Human Research Program
Space Human Factors & Habitability Element
Space Human Factors Engineering Project (SHFE)

Needs Assessment

HUMAN-AUTOMATION INTEGRATION: PRINCIPLE & METHOD FOR DESIGN AND EVALUATION

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Background

- Space missions (ground and in-space) increasingly depend on effective human-system integration.
- How can we ensure developed systems do their job well?

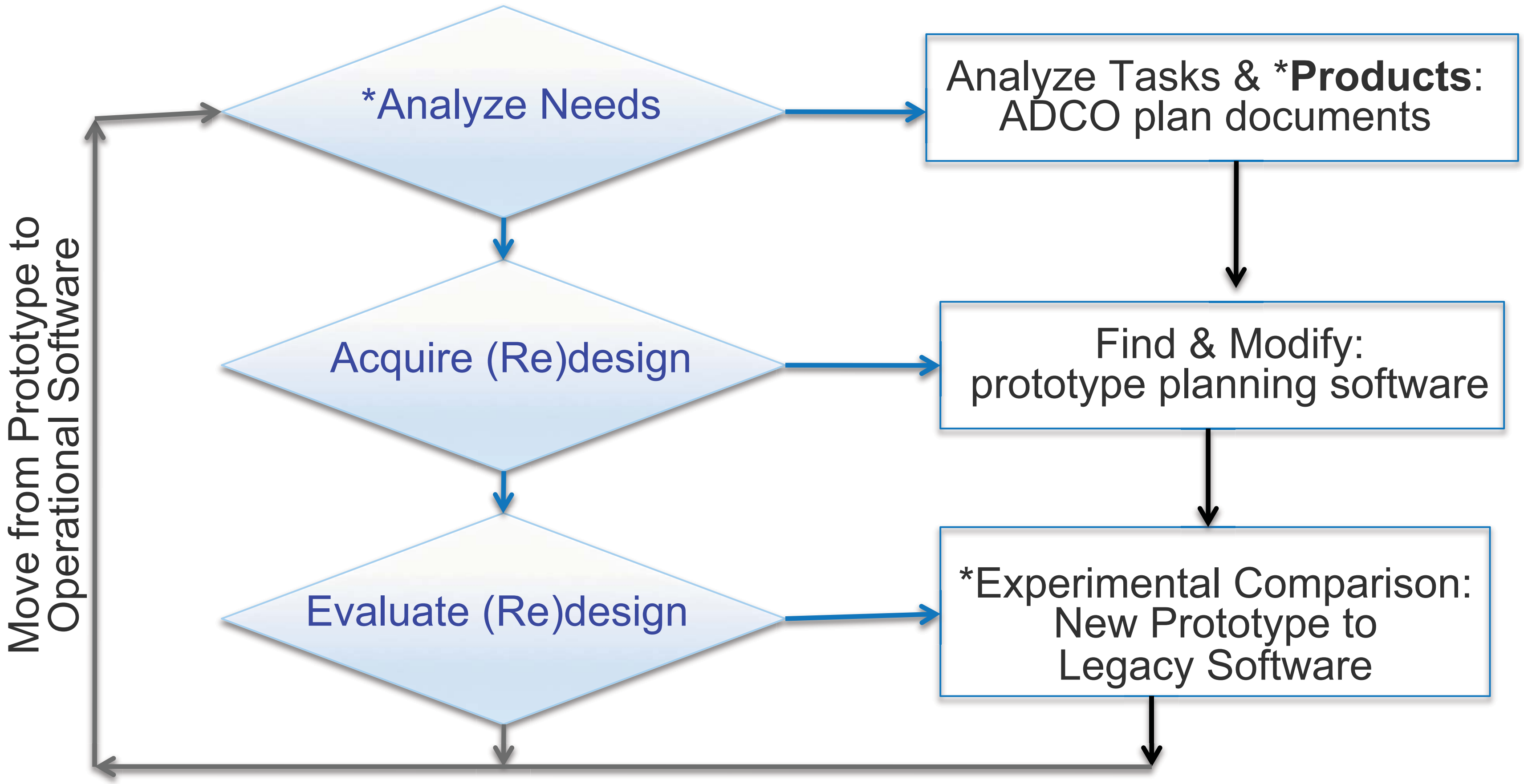
Objectives

Long-term: Develop, apply, and assess needs analysis method

Immediate Payoff: Improve support for ADCO (Attitude Determination & Control) planning work

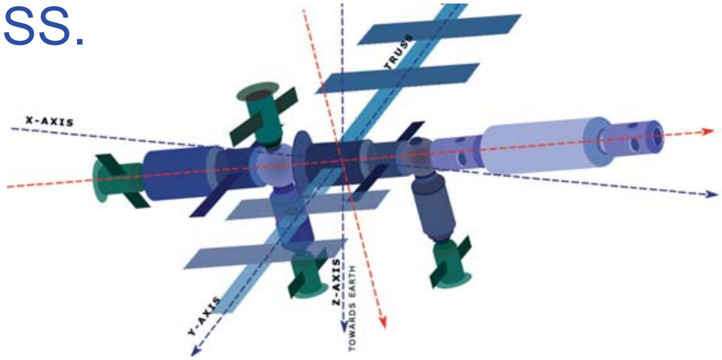
General Method + Specific Case Study:

How can we efficiently develop systems that support work-needs effectively? ADCO Planning Case


*Analyze Needs
Acquire (Re)design
Evaluate (Re)design
Analyze Tasks & ***Products**: ADCO plan documents
Find & Modify: prototype planning software
*Experimental Comparison: New Prototype to Legacy Software
Move from Prototype to Operational Software

ISS Controller Group: ADCO (Attitude Determination & Control Officer)

- Part of NASA Mission Control for ISS
- Works closely with Russian counterparts.
- Motion control, particularly orientation of ISS.



- Requires:
  - Execution & Planning
- Our focus on planning:
  - forming and revising plans

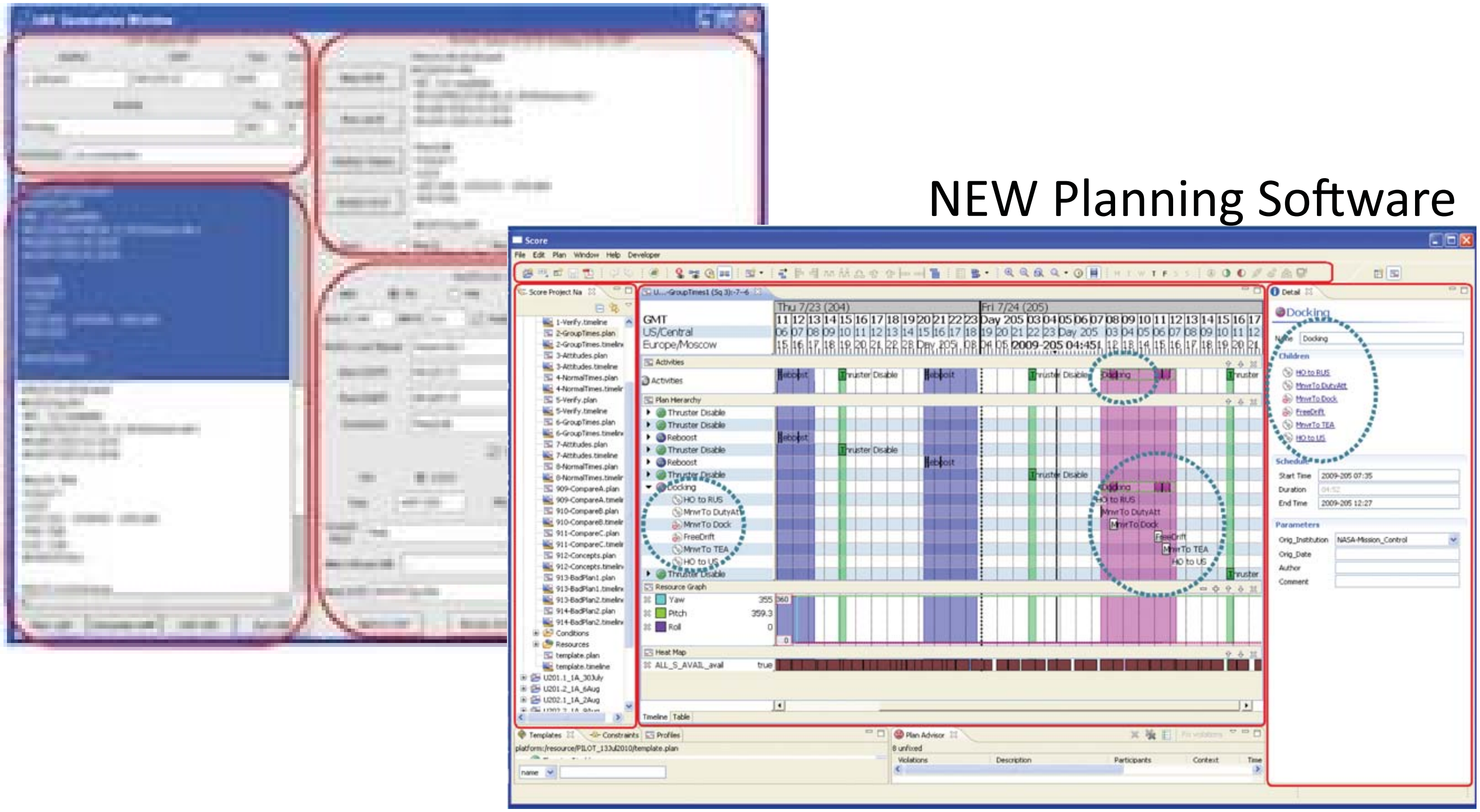
Method & Results

- Identify the information & operations needed to build sound plans.
- Modify other NASA planning software to reflect ADCO needs.
- Compare performance on redesigned prototype to legacy system on key plan-revision tasks.
- Found redesign cuts time and errors on plan revision. ADCO secured funding for new software.
- Supports claim: (product-based) needs analysis improves design outcomes.

Interaction structure

Legacy Planning Software

NEW Planning Software



Name: Docking

Start Time: 2009-205 07:35

Duration: 04:52

End Time: 2009-205 12:27

Orig_Institution: NASA-Mission_Control

8 unfixed

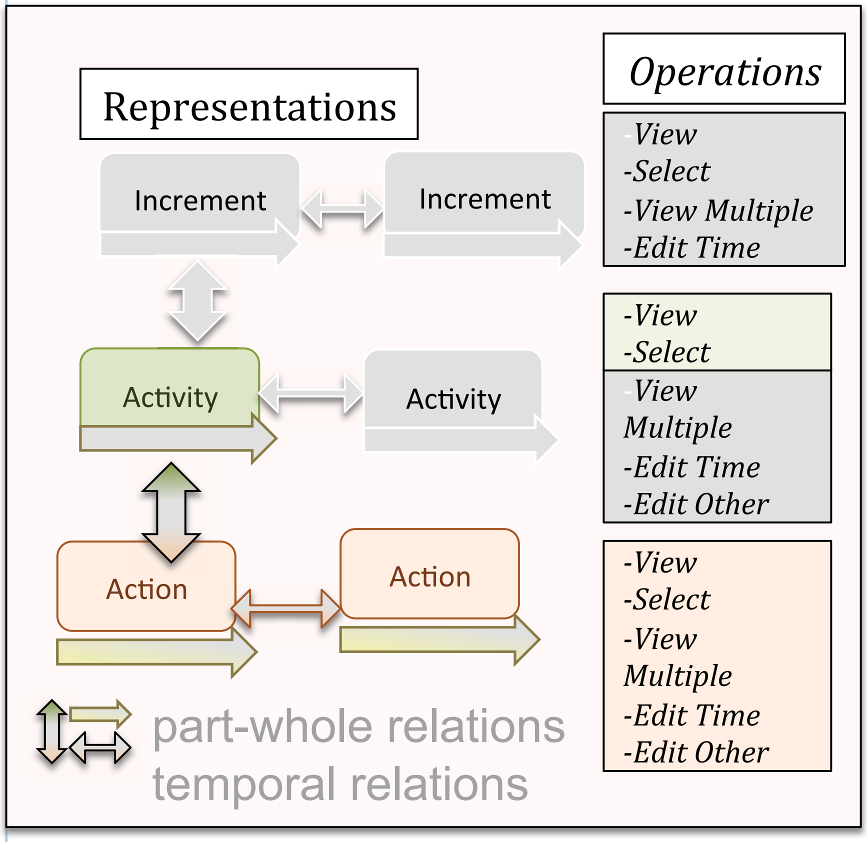
Activity representations circled

New prototype modified from HSI Ames (McCurdy,Ludowise,Marquez,&Li 2009)

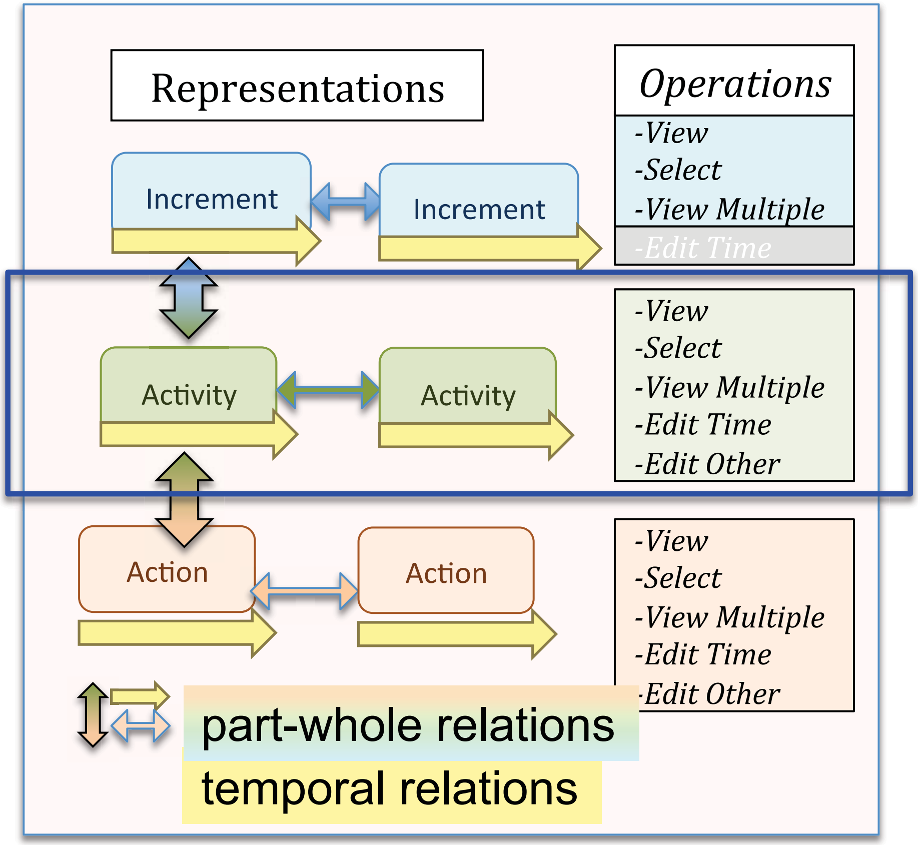
CHI2011: Billman,Arsintescu,Feary,Lee,Smith,&Tiwary

Redesign Matches Domain Needs Better:

(less grey in diagram)



Legacy system



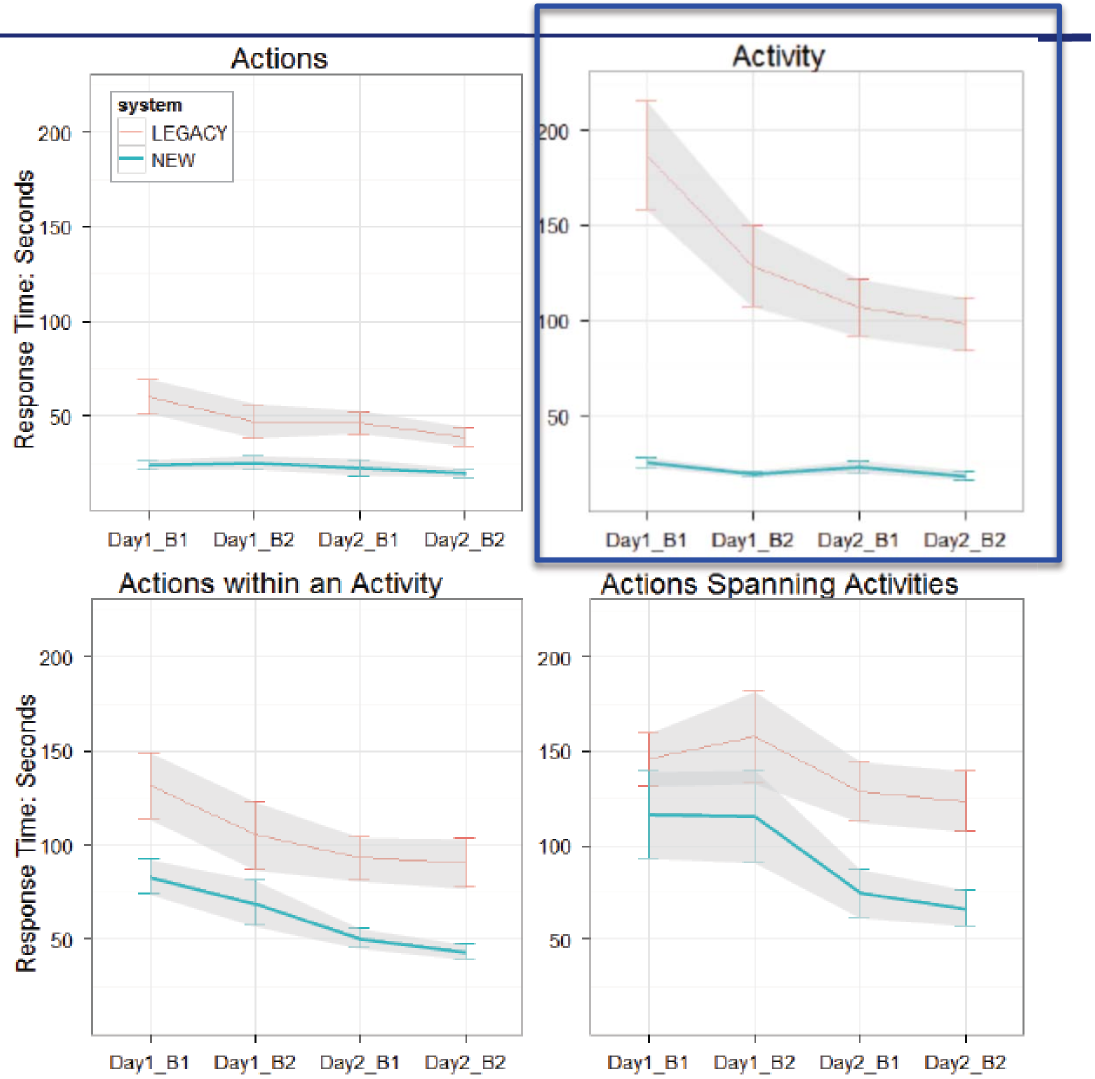
NEW system

New Prototype Makes Revision Tasks Easy

Standard tasks:
Reschedule an Action or Activity

Big performance benefit
where large increase
in match to plan structure.

Unusual tasks:
Reschedule collections of Actions
New prototype still provides benefit



Ave correct-response times (StErr) of New & Legacy software
for revision tasks, 2 Blocks on 2 Days, a week apart.

Conclusions- Reducing Gap for HSI/HAI tools & methods

- Analyzing needs is critical to success.
  Product-document analysis aids needs analysis
  for work domains that are:
    high stakes, technical, information-intensive, with heavily scheduled domain experts.

- Given needs are understood, redesign may find&modify, not just build-from-scratch.

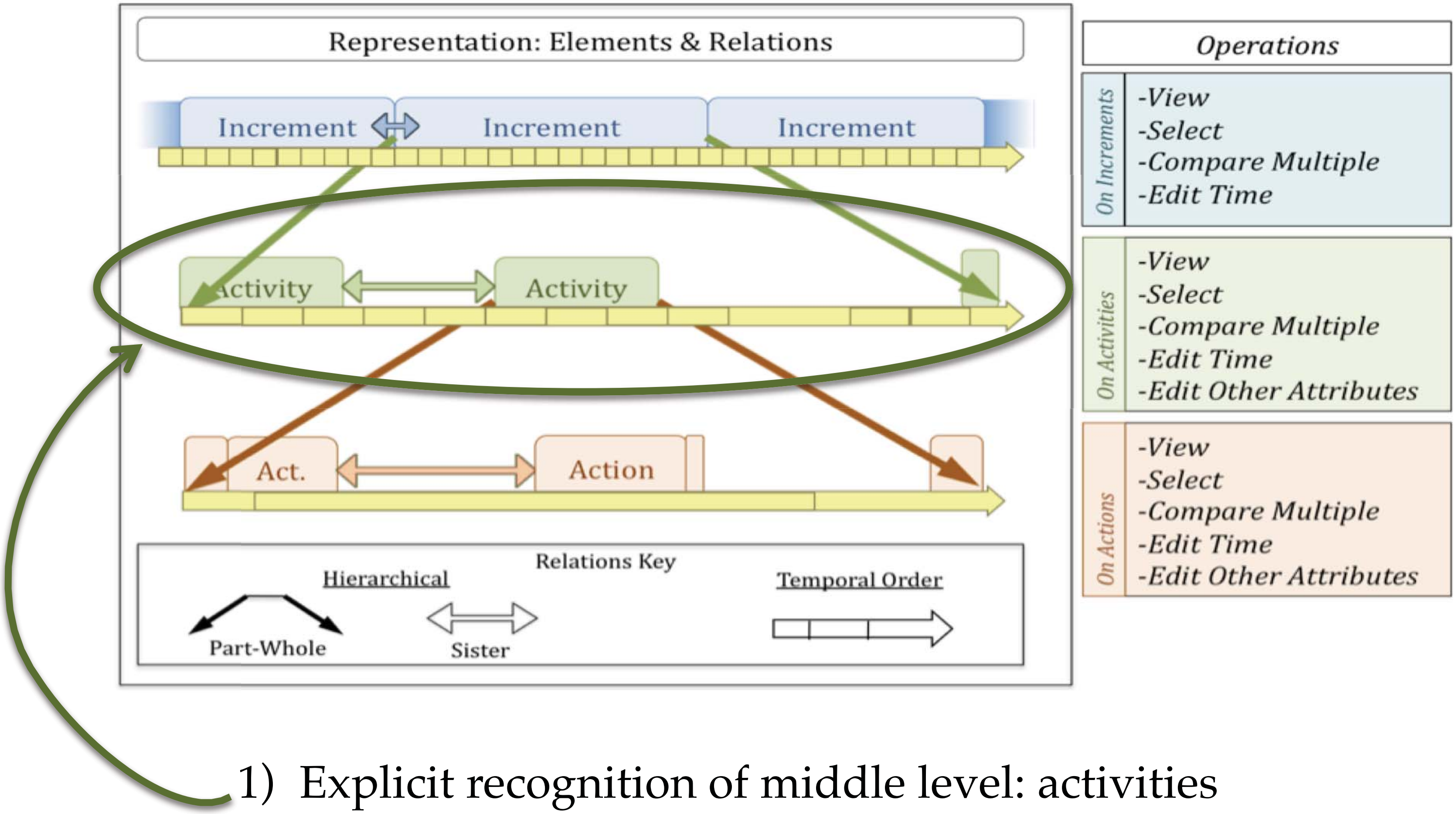
- (Re)design guided by aligning structure-of-interaction with structure-of-domain can have big payoff in improved performance.

- FUTURE RESEARCH: further develop needs analysis methods
  for design (what should it do) & evaluation (does it do what it should).

Questions?

Analysis of domain structure:

Use information products to reveal information structure



Operations	
On Increments	-View -Select -Compare Multiple -Edit Time
On Activities	-View -Select -Compare Multiple -Edit Time -Edit Other Attributes
On Actions	-View -Select -Compare Multiple -Edit Time -Edit Other Attributes

1) Explicit recognition of middle level: activities
2) Temporal relations
3) Part-whole relations

CHI2011: Billman,Arsintescu,Feary,Lee,Smith,Tiwary

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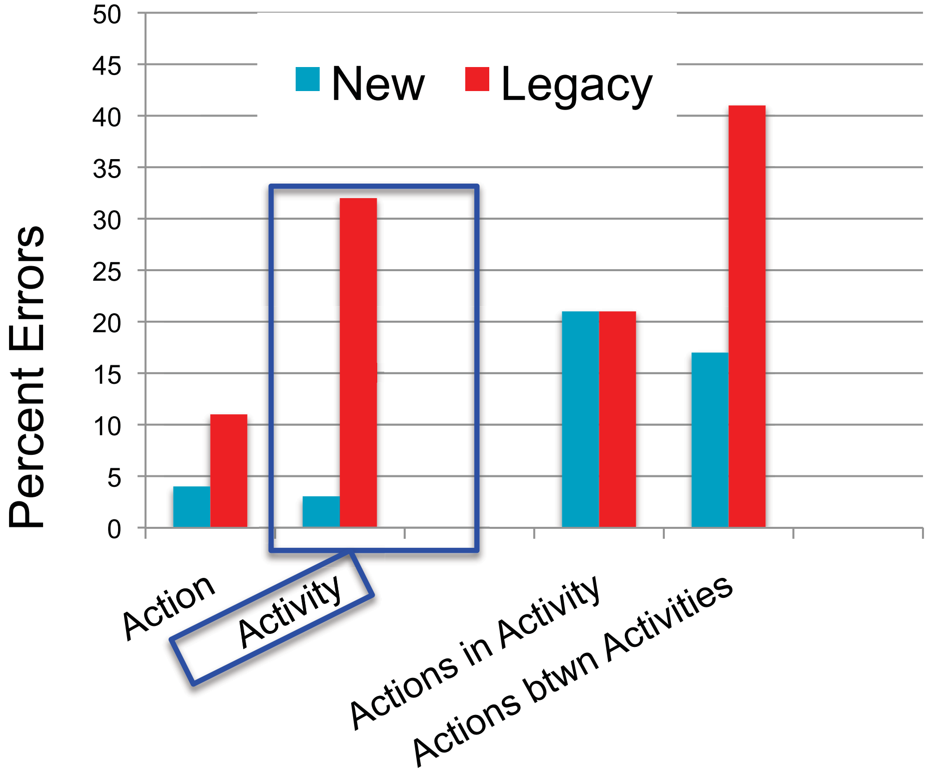

Ave % errors with New & Legacy software
for revision tasks, 2 Blocks on 2 Days, a week apart.

New Prototype Benefit Persists Longer-Term

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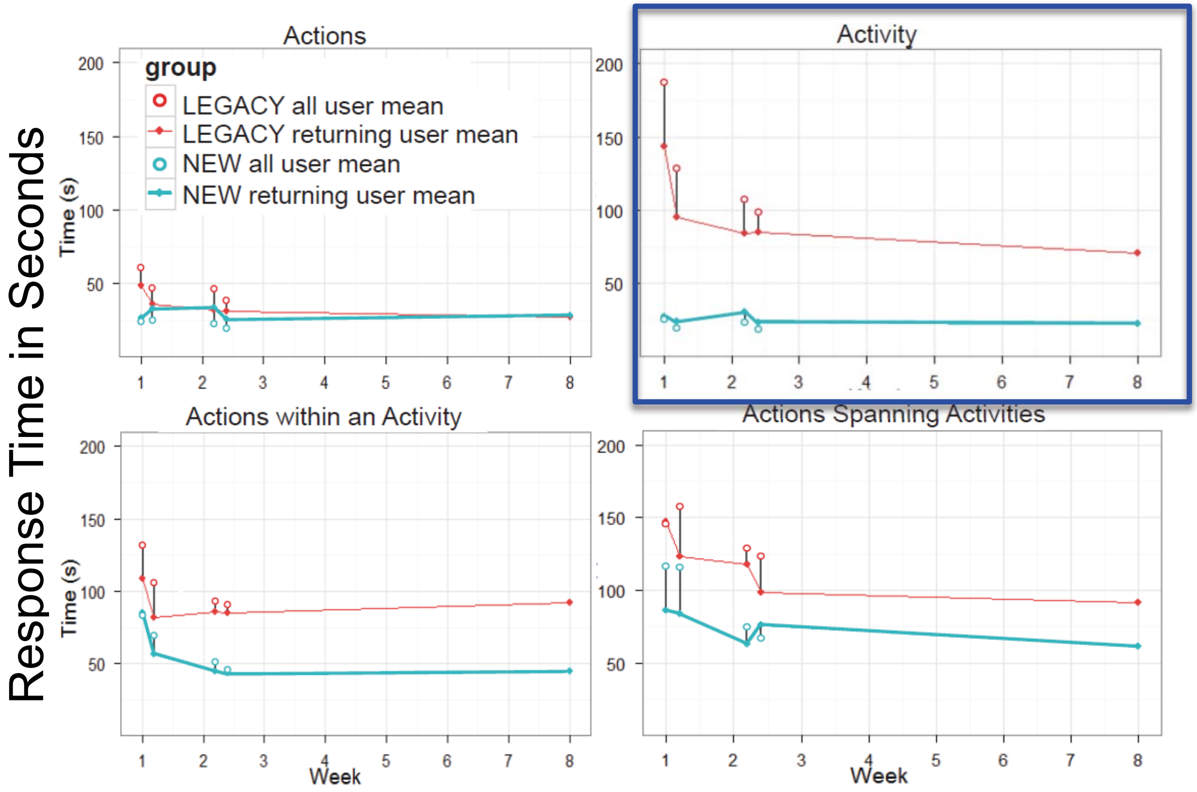
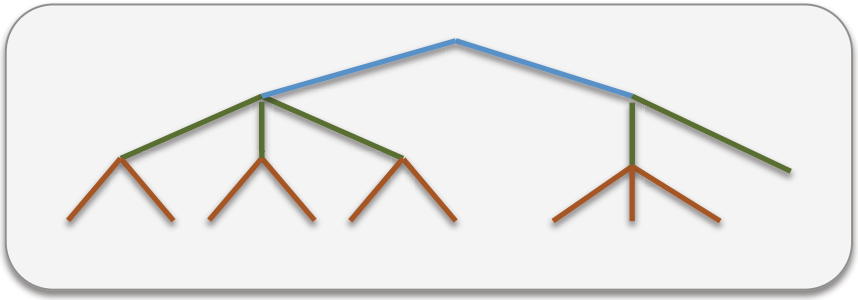


Performance by small number of New (3) & Legacy(4) users
on initial 2 Days, a week apart,
and **returning 7 weeks later**

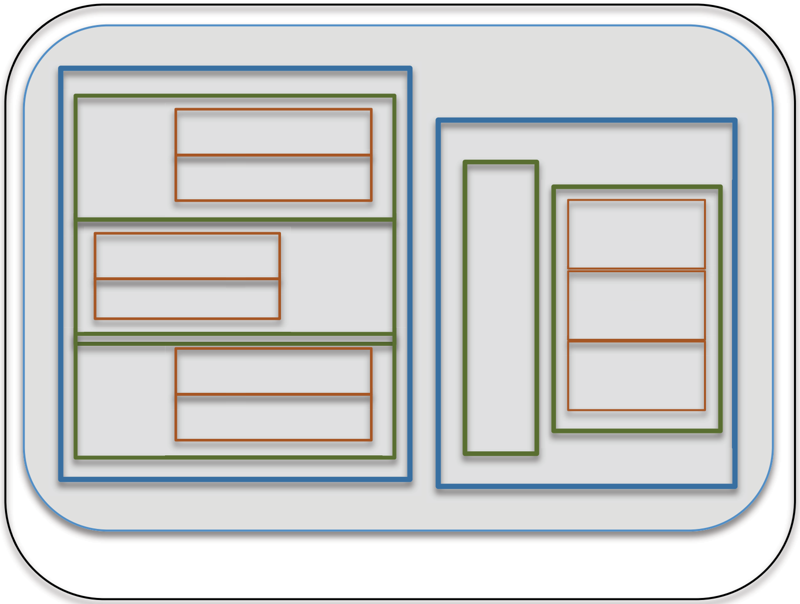
Structure-Matching Illustration

Example: Hierarchy organizes structure

Domain structure

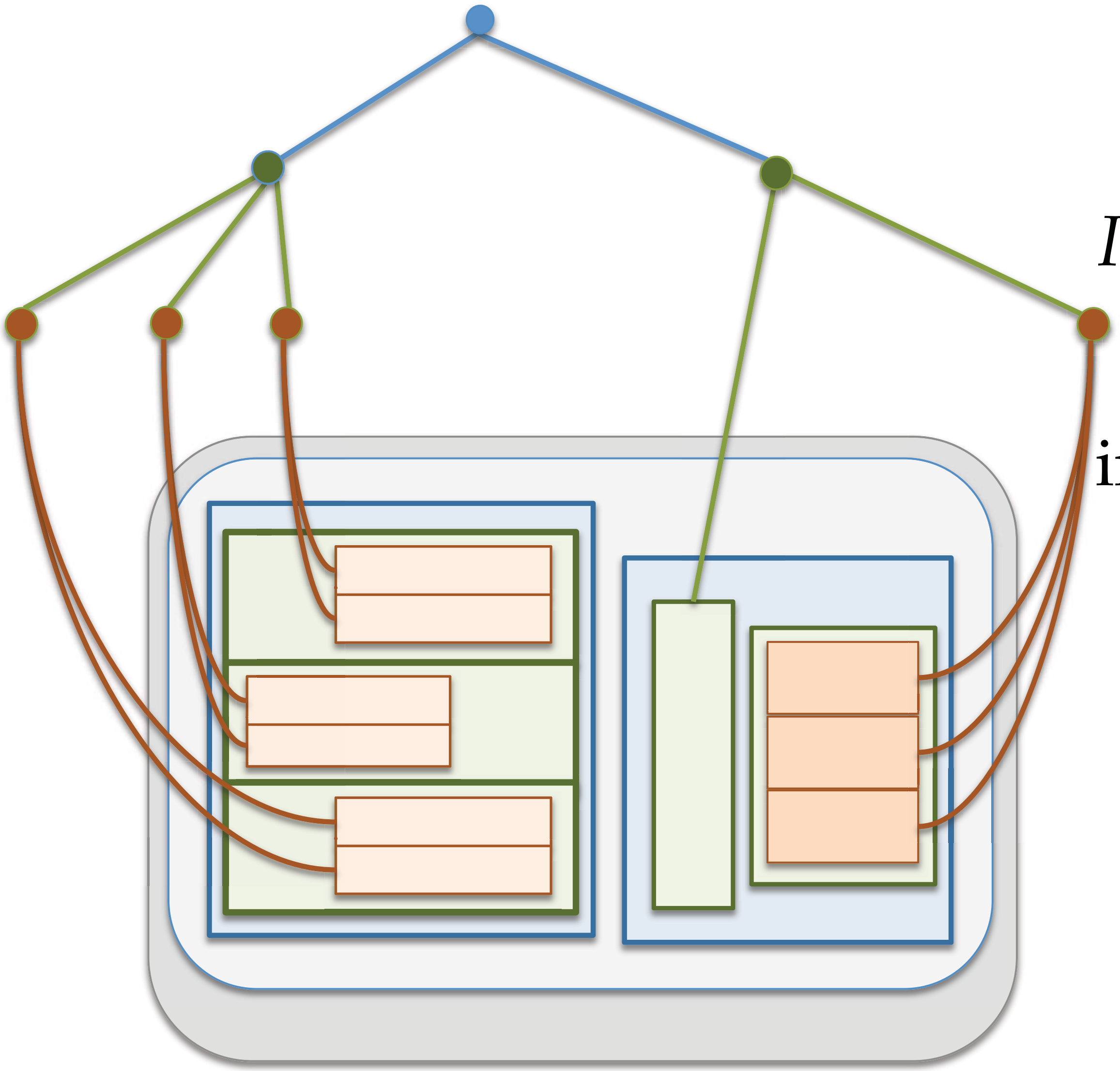


Interaction Structure
(display & control)



Structure-Matching Illustration:

Hierarchy organizes structure

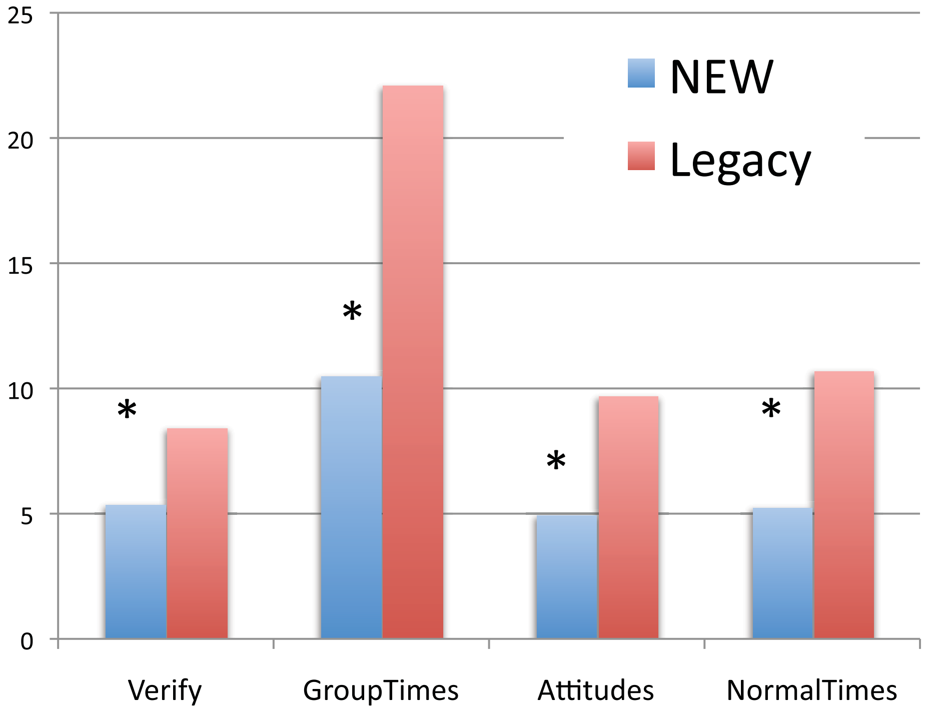


When *Interaction Structure* aligns with *Domain Structure,* interaction should be transparent.

Is performance better in NEW vs Legacy?
Yes: faster across all revision tasks

Huge impact: required procedure change.

On the 4 Revision tasks:
Total time-
half as long in NEW
51 vs 26 minutes



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