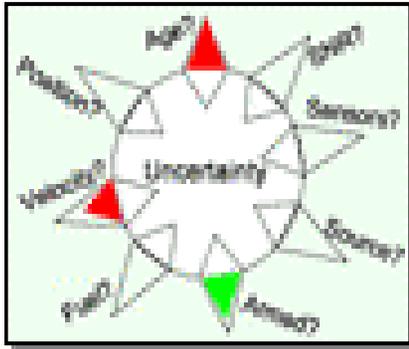
Using novel representational elements to denote probabilistic states

Using combination / overlay tactics to indicate estimated degree of feature applicability or impact.



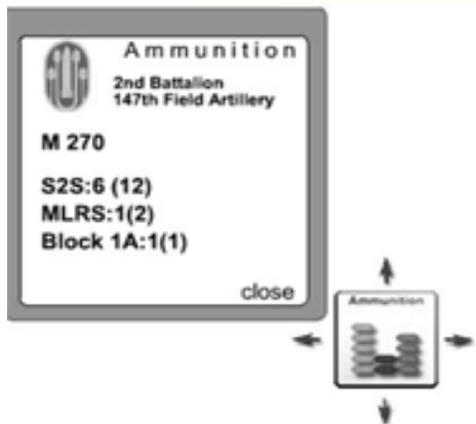
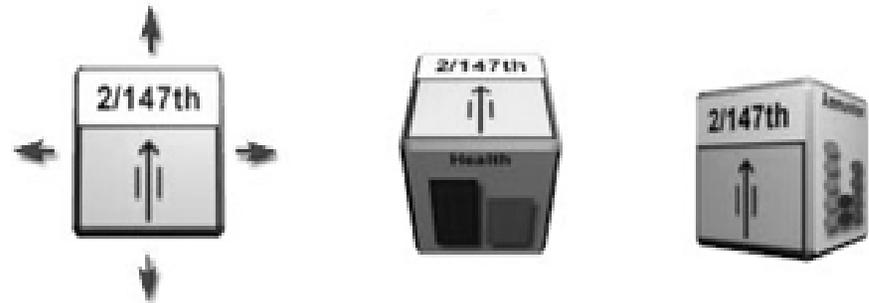


# EXAMPLE: FACILITATING DATA ACCESS



Introducing novel 'mini-interface' modules associated with entities affording links to additional data sources.

Providing summary data on the face of the entity representation itself.



Providing direct 'drill-down' linkage from the entity representation to outboard data sources.



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# KEY CHARACTERISTICS OF THE CONCEPT



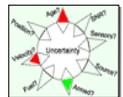
- **A Knowledge Glyph is a Form of 'Glyph'**
  - Beyond simple entity denotation.
  - Provide additional or deeper information.



- **A Knowledge Glyph is a 'Super-Icon'**
  - Presentational utility is not limited to denoting the simple fact of an entity's existence and relative 'position.'



- **A Knowledge Glyph is a 'Micro-Interface'**
  - Means for accessing additional data.
  - Capable of dynamic manipulation.



- **A Knowledge Glyph Interrelates Referential Contexts**
  - Examine the entity from another system's contextual vantage.
  - Maintain user focus on the current entity under examination.





# KEY CRITERIA FOR THEORY DEVELOPMENT



- Whatever a 'glyph' may be, it needs to be defined in terms of being a visualization element associated with a given thing or 'entity'.



- This means the definition must account for the referential context underlying the visualization at hand as well as any additional contexts in which the entity is to be portrayed.



- A 'glyph' needs to be defined as something more than an 'icon'.



- We need to explain how the 'micro-interface' functional attribution fits into the otherwise 'structural' definitional framework.



- We need to account for implicit distinctions among 'data', 'information', and 'knowledge' (for our purposes).



# OUTLINE

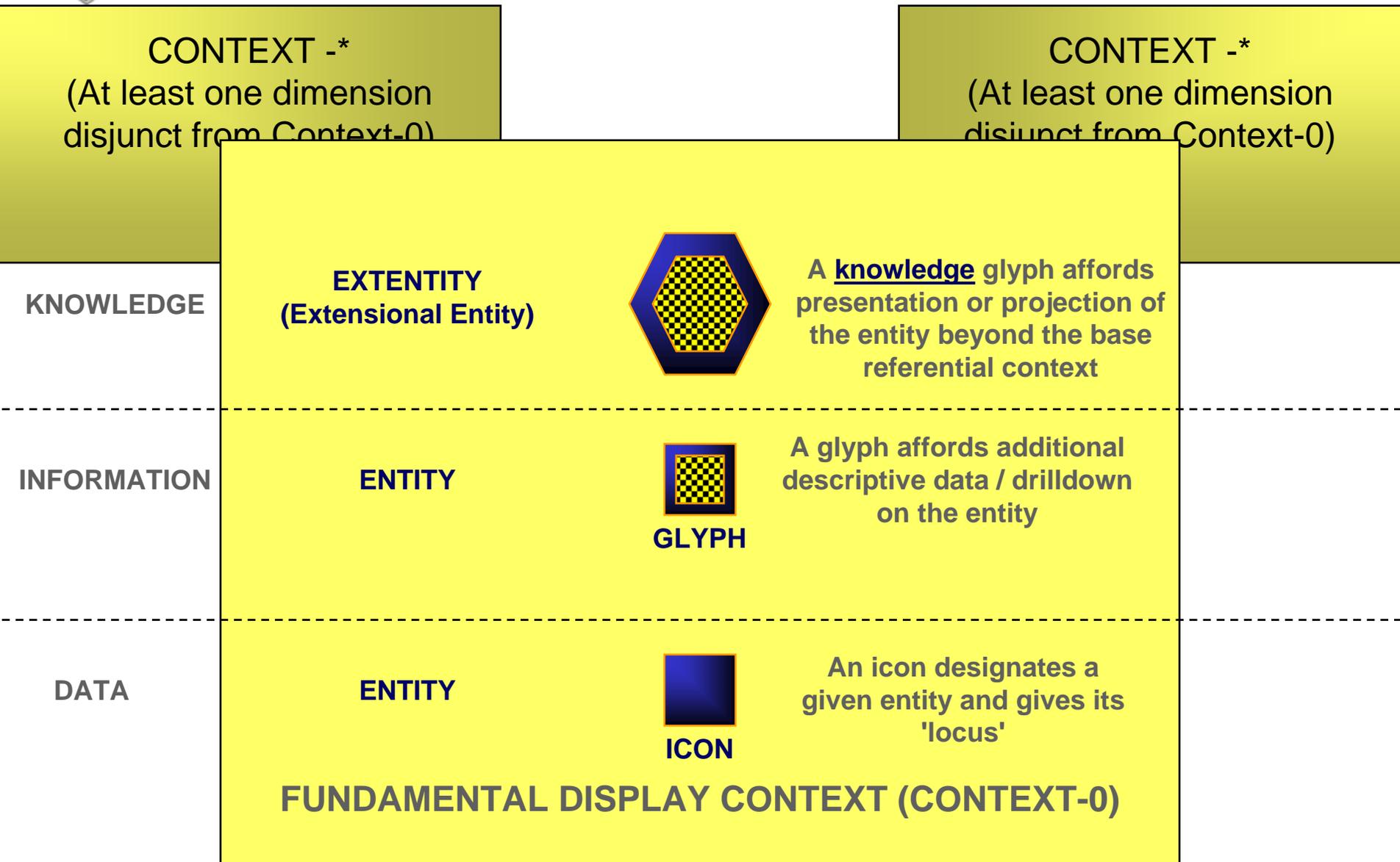


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# WORKING BASIS FOR DELINEATING OUR MODEL



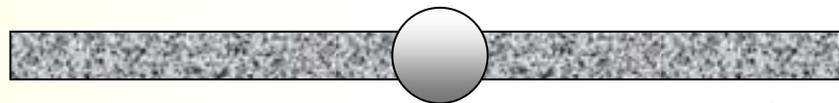


## DEFINITION: ICON



*An **icon** is a presentational element which designates an object of reference and specifies its 'locus' in the presentation context.*

ICON



Present Referential Context



# DEFINITION: GLYPH



***A **glyph** is an icon which additionally affords the user access to information about the denoted entity on its face.***

***This information may be data concerning the denoted entity or data about available redirection to another presentational device where such additional information may be obtained.***

**GLYPH**



**ICON**

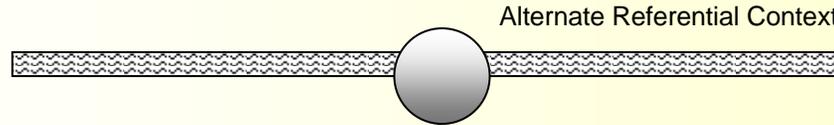




# DEFINITION: KNOWLEDGE GLYPH



**KNOWLEDGE  
GLYPH**



**GLYPH**



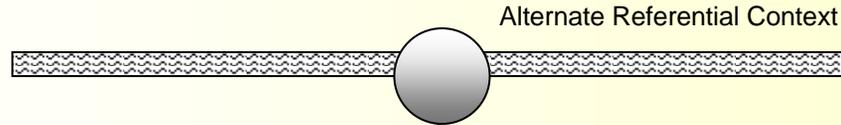
***A **knowledge glyph** is a glyph affording its user the ability to access extra-glyphic information in such a form that the extra-glyphic presentation is anchored with respect to the same entity (or other discrete object of reference) denoted iconically by the originating glyph.***



# THE COMPOSITE MODEL



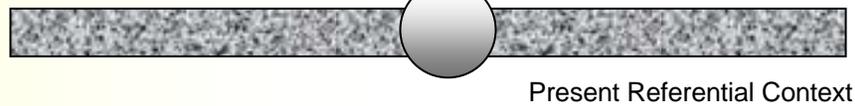
**KNOWLEDGE  
GLYPH**



**GLYPH**



**ICON**





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# NEW THEORY SUGGESTS NEW PRACTICE(S)



- The definitional model was crafted to coherently ‘telescope’ (conceptually) from basic icons to knowledge glyphs and vice versa.



- This opens up the prospect of an icon being capable of ‘telescoping’ to a knowledge glyph *at the same position / location within the user’s visual field.*



- In effect, this could permit the user to focus his / her gaze on one entity and ‘rotate’ referential contexts in and out to inspect that entity as it ‘plays’ in each of those distinct contexts.



- This would reduce cognitive and procedural burdens for having to open up different presentations (e.g., windows) and seek out the given entity in each.

*Thus we complete a cycle from practice to theory and back to practice...*



# SUMMARY



- **Current Practices Recommend Innovation:**

- *Extending or Surpassing MIL STD 2525 Symbology*
- *Portrayal of Uncertainty or Probability*
- *Richer Representations for Entities Portrayed on the Battlespace Display*



- **Analysis of Needs has Guided Formulation of New Theory:**

- *We specified the essential issues to be addressed via theory.*
- *We specified the key criteria to target improvement in practice.*
- *We developed a coherent model suited to the purpose.*



- **This Theoretical Innovation Already Suggests New Practice(s)**



# QUESTIONS?

