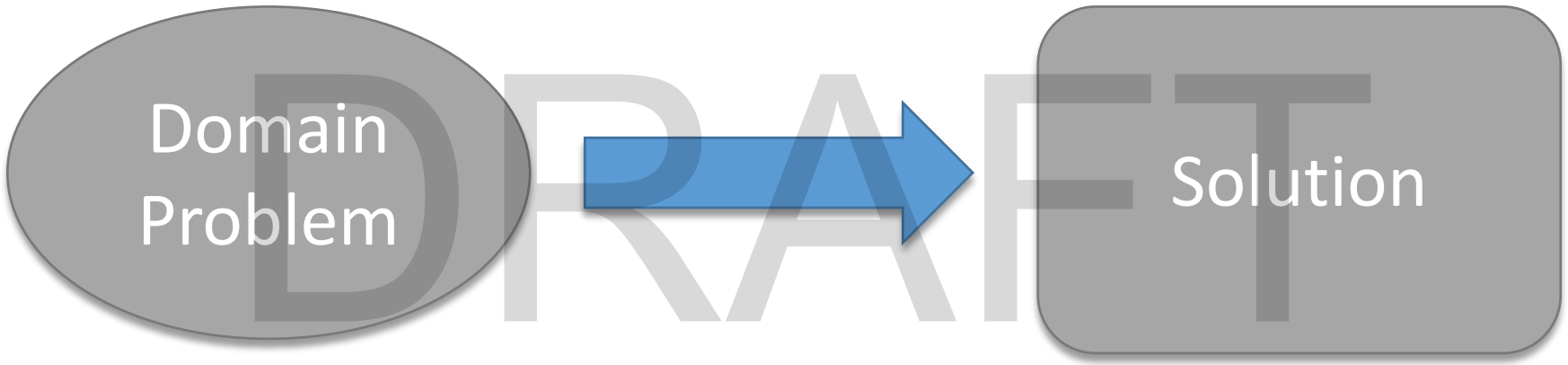
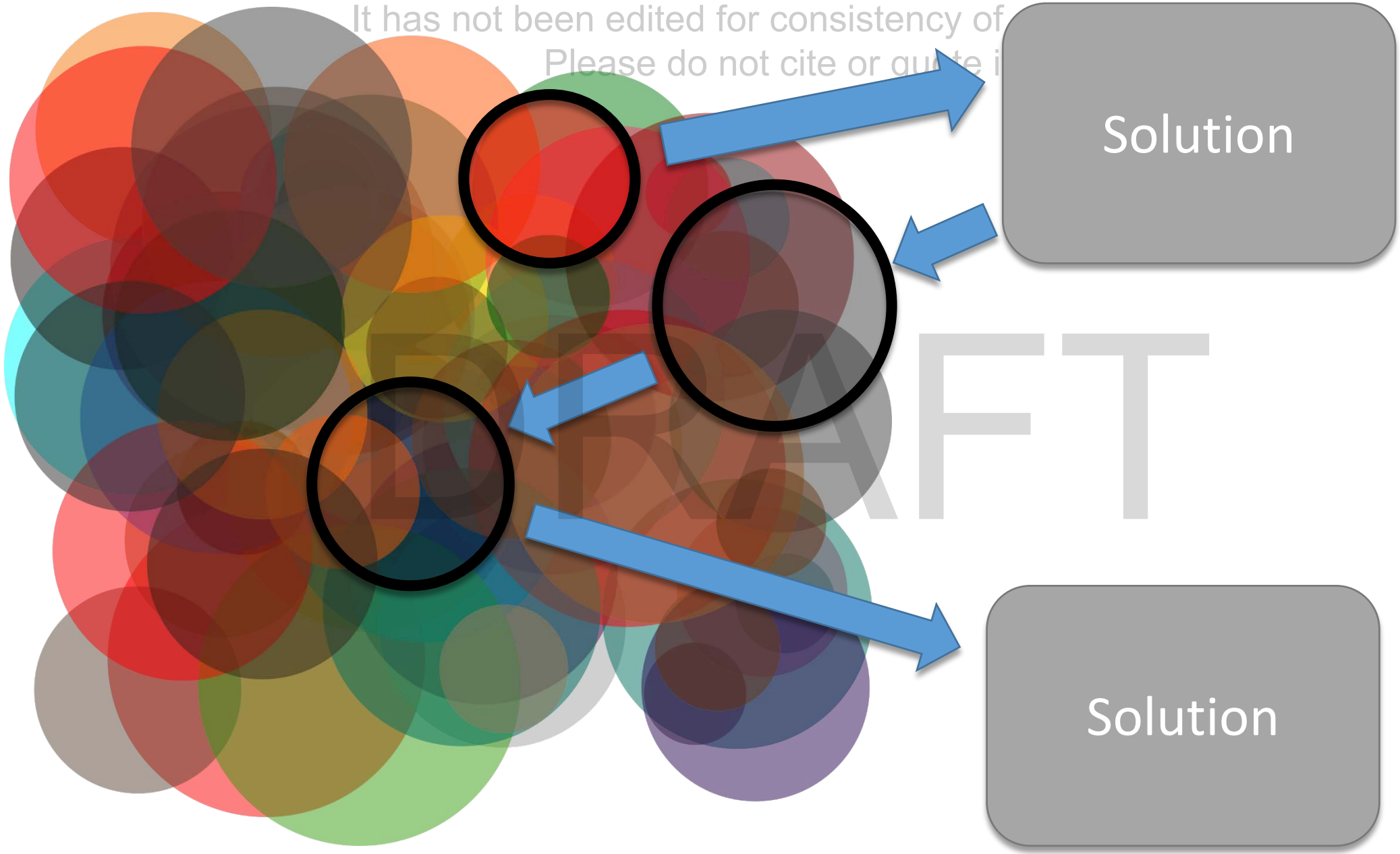
Creativity workshops for visualization design studies

Ethan Kerzner

Proposal defense





Design studies are challenging

- **Intellectual:** ill-defined and conflicting needs
  [Sedlmair et al. 2012]

- **Organizational:** bureaucracy and politics
  [Sedlmair et al. 2010]

- **Interpersonal:** trust and rapport
  [Sedlmair et al. 2012]

Interviews and contextual inquiry

- Consume time and energy
  [Holtzblatt and Jones 1993]
- Require engagement
  [Sedlmair et al. 2012]
- Establish piecemeal view
  [Kerzner et al. 2015]

Creativity methods and workshops

- Aimed at fostering creativity with groups of individuals
  [Osborn 1953]

- Pioneered for problem solving and software engineering
  [Osborn 1953, Maiden 2004]

- Use time efficiently, build engagement, establish holistic view
  [Goodwin et al. 2013, Goodwin et al. 2016, Kerzner et al. 2017]

Creativity workshops in visualization

- Used in a variety of projects
  [Dykes et al. 2010, Walker et al. 2013, Goodwin et al. 2013, Kerzner et al. 2015, Goodwin et al. 2016, Rogers et al. 2016, Kerzner et al. 2017, Nobre et al. 2017 (anticipated), Lisle and Kerzner 2017, Rogers et al. 2017]

- Report what was done in the workshop, leave the reader to figure out how and why to do it

- No established guidelines nor best practices for using creativity workshops in visualization design studies

Anticipated contributions

- An actionable framework that describes the practical and theoretical aspects of creativity workshops in design studies

- Two formative design studies where we used creativity methods and workshops to jump-start the project

Today

1. Related work: defining and applying creativity
2. Completed formative work: visual vulnerability analysis
3. Completed formative work: connectome visualization
4. Proposed work: visualization creativity workshops

Related work

Defining creativity

Creativity for problem solving and software engineering

Creativity in visualization

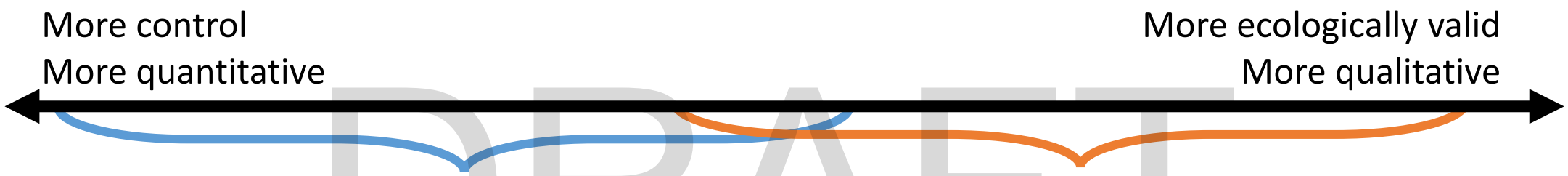
Defining creativity

- **Creativity** is the generation of ideas that are both **new** and **useful**
  [Mayer 1999]

- **Group creativity** emerges from group interactions
  [Sawyer 2003]

- Creativity in visualization is about new and useful:
  - Problem characterization
  - Data/task analysis
  - Encoding/interaction techniques

Creativity research



Laboratory studies

Psychometric [Plucker 1999]

Biological [Martindale 1999]

Contextual studies

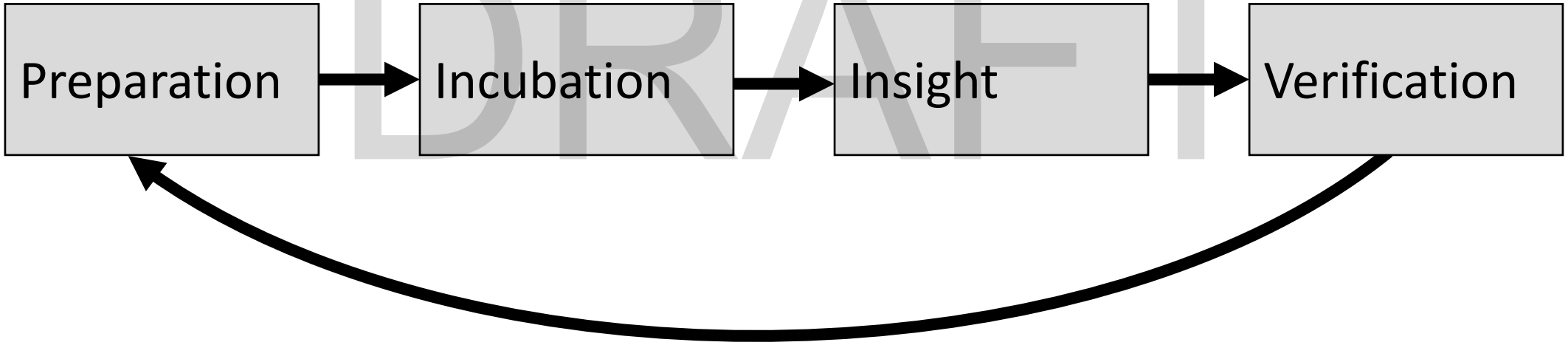
Biographical [Csikszentmihalyi 1997]

Organizational [Ekvall 1983]

Support [Shneiderman et al. 2005]

Four stage model of creativity

[Hadamard 1945; Sawyer 2006]



Fostering creativity

- Focused work – *flow*
  [Csikszentmihalyi 1997]

- Many interconnected insights
  [Sawyer 2006]

- Externalization and open communication
  [Glaveneau et al. 2013; Ekvall 1983]

Creativity for problem solving

- Creative problem solving methodology – diverge-converge
  [Osborn 1953]

- Synectics – analogy and focused workshops
  [Gordon 1961]

- Lateral thinking – metacognition
  [de Bono 1983]

Creativity methods for software engineering

- Examples: storyboarding, inspiration cards, personas
  [Kumar 2012]

- Output: structured vs unstructured
  [Horkoff et al. 2015]

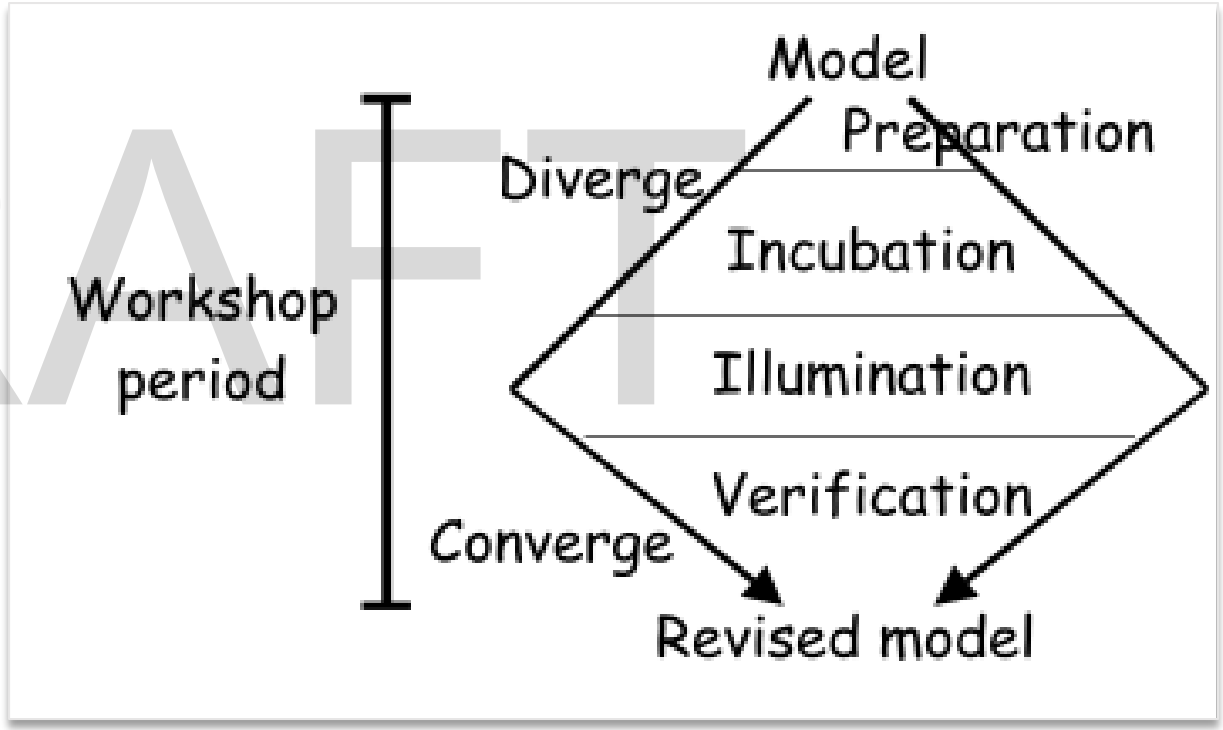
- Activity properties e.g., divergence vs convergence
  [Biskjear et al. 2017]

Creativity workshops for software engineering

- 2-day workshop for aircraft scheduling software
  [Maiden et al. 2004]

- Structured activities
  - Establish creative climate
  - Discuss current requirements
  - Analogical reasoning
  - Revise requirements

- Proposed insights based on experience

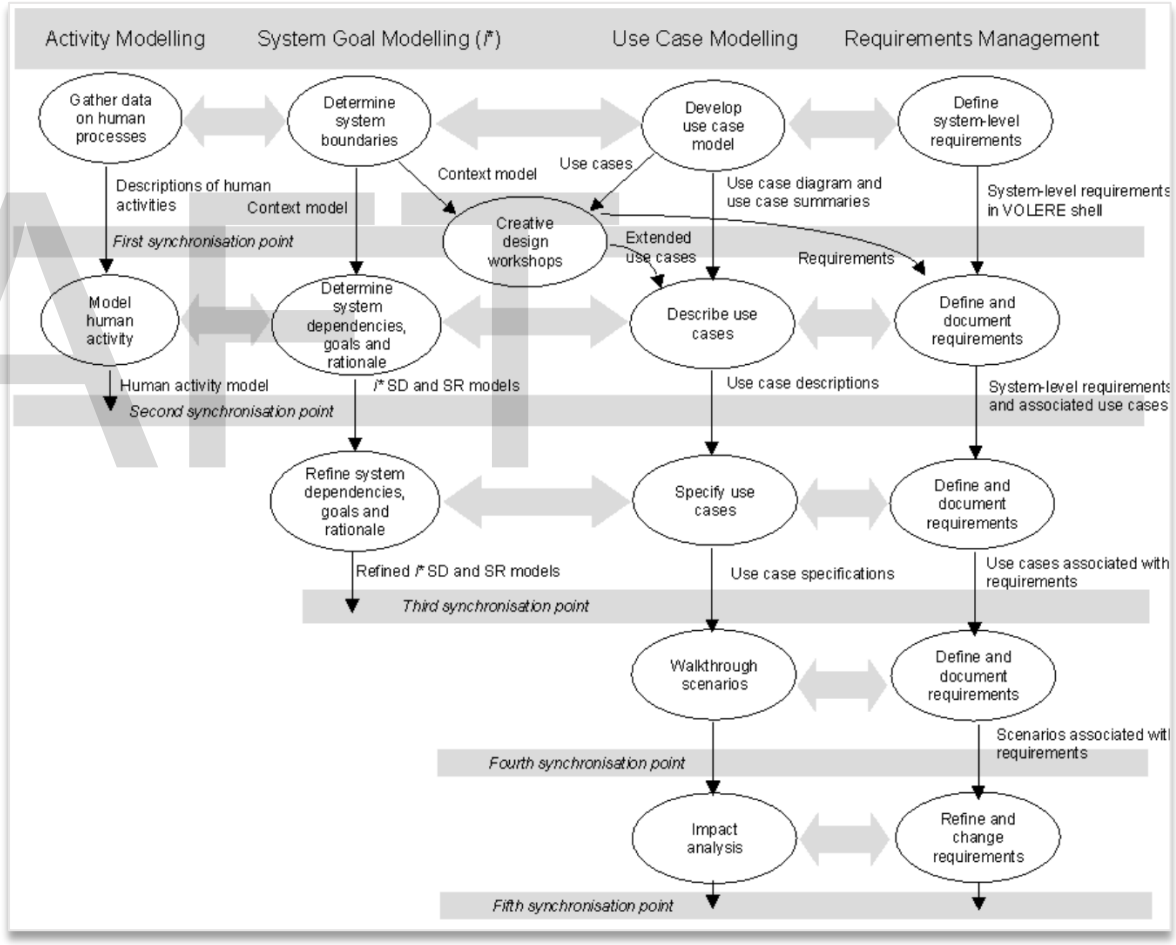


Creativity workshops for software engineering

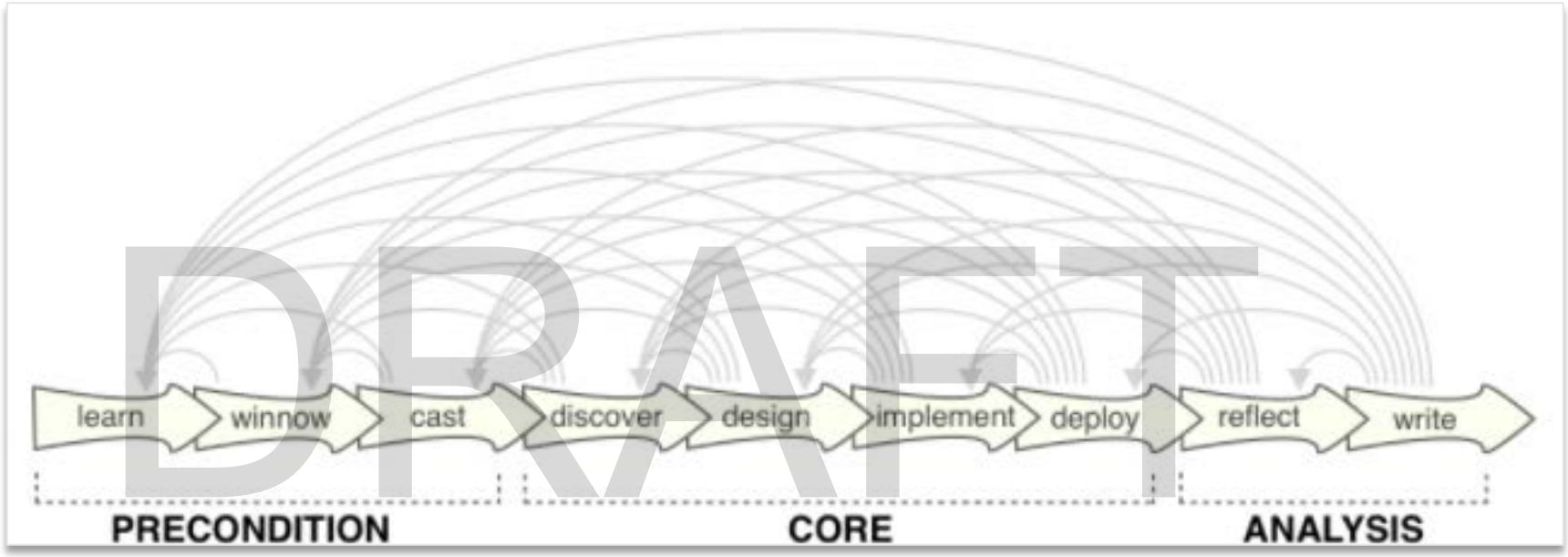
- Similar structures and goals
  [Maiden et al. 2004; Maiden et al. 2005; Maiden et al. 2007;Jones et al. 2007; Jones et al. 2008; Dove. 2015]

- Common parameters [Jones 2007]
  - Participants: 8 – 25
  - Duration: 2 hrs – 2 days
  - Ideas: hundred per workshop

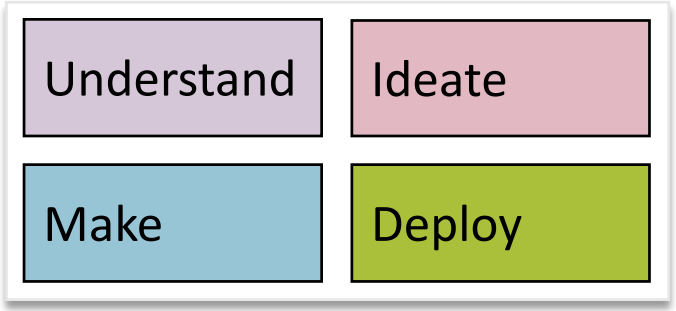
- Part of larger requirements engineering processes
  [Jones and Maiden 2005]



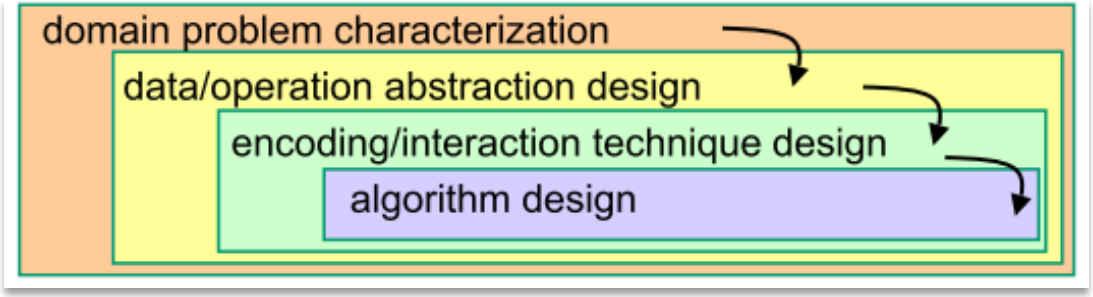
Vis design: iterative, messy, and cascading



[Sedlmair et al. 2012]



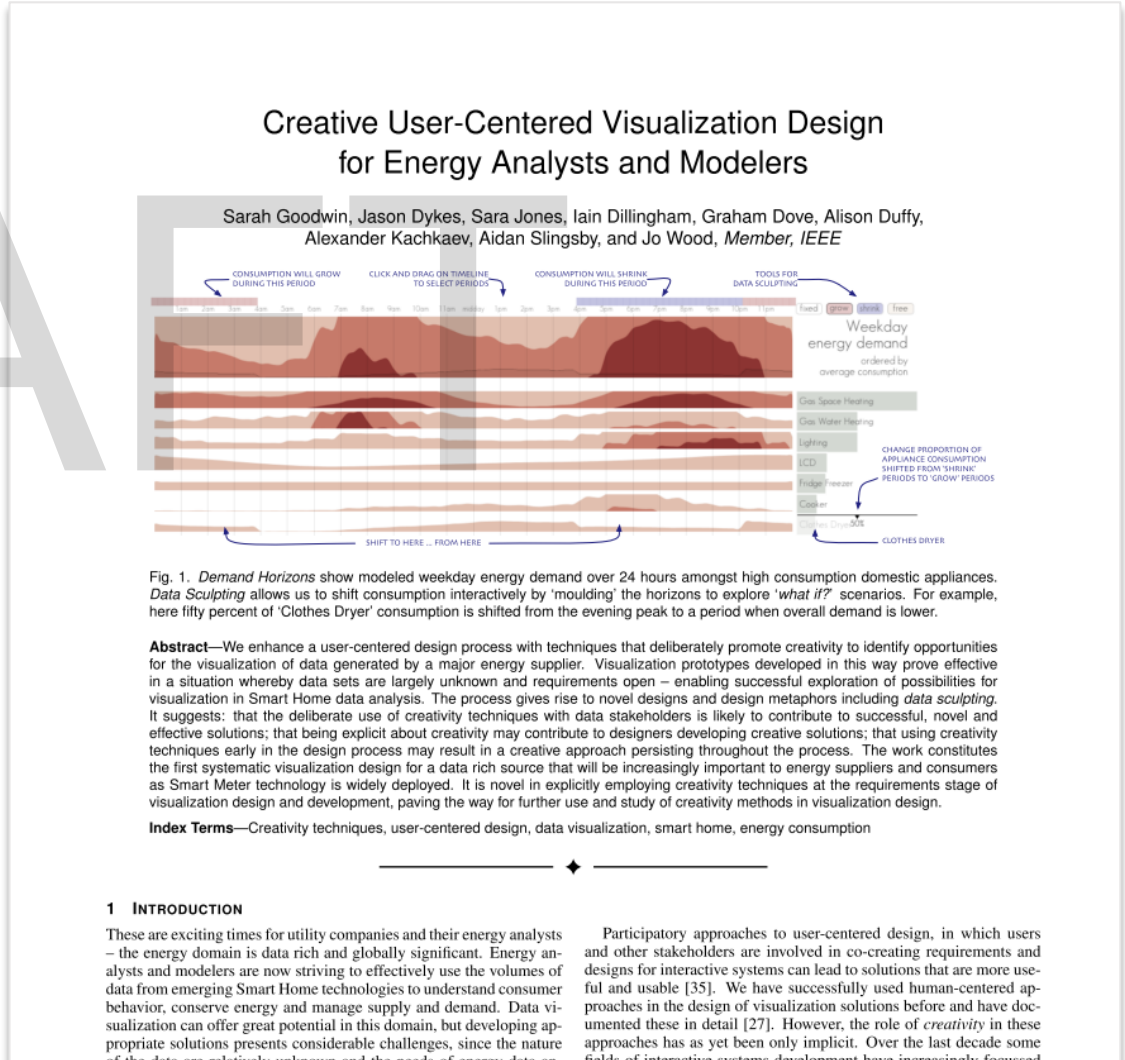
[McKenna et al. 2014]



[Munzner 2009]

Creativity workshops for visualization

- Design study with energy analysts [Goodwin et al. 2013]
- Requirements workshop followed diverge-converge pattern
- Identified key themes for designs
- Additional workshops: design, feedback, and evaluation



Creative User-Centered Visualization Design for Energy Analysts and Modelers

Sarah Goodwin, Jason Dykes, Sara Jones, Iain Dillingham, Graham Dove, Alison Duffy, Alexander Kachkaev, Aidan Slingsby, and Jo Wood, *Member, IEEE*

Fig. 1. *Demand Horizons* show modeled weekday energy demand over 24 hours amongst high consumption domestic appliances. *Data Sculpting* allows us to shift consumption interactively by 'moulding' the horizons to explore '*what if?*' scenarios. For example, here fifty percent of 'Clothes Dryer' consumption is shifted from the evening peak to a period when overall demand is lower.

Abstract—We enhance a user-centered design process with techniques that deliberately promote creativity to identify opportunities for the visualization of data generated by a major energy supplier. Visualization prototypes developed in this way prove effective in a situation whereby data sets are largely unknown and requirements open – enabling successful exploration of possibilities for visualization in Smart Home data analysis. The process gives rise to novel designs and design metaphors including *data sculpting*. It suggests: that the deliberate use of creativity techniques with data stakeholders is likely to contribute to successful, novel and effective solutions; that being explicit about creativity may contribute to designers developing creative solutions; that using creativity techniques early in the design process may result in a creative approach persisting throughout the process. The work constitutes the first systematic visualization design for a data rich source that will be increasingly important to energy suppliers and consumers as Smart Meter technology is widely deployed. It is novel in explicitly employing creativity techniques at the requirements stage of visualization design and development, paving the way for further use and study of creativity methods in visualization design.

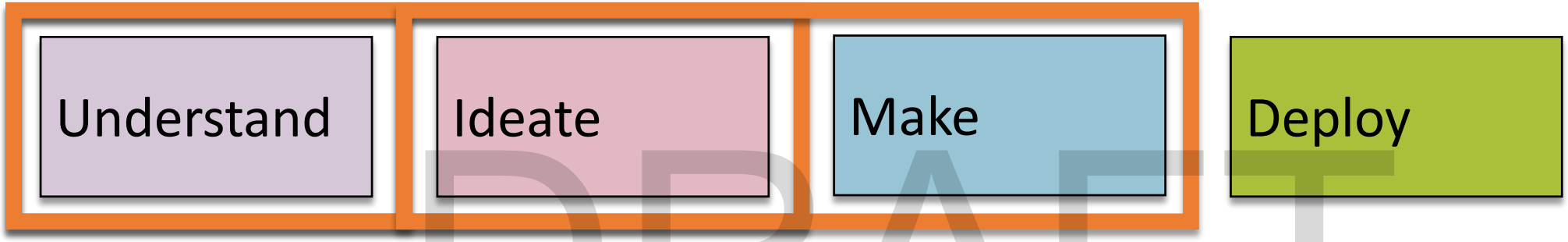
Index Terms—Creativity techniques, user-centered design, data visualization, smart home, energy consumption

1 Introduction

These are exciting times for utility companies and their energy analysts – the energy domain is data rich and globally significant. Energy analysts and modelers are now striving to effectively use the volumes of data from emerging Smart Home technologies to understand consumer behavior, conserve energy and manage supply and demand. Data visualization can offer great potential in this domain, but developing appropriate solutions presents considerable challenges, since the nature

Participatory approaches to user-centered design, in which users and other stakeholders are involved in co-creating requirements and designs for interactive systems can lead to solutions that are more useful and usable [35]. We have successfully used human-centered approaches in the design of visualization solutions before and have documented these in detail [27]. However, the role of *creativity* in these approaches has as yet been only implicit. Over the last decade some

Creativity workshops in design studies



[Lisle and Kerzner 2017]
[Boyko et al. 2010]
[Walker et al. 2013]
[Goodwin et al. 2013]
[Kerzner et al. 2015]
[Goodwin et al. 2016]
[Kerzner et al. 2017]
[Nobre et al. 2017 (anticipated)]
…

[Goodwin et al. 2013]
[Roger et al. 2016]
[Roger et al. 2017 (anticipated)]

- Despite repeated success, no guidelines exist for visualization creativity workshops

[McKenna et al. 2014]

Completed formative work: Visual vulnerability analysis

- **E. Kerzner**, L. A. Butler, C. Hansen, and M. Meyer. A shot at visual vulnerability analysis. Computer Graphics Forum, 34(3), 2015
- C. Gribble, A. Naveros, and **E. Kerzner**. Multi-hit ray traversal. J. Computer Graphics Techniques, 3(1), 2014

Contributions

Primary contributions

- Reflection on role of creativity methods in this project
- Problem characterization, data abstraction, and tasks analysis
- Shotviewer – a validated prototype tool

Secondary contributions

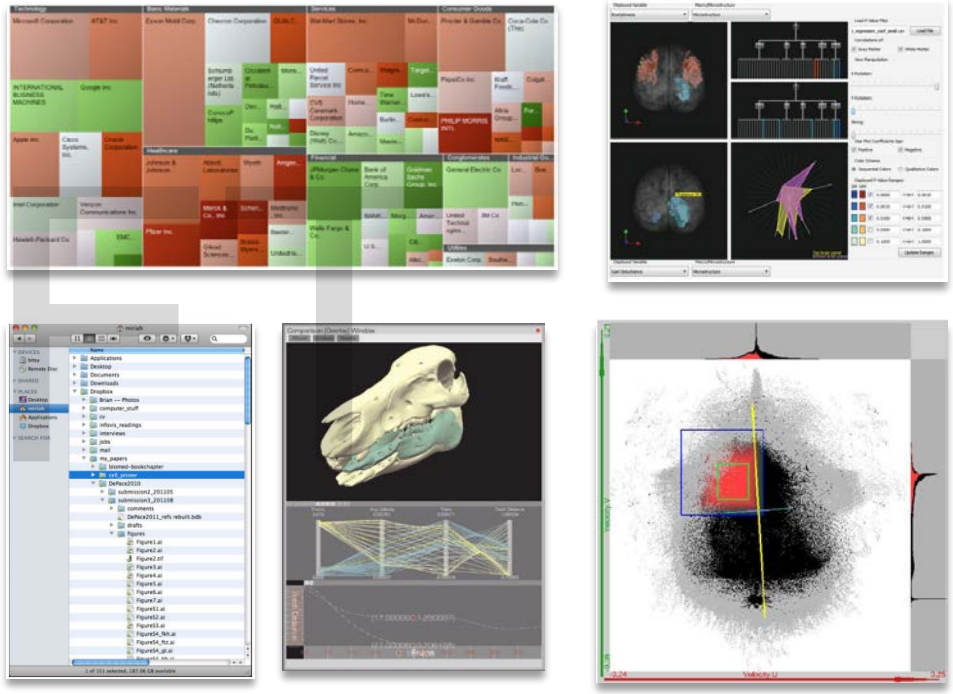
- Strategy for view-design parallelism
- Four recommendations for working in large orgs with sensitive data
- Algorithm for increased efficiency of simulations

Challenges of this design study

- Remote collaboration
- Limited face time
- Large organization
- No relationships

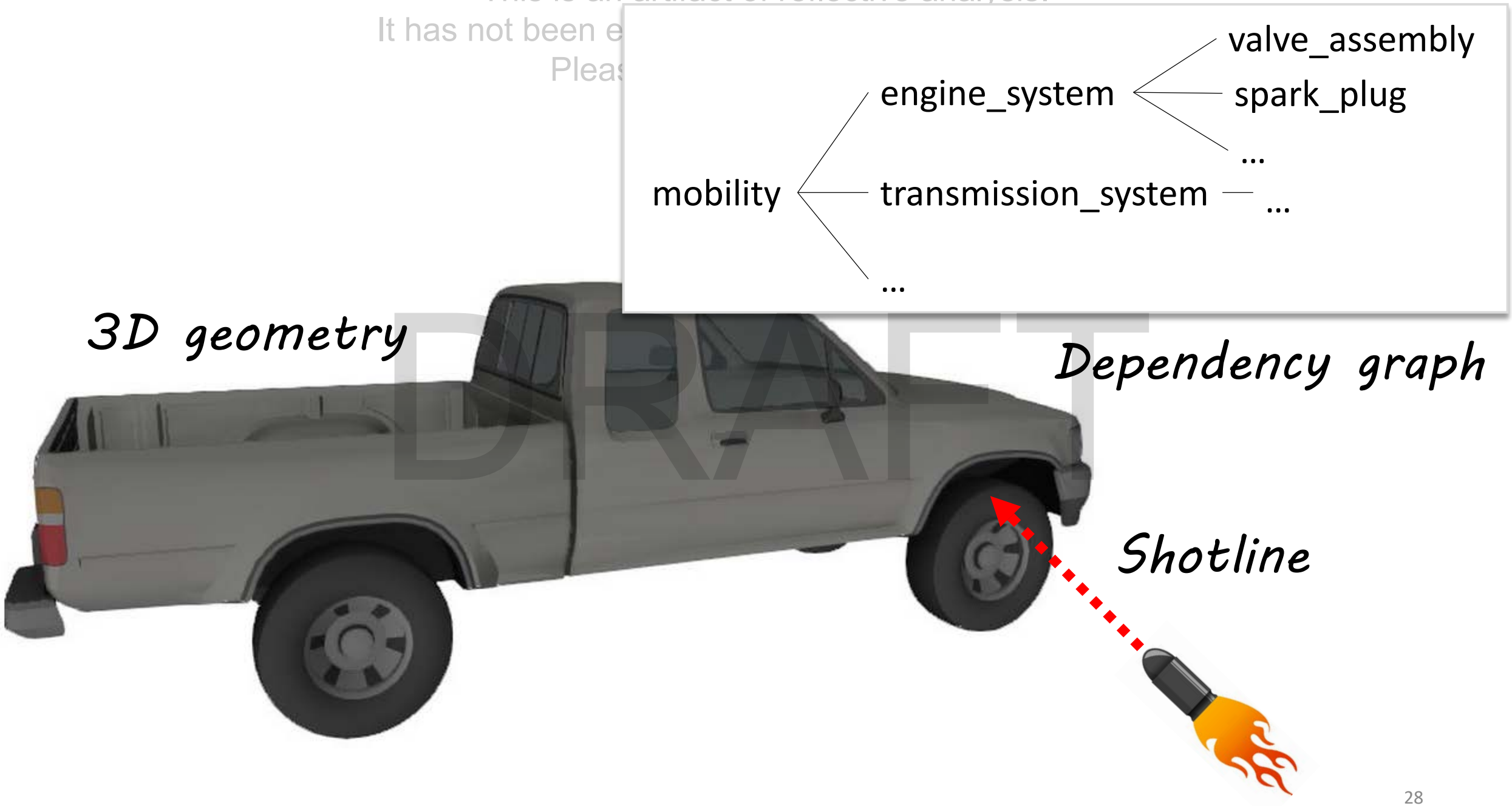
Creativity methods to navigate challenges

- Half day meetings with analysts and managers
- Visualization awareness workshops
  [Koh and Slingsby 2011]
- Brainstorming
  [Osborn 1953]

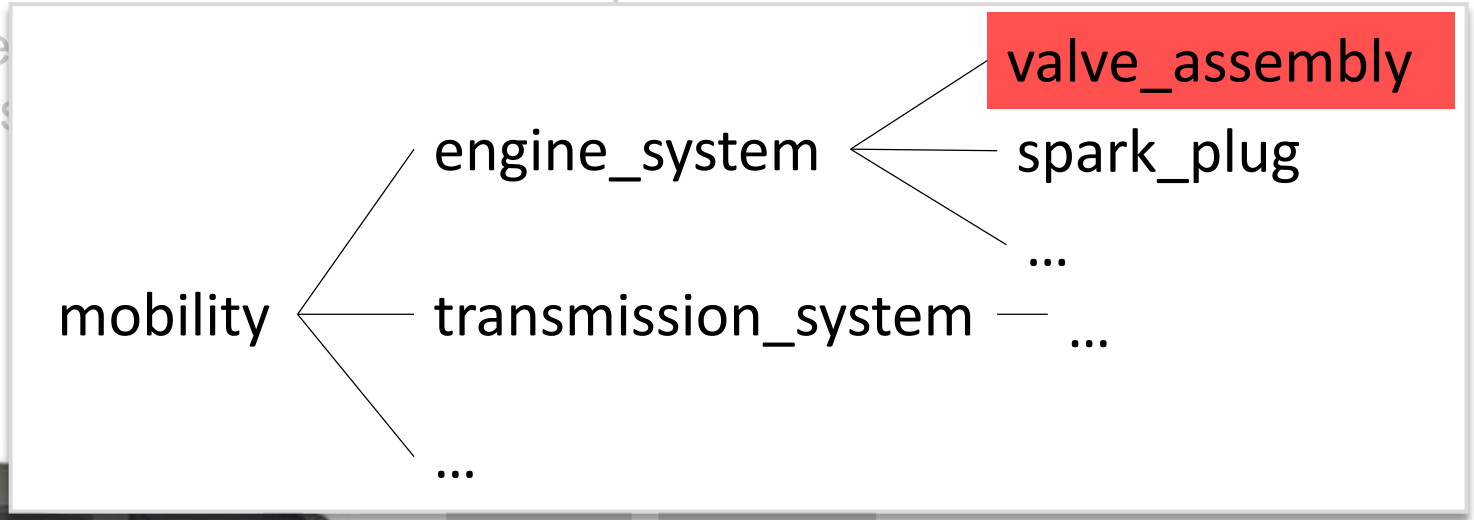


Creativity methods outcomes

- More engagement – increased meeting frequency
- Access to developers and existing applications
- Abstract understanding of domain problem and analysis tasks

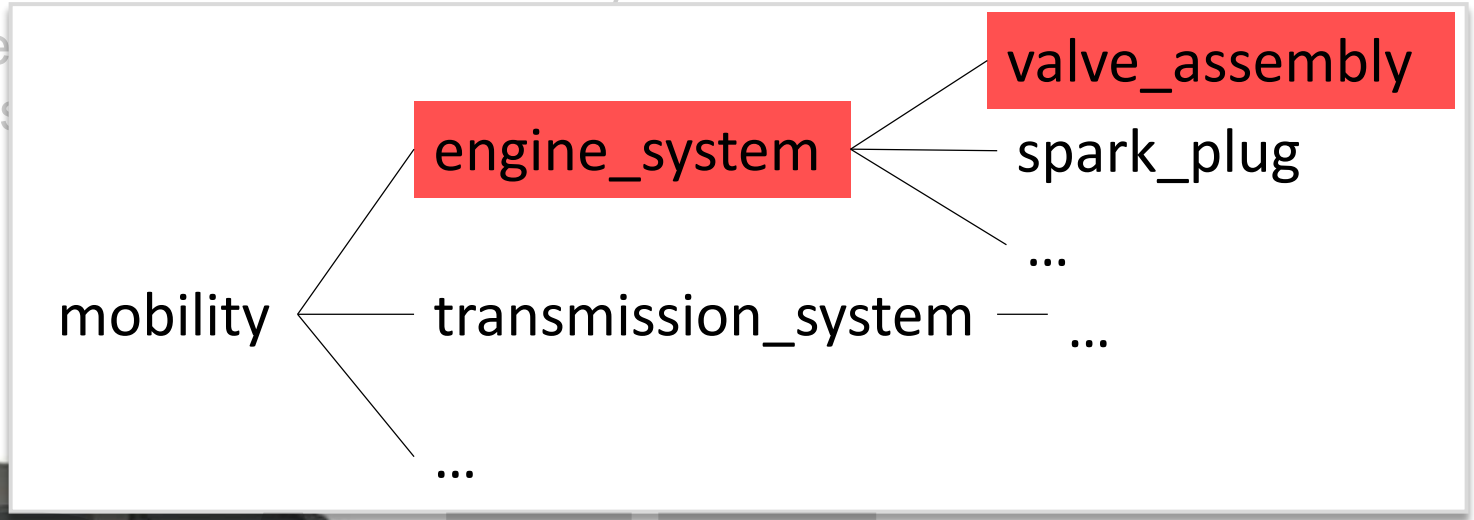


3D geometry



Dependency graph

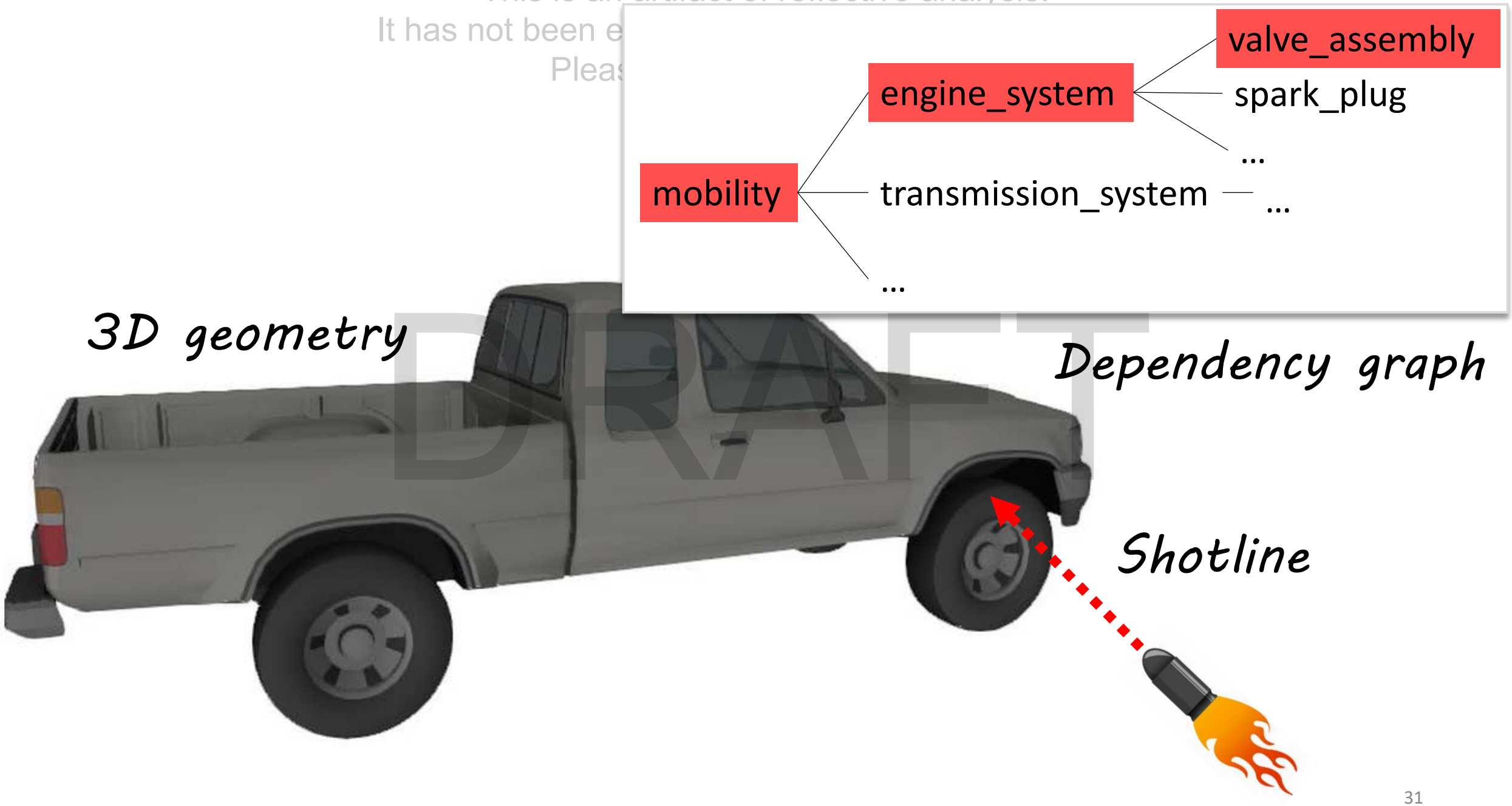
Shotline



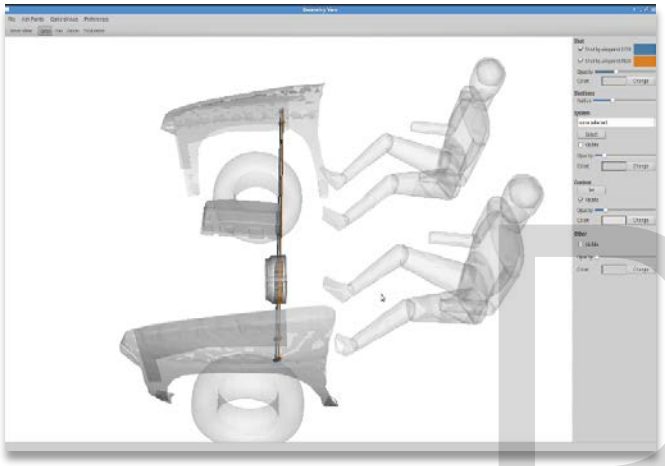
3D geometry

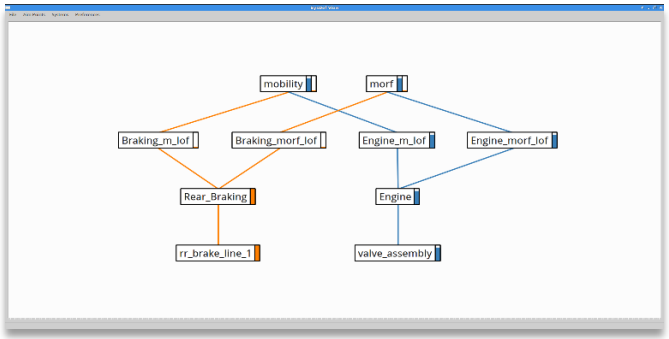
Dependency graph

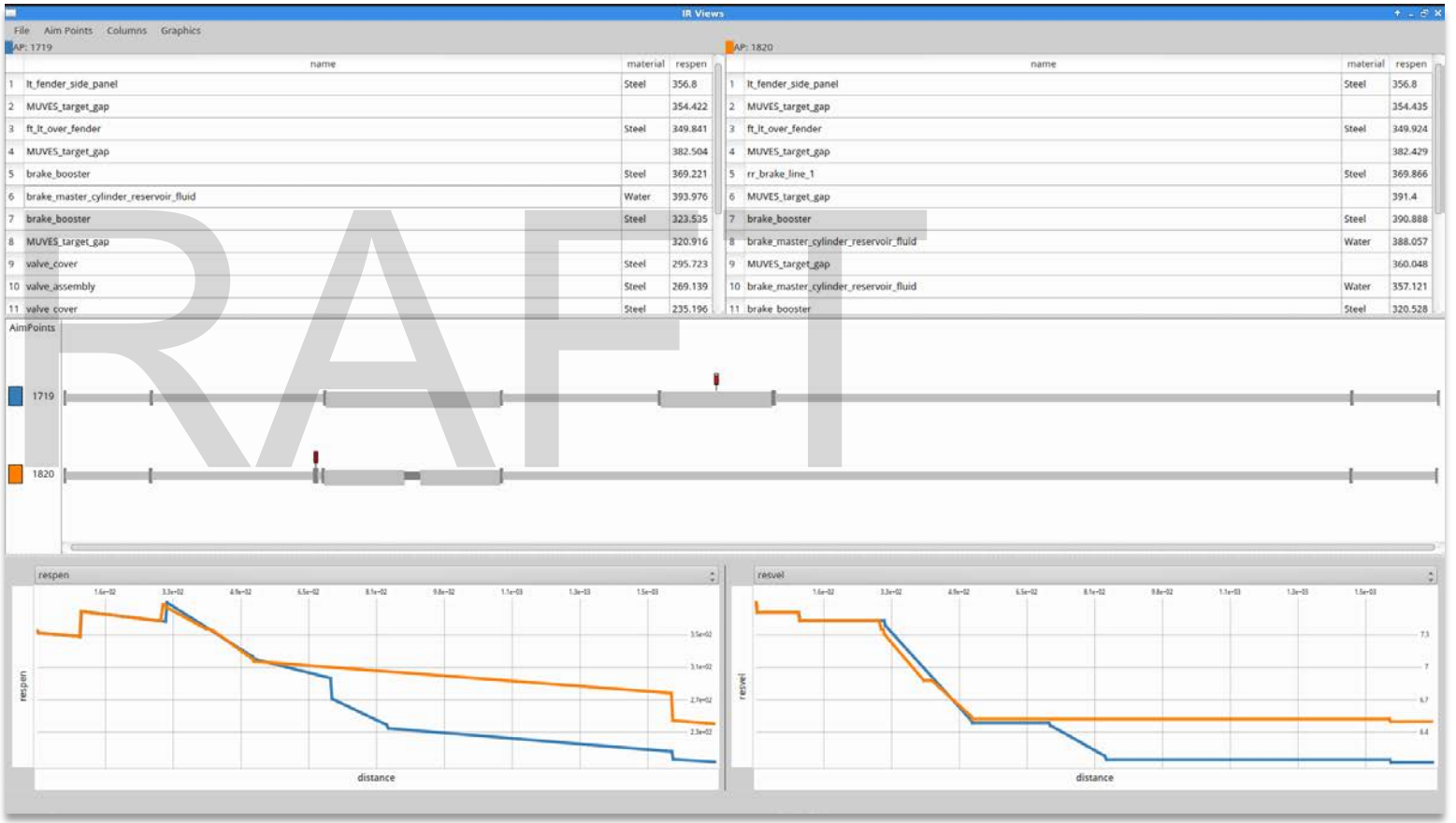
Shotline



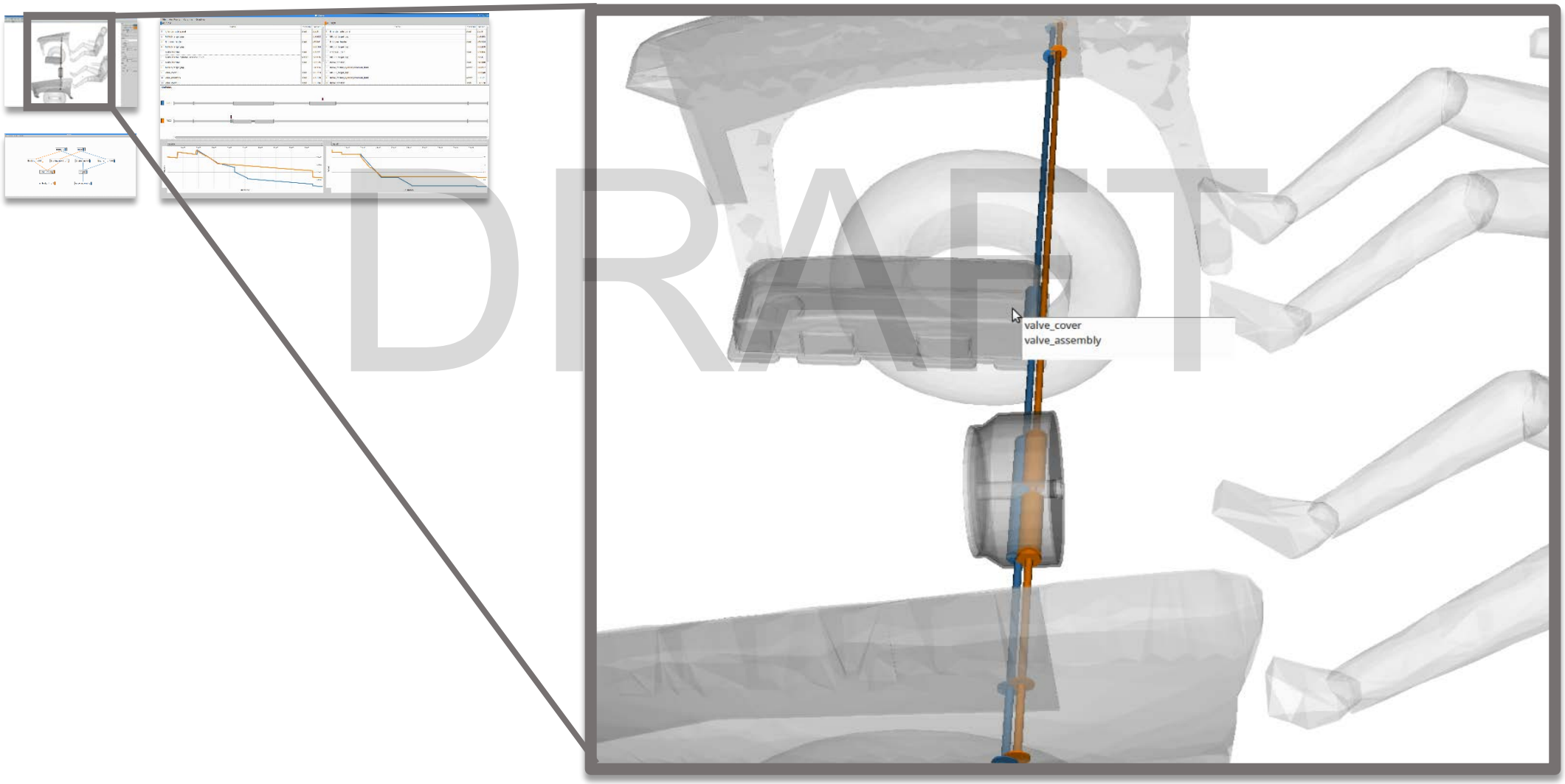
Shotviewer: spatial + non-spatial visualization



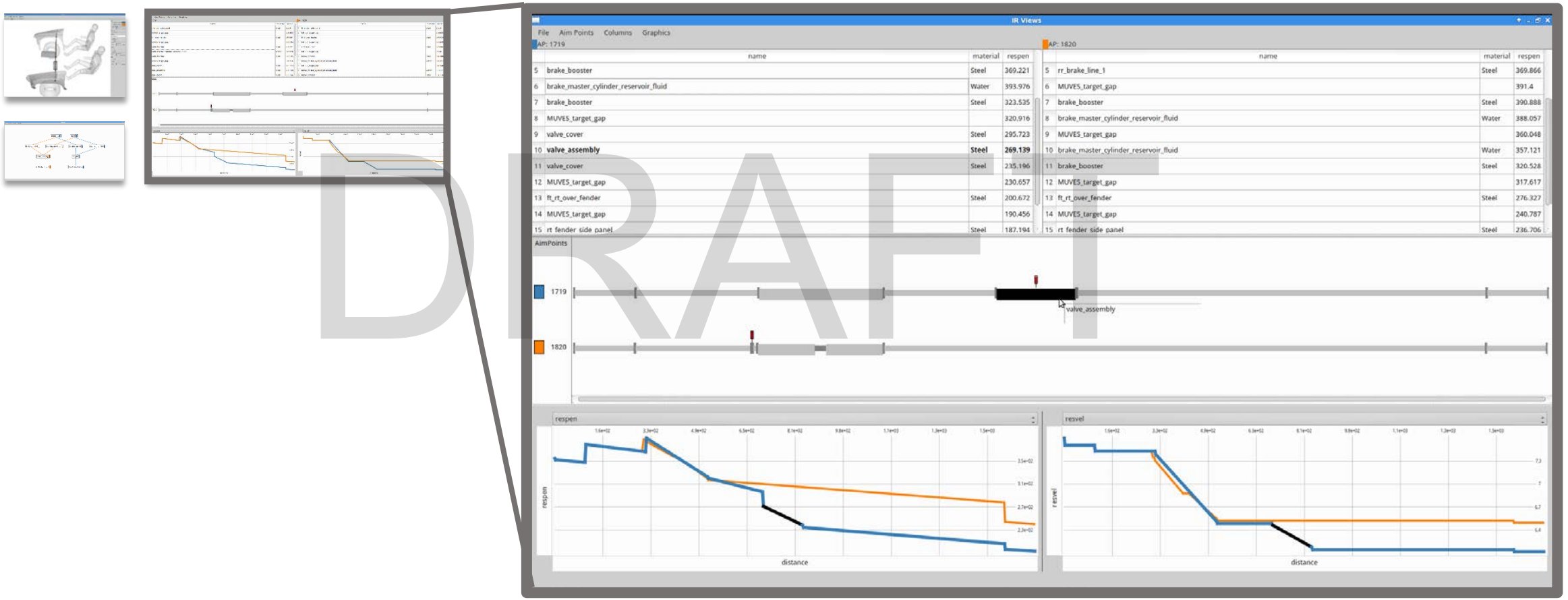




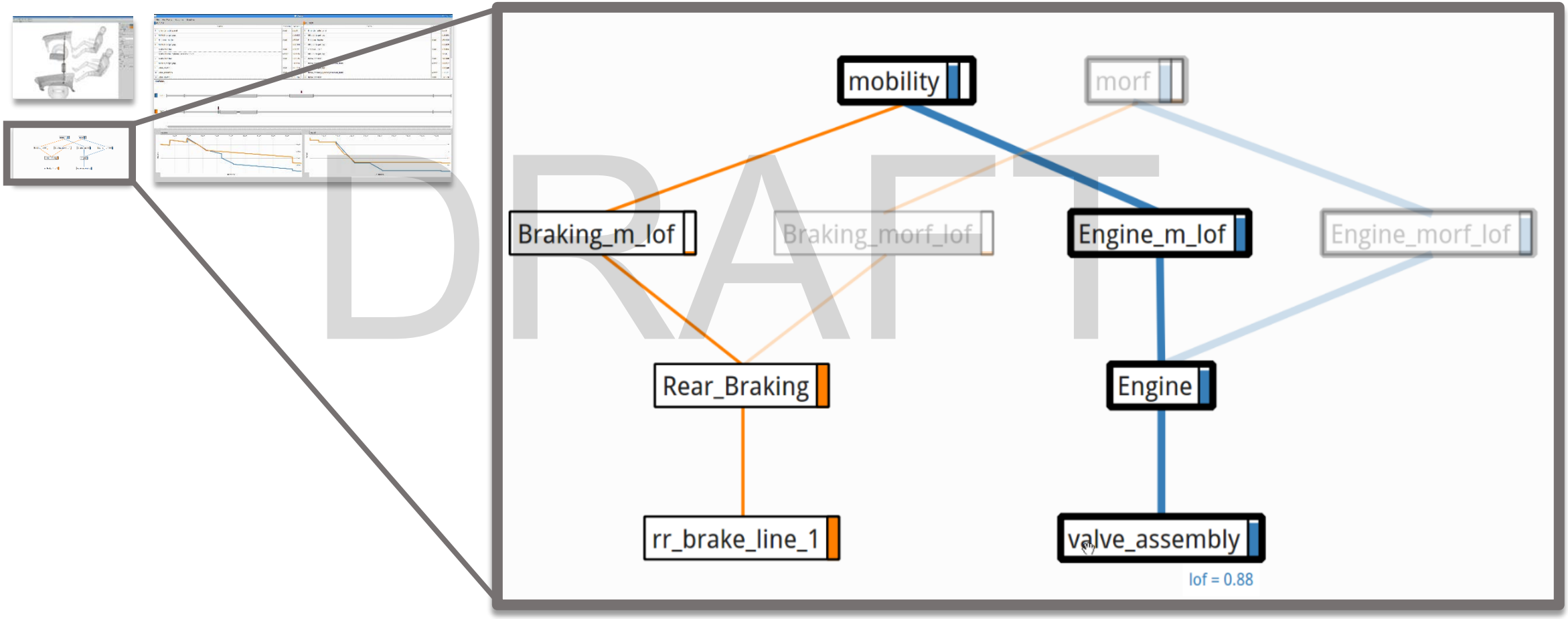
Shot spatial context



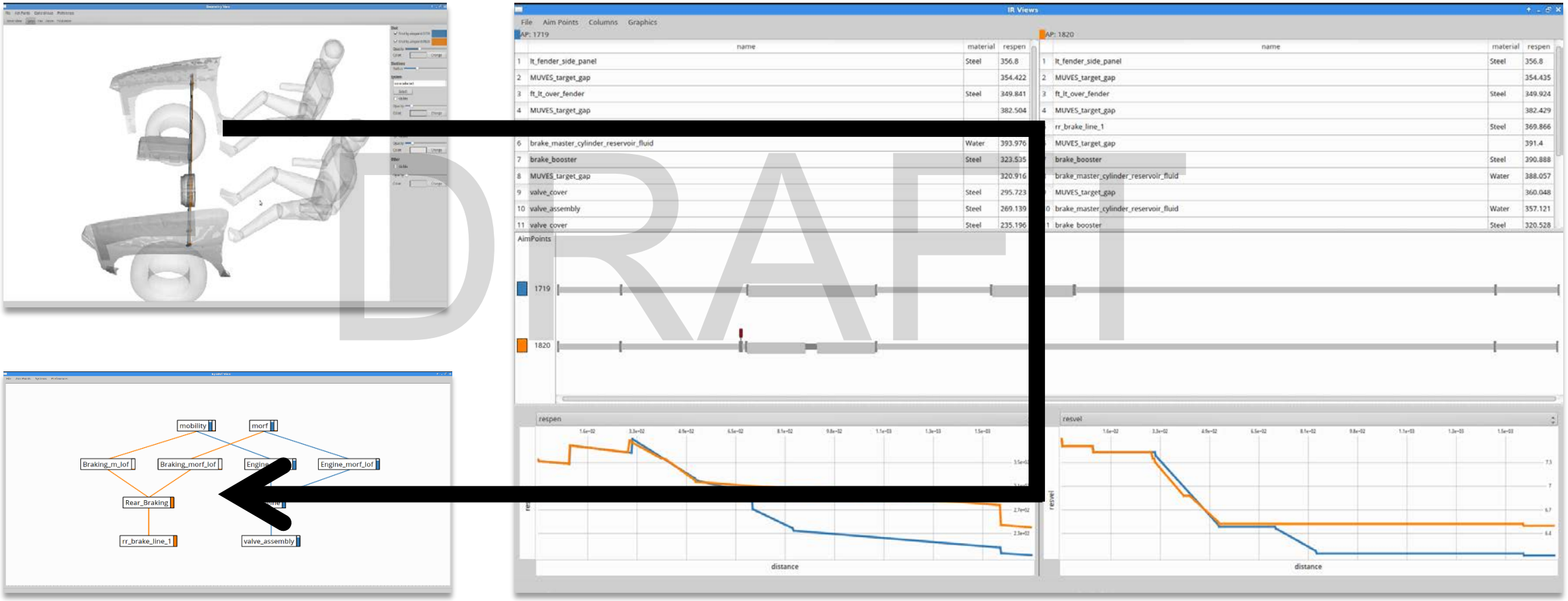
Shot degradation and damage



Shot systemic impact



Shotviewer: spatial + non-spatial visualization



Summary

- Design study with defense analysts
- Reflection on creativity methods
- Vulnerability data + task analysis and prototype tool
- Publications
  - **E. Kerzner**, L. A. Butler, C. Hansen, and M. Meyer. A shot at visual vulnerability analysis. Computer Graphics Forum, 34(3), 2015.
  - C. Gribble, A. Naveros, and **E. Kerzner**. Multi-hit ray traversal. J. Computer Graphics Techniques, 3(1), 2014

Completed formative work: Connectome visualization

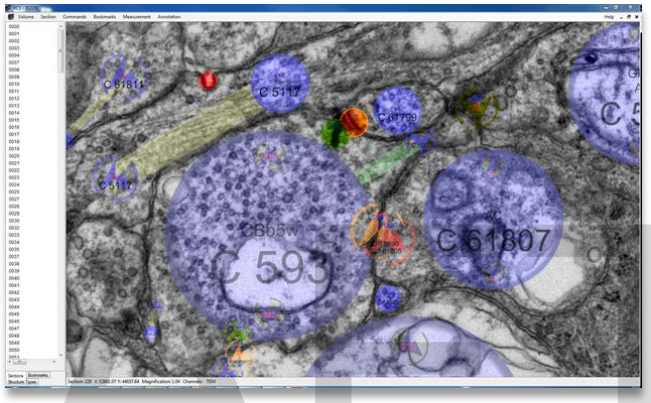
- **E. Kerzner**, A. Lex, T. Urness, C. L. Sigulinsky, B. W. Jones, R. E. Marc, and M. Meyer. Graffinity: visualizing connectivity in large graphs. Computer Graphics Forum, 34(3), 2017
- J. S. Lauritzen, C. L. Sigulinsky, J. R. Anderson, M. Kalloniatis, N. T. Nelson, D. P. Emrich, C. Rapp, N. Mccarthy, **E. Kerzner**, M. Meyer, B. W. Jones, and R. E. Marc. Rod-cone crossover connectome of mammalian bipolar cells. J. of Comparative Neurology, 2016.

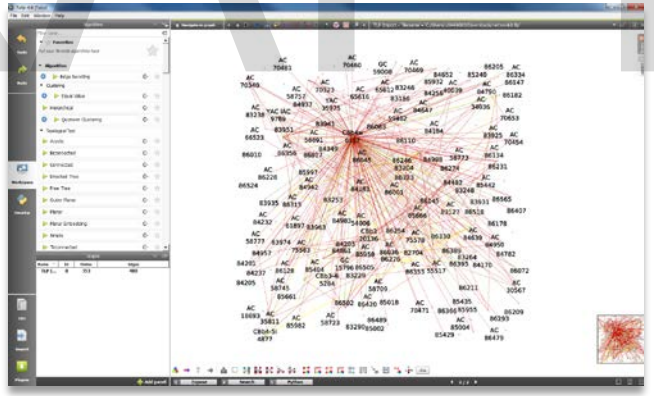
Contributions

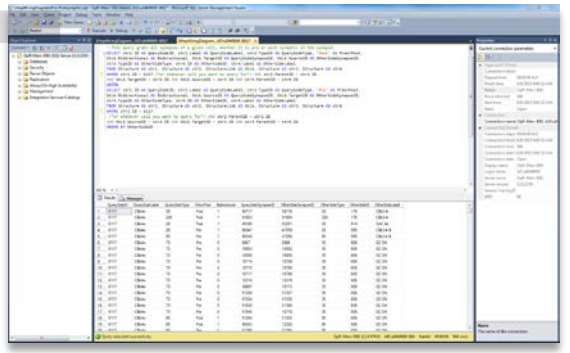
- Reflection on creativity workshop
- Task analysis and two new visualization techniques
- Graffinity – a prototype tool for connectivity analysis
- Results appear in the Journal of Comparative Neurology

Challenges of this design study

- Existing tools
- Diverse users
- *“Talk to my post-doc”*







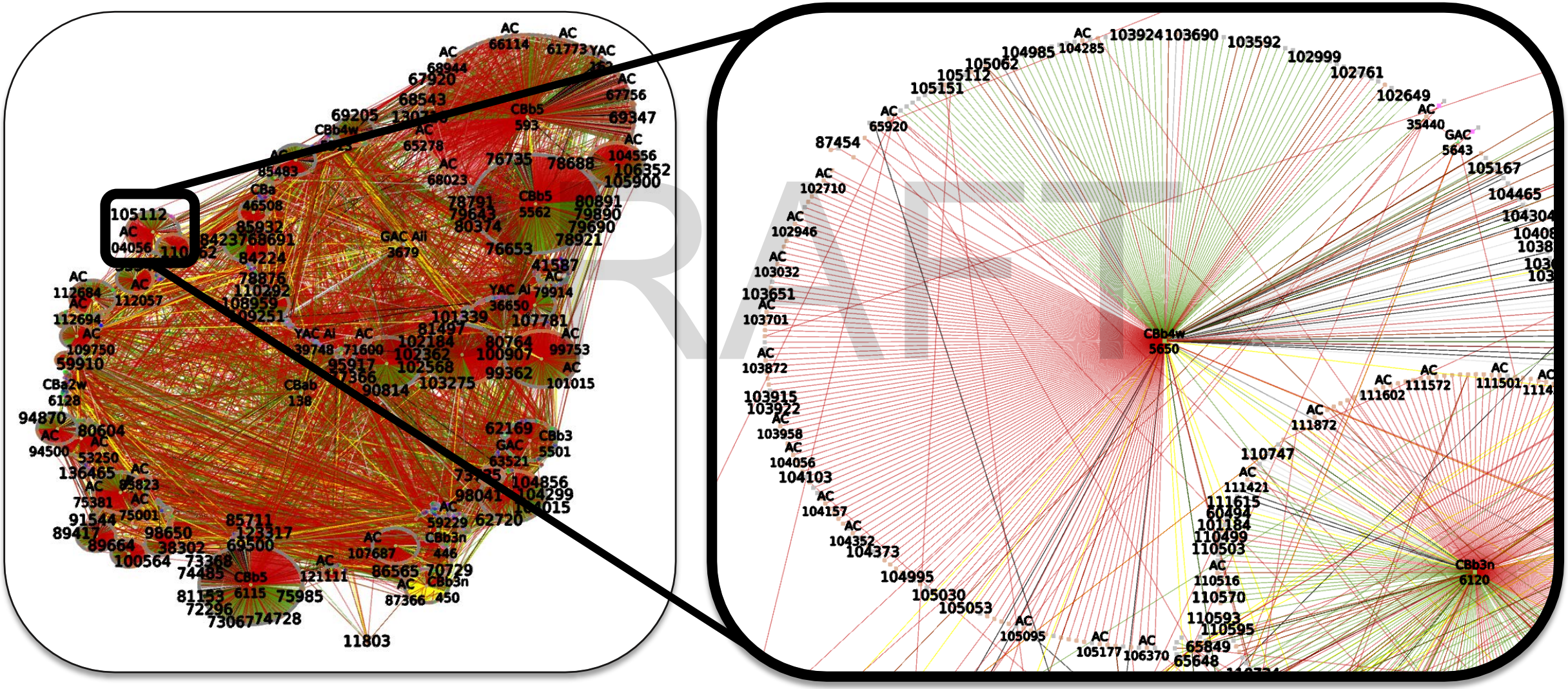
Creativity workshop

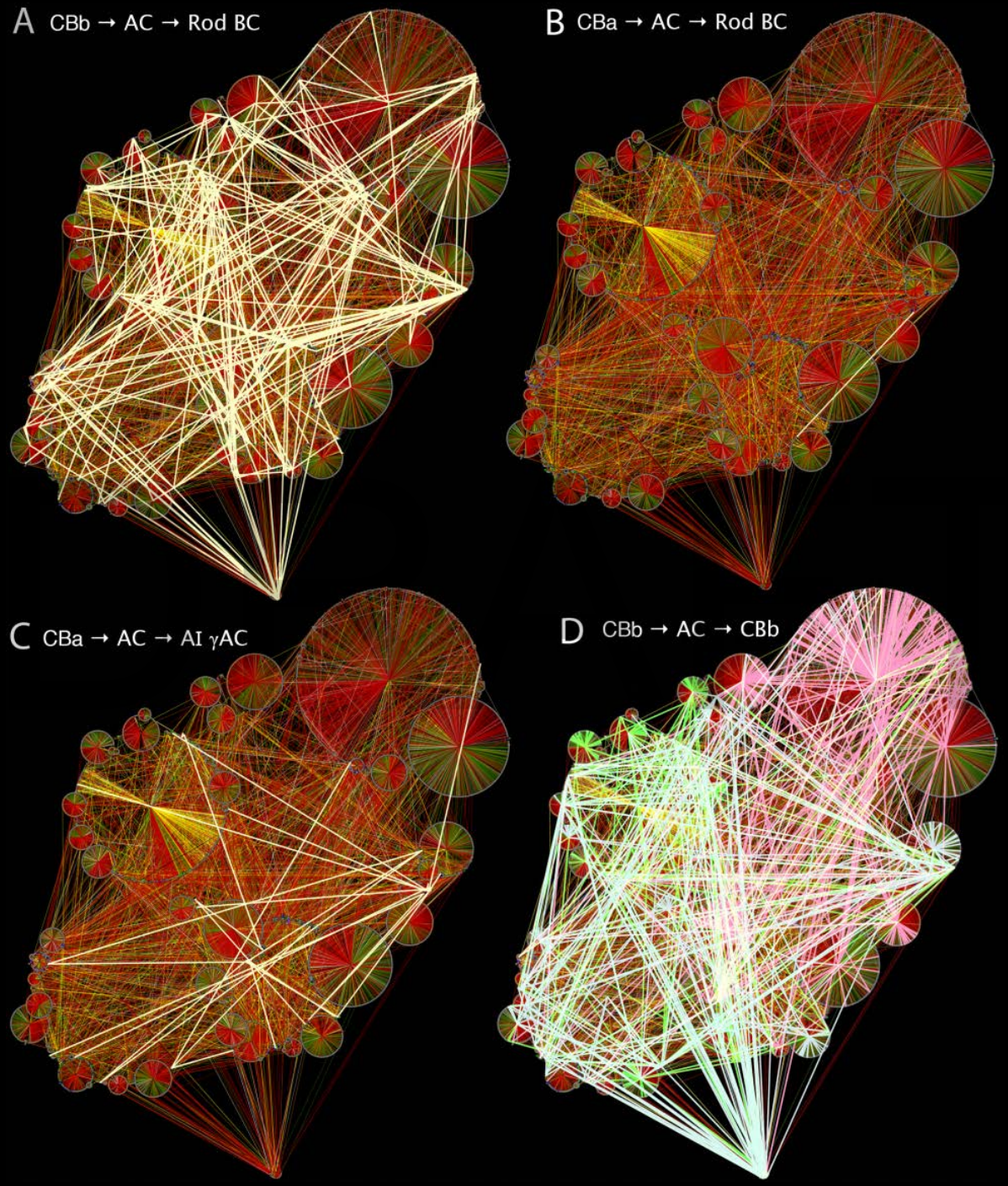
- Motivation
  - Wanted structured activities
  - Success with previous methods
- Based on Goodwin et al. [2013]
- Surprisingly successful

Creativity workshop outcomes

- Articulated domain challenges
- Engaged all stakeholders – increased meetings with senior analysts
- Identified shared needs: visualizing multi-hop relationships i.e., connectivity analysis

Connectome: a large multivariate graph





[Lauritzen et al. 2016]

Graffinity

Show list | Show panel

Connectome Query

Len	2
Start	CBb3n (label) × CBb5 (label) × CBb4w (label) × CBb4 (label) × CBb3 (label) × CBb5w (label) ×
Edge	* (wildcard) ×
Node	AC (label) × AC OFF (label) × AC ON (label) × YAC (label) × YAC Ai (label) × YAC OFF (label) ×
Edge	* (wildcard) ×
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Show cypher | Submit

Connectivity Matrix Controls

Aggregate rows	none
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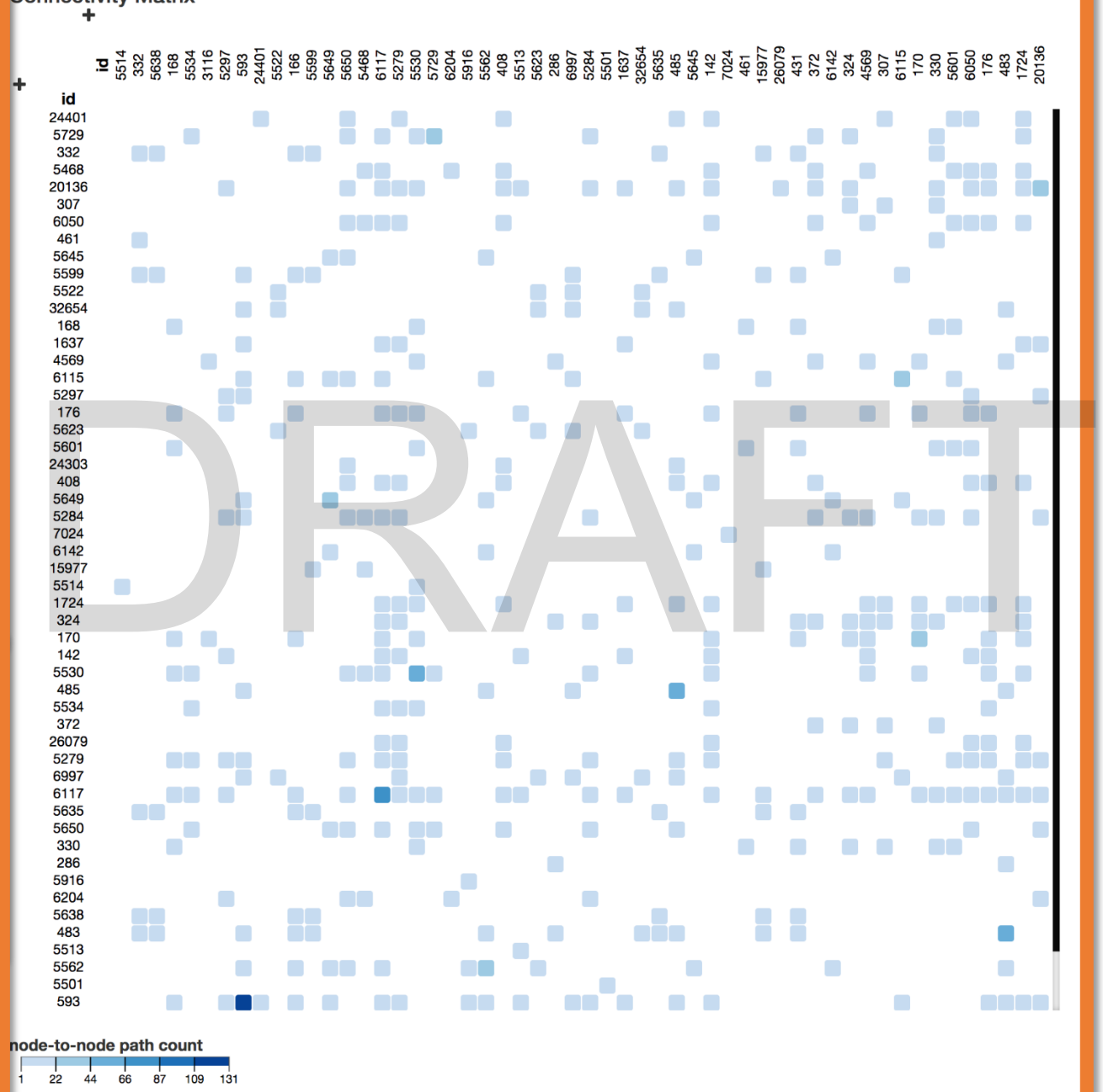
Sort order	optimal leaf
Metric	path count
Encoding	colormap
Scale	linear

Connectivity Matrix



Graffinity

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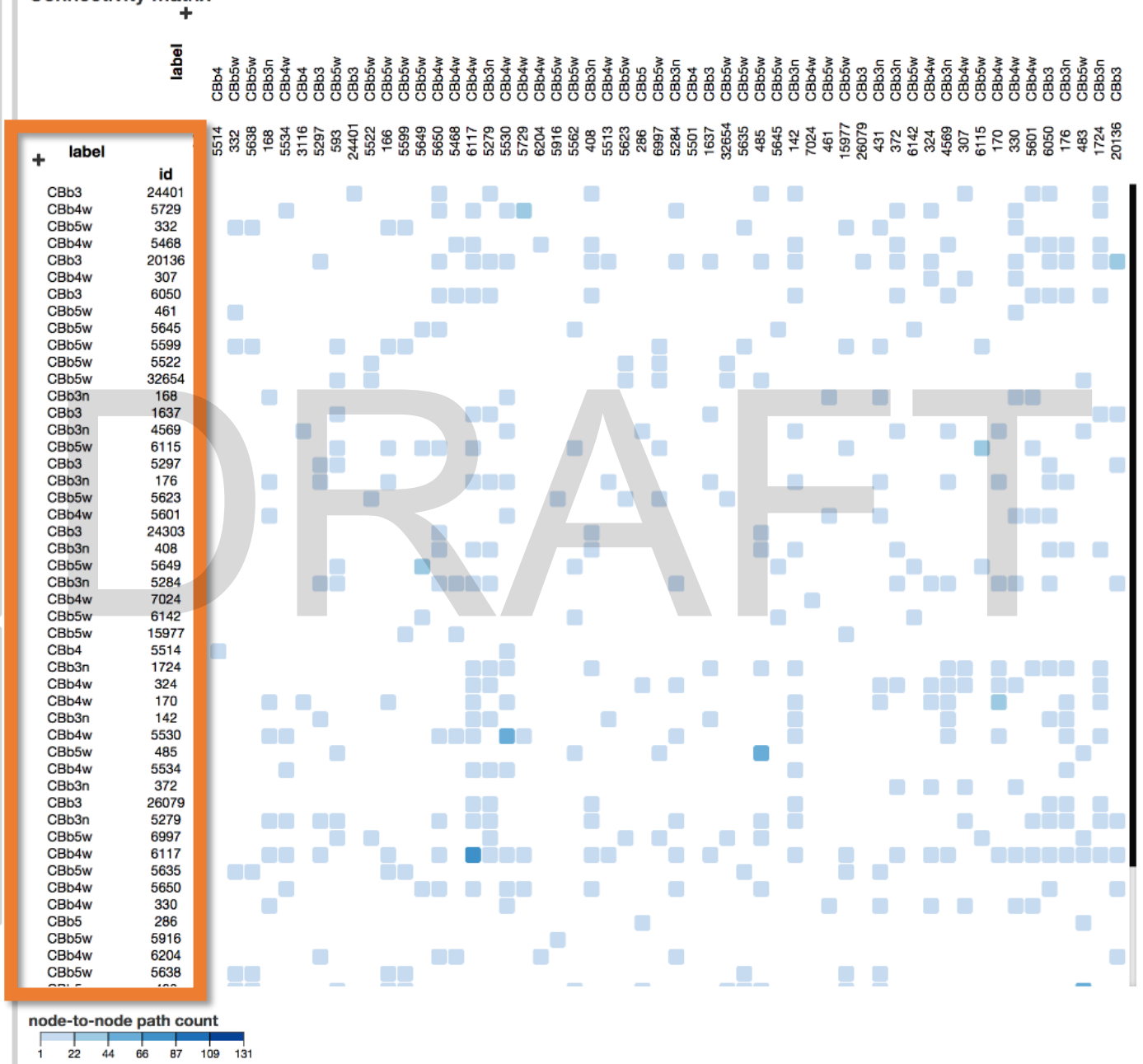
Scale: linear

Connectivity Matrix



Graffinity

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Connectome Query

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Connectivity Matrix Controls

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Sort order: optimal leaf

Metric: path count

Encoding: colormap

Scale: linear

Connectivity Matrix

label | id

node-to-node path count

1 22 44 66 87 109 131

Graffinity

Hide list | Show panel

Connectome Query

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Show cypher | Submit

Connectivity Matrix Controls

Aggregate rows: none

Aggregate cols: none

Sort order: custom

Metric: path count

Encoding: colormap

Scale: linear

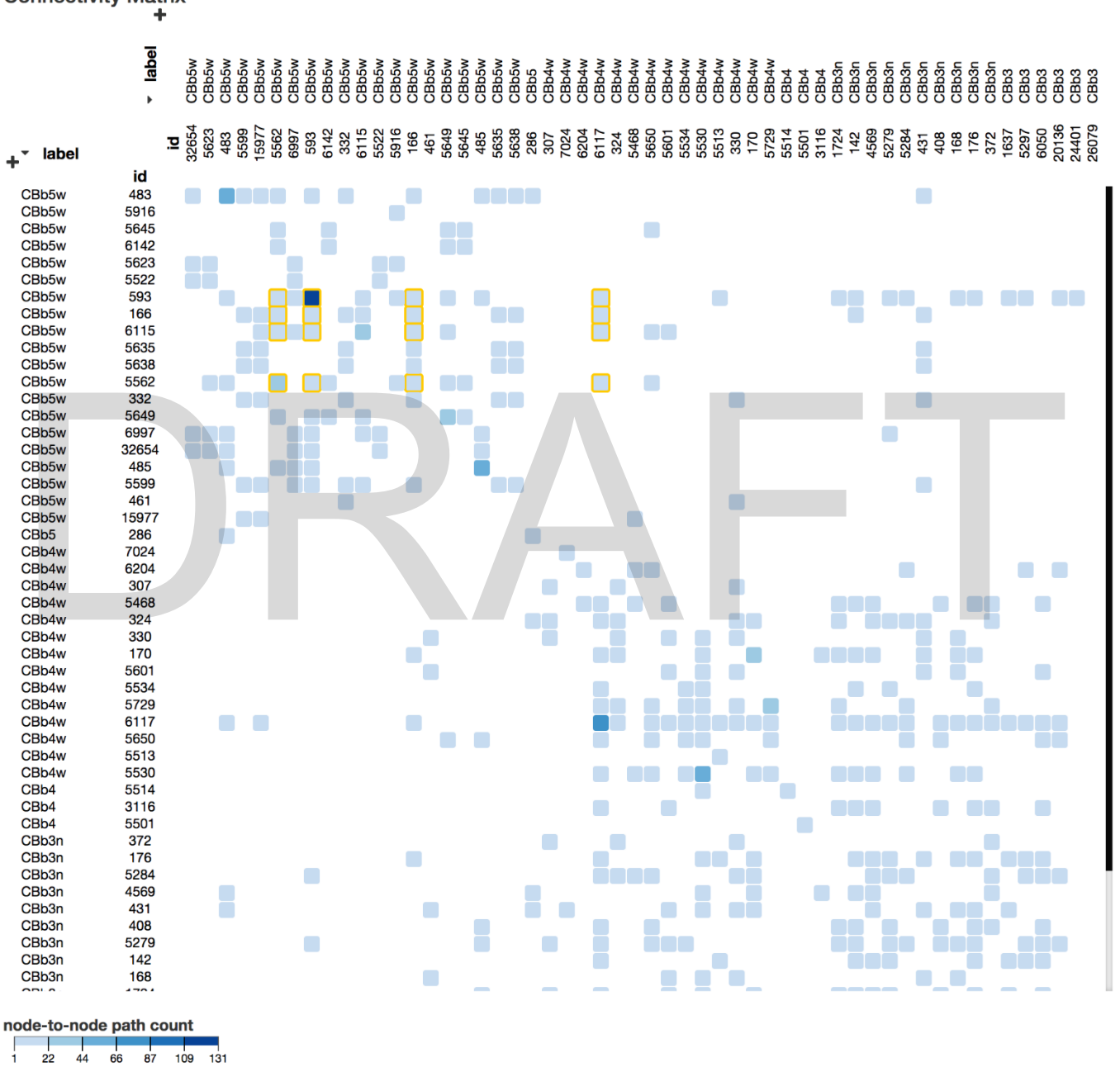
Int. Node Table Controls

Aggregate rows: none

Metric: path count

Encoding: colormap

Connectivity Matrix



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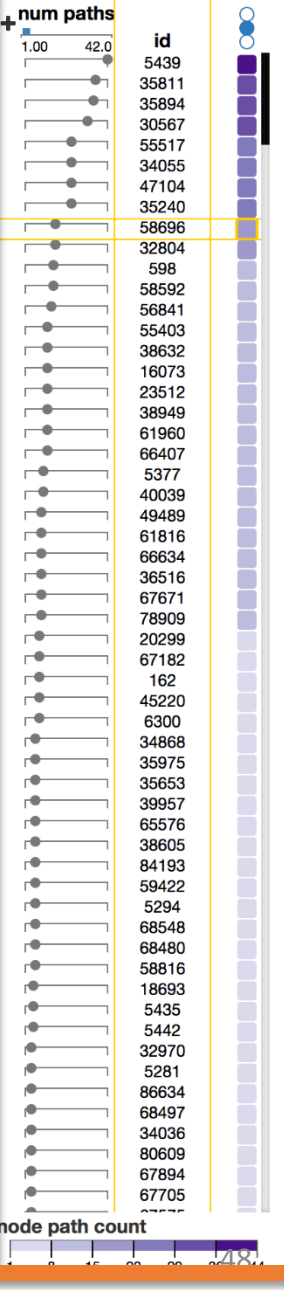

Graffinity

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Connectome Query

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Show cypher | Submit

Connectivity Matrix Controls

Aggregate rows: none

Aggregate cols: none

Sort order: custom

Metric: path count

Encoding: colormap

Scale: linear

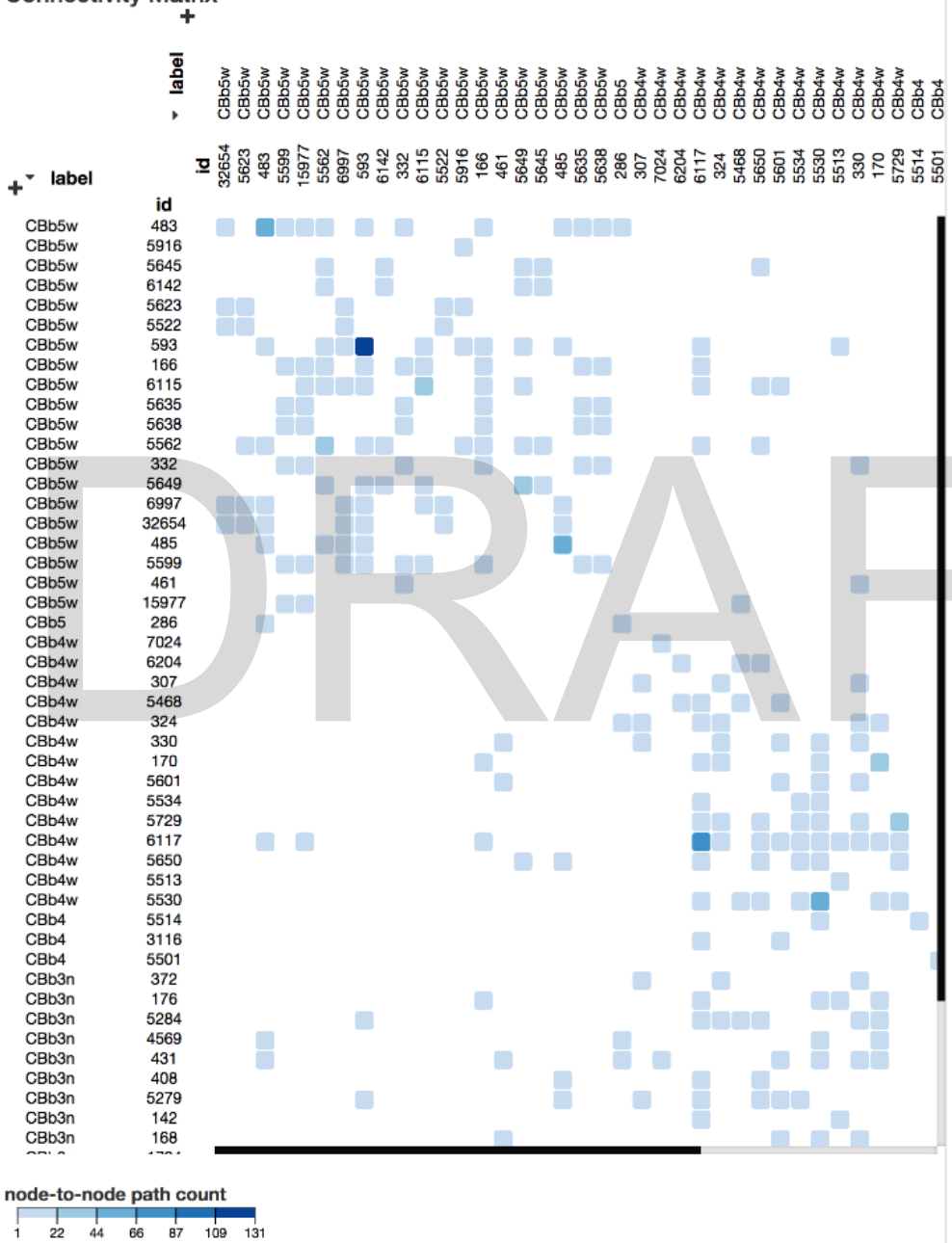
Int. Node Table Controls

Aggregate rows: none

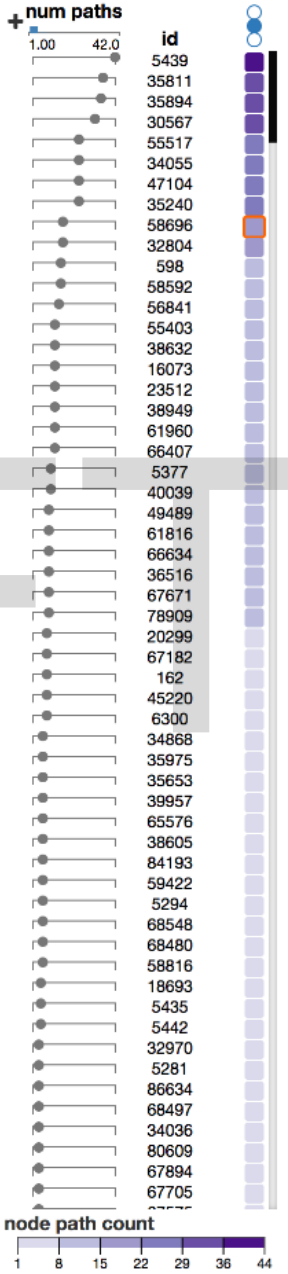
Metric: path count

Encoding: colormap

Connectivity Matrix



Int. Node Table



Node Link | Path List

Path List

Paths	Len	Freq
5562 CBb5w — 58696 AC — 6117 CBb4w	3	1
5562 CBb5w — 58696 AC — 5562 CBb5w	3	1
5562 CBb5w — 58696 AC — 593 CBb5w	3	1
5562 CBb5w — 58696 AC — 166 CBb5w	3	1
6115 CBb5w — 58696 AC — 6117 CBb4w	3	1
6115 CBb5w — 58696 AC — 5562 CBb5w	3	1
6115 CBb5w — 58696 AC — 593 CBb5w	3	1
6115 CBb5w — 58696 AC — 166 CBb5w	3	1
166 CBb5w — 58696 AC — 6117 CBb4w	3	1
166 CBb5w — 58696 AC — 5562 CBb5w	3	1
166 CBb5w — 58696 AC — 593 CBb5w	3	1
166 CBb5w — 58696 AC — 166 CBb5w	3	1
593 CBb5w — 58696 AC — 6117 CBb4w	3	1
593 CBb5w — 58696 AC — 5562 CBb5w	3	1
593 CBb5w — 58696 AC — 593 CBb5w	3	1
593 CBb5w — 58696 AC — 166 CBb5w	3	1

Summary

- Design study with neuroscientists
- Creativity workshop engaged users and exposed shared needs
- Contributed two new visualization techniques for connectivity analysis
- Publications:
  - **E. Kerzner**, A. Lex, T. Urness, C. L. Sigulinsky, B. W. Jones, R. E. Marc, and M. Meyer. Graffinity: visualizing connectivity in large graphs. Computer Graphics Forum, 34(3), 2017
  - J. S. Lauritzen, C. L. Sigulinsky, J. R. Anderson, M. Kalloniatis, N. T. Nelson, D. P. Emrich, C. Rapp, N. Mccarthy, **E. Kerzner**, M. Meyer, B. W. Jones, and R. E. Marc. Rod-cone crossover connectome of mammalian bipolar cells. J. of Comparative Neurology, 2016.

Proposed remaining work: Visualization creativity workshops

Anticipated publication in IEEE TVCG, co-authored by J. Dykes, S. Goodwin, S. Jones, and M. Meyer

Problem statement

- We have used workshops in 15+ projects, including this proposal's completed formative work

- No formal guidelines exist for *visualization* creativity workshops:
  - Evolution of data and tasks [Tory and Moller 2004]
  - Specialized process models [Sedlmair et al. 2012]
  - Importance of data and abstraction [Munzner 2009]
  - Mutual influence of stakeholders [McCurdy et al. 2016]

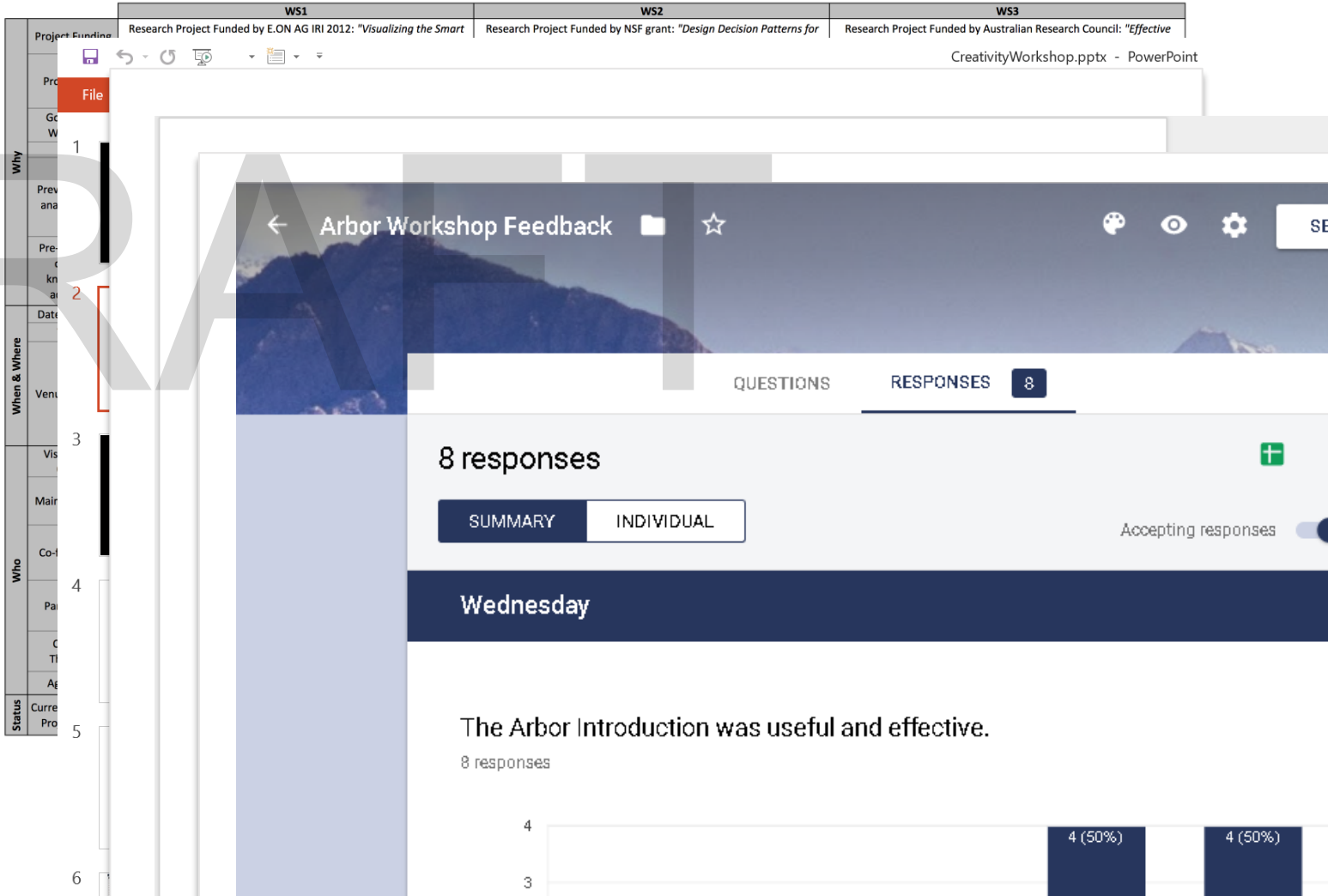
Problem statement

- Communicate insights from our experience using creativity workshops in various visualization design studies
  - Practical – describe process of planning, running, and analyzing workshops
  - Theoretical – connect workshops to creativity and visualization theory
- Hedge appropriately: from *our experience* what has worked (or not)

Framework based in qualitative data

- Creativity literature review
  - Psychology
  - Problem solving
  - Software engineering
  - Visualization

- Data from past projects
  - Project context
  - Workshop plan
  - Notes and transcripts
  - Artefacts
  - Project output
  - Feedback



Qualitative analysis methods

- Thematic analysis
  [Braun and Clark 2006]
- Collaborative reflection
  [Prilla et al. 2012]
- Writing as a creative analytical process
  [Richardson and Pierre 2005]

Visualization creativity workshop framework

- Describes how to use creativity workshops
- Connects workshop methods to underlying theory
- Details workshop common mistakes and pitfalls
- Identifies areas for future work

Timeline

Completed and remaining work

Three projects of this proposal

- **2013 – ’15:** Visual vulnerability analysis (completed)
- **2015 – ’17**: Connectome visualization (completed)
- **2015 – present**: Visualization creativity workshops (remaining)

Visualization creativity workshops: completed

- ✓**Jun ’15 – Sep ‘16:** informal discussions and reflection; narrow literature review

- ✓**Sep ‘16 – May ’17**: assisted in running 4 creativity workshops; qualitative data analysis

- ✓**Jan ‘17 – Jun ’17**: broad literature review; proposed the current framework; iterated with collaborators

Visualization creativity workshops: remaining

- **July ‘17 – Aug ‘ 17**: qualitative analysis; draft paper; get feedback
- **Aug ‘17 – Sept ’17**: revise paper from feedback; submit to IEEE TVCG
- **Sept ‘17 - Dec ’17**: write dissertation

Creativity workshops for visualization design studies

Publications

- **E. Kerzner**, L. A. Butler, C. Hansen, and M. Meyer. A shot at visual vulnerability analysis. Computer Graphics Forum, 34(3), 2015
- C. Gribble, A. Naveros, and **E. Kerzner**. Multi-hit ray traversal. J. Computer Graphics Techniques, 3(1), 2014

- **E. Kerzner**, A. Lex, T. Urness, C. L. Sigulinsky, B. W. Jones, R. E. Marc, and M. Meyer. Graffinity: visualizing connectivity in large graphs. Computer Graphics Forum, 34(3), 2017
- J. S. Lauritzen, C. L. Sigulinsky, J. R. Anderson, M. Kalloniatis, N. T. Nelson, D. P. Emrich, C. Rapp, N. Mccarthy, **E. Kerzner**, M. Meyer, B. W. Jones, and R. E. Marc. Rod-cone crossover connectome of mammalian bipolar cells. J. of Comparative Neurology, 2016.

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