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Providing Tailored Heuristic Advice to Systems Engineers

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Contents

Introduction

Motivation

- The purpose of the Complex Systems Working Group is to enhance the ability of the systems engineering community to deal with complexity.

- But what do we mean by Complex Systems

Motivation

- A **complicated system** has elements, the relationship between the states of which can be unfolded and ***comprehended***, leading to ***sufficient certainty between cause and effect***.
- A **complex system** has elements, the relationship between the states of which are weaved together so that they are *not fully comprehended*, leading to *insufficient certainty between cause and effect.*
- Understanding the difference means understanding the need to change everything
- How can we help?

Leveraging INCOSE Expertise

- INCOSE Heuristics team have created 600+ Heuristics on how to handle Difficult Problems.

Heuristics Definition: *"Enabling one to discover or learn something for themselves base on the experience of others"*

To be useful they need to be **memorable, simplified** difficult concepts that can **change** your normal **response**.

But how do we make 600+ useful

Code	Group 1 Heuristics
A	Compelling Community Vision; Establish a Common Compelling Community Vision that aligns distributed stakeholders
B	Continuous Learning; Have a learning organization that accumulates and uses new insight
C	Proactive Feedback; Have a proactive feedback mechanism to sense change in the system or environment early
D	Living Systems; Have a living system that is able to adapt to new knowledge or insight
E	Generous Leadership; Have generous leaders that protect and enable the expertise to lead decision-making, rather than seniority
F	Equality Mindset; Have an Equality mindset, treating others' views and visions as equal to your own
G	Robust Relationships; Develop robust relationships between the organizational elements.

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#	Group 2 Heuristics
1	Iterate to evolve complex systems
2	Multiple perspectives identifies complexity
3	Complex systems are not wholly complex
4	Do not assume complicated pegs fit in complex holes
5	For every complex problem, there is an answer that is clear, simple, and wrong
6	Complexity understanding should precede action
7	Iterate and/or aggregate with stable system steps
8	Culture mismatch kills complex systems
9	Think big, evolve from small
10	Complexity necessitates continuous organizational learning and adaptation
11	Deprioritize optimization, prioritize multiple perspectives.
12	Keep options open to evolve
13	Complex Systems: As simple as possible, but no simpler!
14	Reuse with extreme care
15	Focus on holistic utility
16	Complex problems call for strategic thinking
17	Holistic system health avoids complex system failures
18	Manage emergence holistically

Code	Group 3 Heuristics
19	Successful communication requires an understanding of the listeners' mental models
20	Complex system failures enable accelerated learning
21	It is better to be roughly right than precisely wrong
22	The unrecognized assumptions are the most dangerous
23	Good solutions emerge through creative environments
24	Manage adverse consequences with proactive feedback structures or mechanisms
25	Every attempted fix of a complex problem, changes the problem
26	Identify a compelling community vision to address complex problems
27	In introducing complex solutions, "how" trumps "what"
28	It is easier to ignore complexity – and fail
29	Maintain a compelling community Vision through respectful collaboration
30	Evolving is the complex system's superpower
31	Minimizing harmful element interactions supports resilient complex systems
32	Complex systems should allow and enable human flexibility
33	Bear-hug complex problem unknowns
34	For complex systems, being useful is more important than being right

Code	Systems Engineering Principles
P1	Systems engineering in application is specific to stakeholder needs, solution space, resulting system solution(s), and context through the system life cycle
P2	Systems engineering has a holistic system view that includes the system elements and the interactions amongst themselves, the enabling systems and the system environment
P3	Systems engineering influences and is influenced by internal and external resource, political, economic, social, technological, environmental and legal factors
P4	Both Policy and Law must be properly understood to not overly constrain or under constrain the system implementation
P5	The real physical system is the only perfect representation of the system
P6	A focus of systems engineering is a progressively deeper understanding of the interactions, sensitivities and behaviors of the system, stakeholder needs and its operational environment
P7	Stakeholder needs change and must be accounted for over the system life cycle
P8	Systems engineering addresses stakeholder needs taking into consideration budget, schedule, technical, and other expectations and constraints
P9	Systems engineering decisions are made under uncertainty accounting for risk
P10	Decision quality depends on knowledge of the system, enabling system(s), and interoperating system(s) present in the decision-making process

Code	Complicated System Heuristics applicable to Complex Systems
C1	Seek external subject-matter experts when in-house knowledge is lacking
C2	Weakest links fail first – reliably and predictably
C3	Simplify, combine and eliminate, or simplify with smarter elements
C4	Do the hard parts first, not the fun or familiar parts first
C5	If in difficulty, re-formulate the problem and re-allocate the system functions and interfaces
C6	Periodically, pause and reflect!
C7	For suitability, such as safety and each other relevant “ility”, it is important to articulate what the minimal acceptable level is, as well as the level beyond which little added value is added or is feasible
C8	Each interface requires an owner
C9	Only insist on requirements which are essential
C10	Testing is expensive – make it efficient
C11	Delve beneath the symptoms
C12	Developing the system design in stages can reduce risk if the critical system behaviors are designed first
C13	Change is inevitable – plan to deal with it
C14	Minimize effort by focusing on the main mission objective first
C15	Ensure that the culture can support the strategy
C16	Bring solutions, not just problems

Prior Work

- Look at identifying a memorable set of heuristics. This was challenging because:
  1. There are too many to boil down
  2. Good heuristics constantly being developed and identified
  3. Heuristic's meaning context specific
  4. Heuristic wording never quite right

Never ending – Alternative approach required

System Elements	Difficulty Elements: Intricacy	Unpredictability	Unfamiliarity	Constraints/Enablers
Organization	0	1	4	0
Technology	0	3	4	0
Process	0	3	4	0
Information	0	2	4	0
Benefits	0	3	4	0
Environment	0	4	4	0

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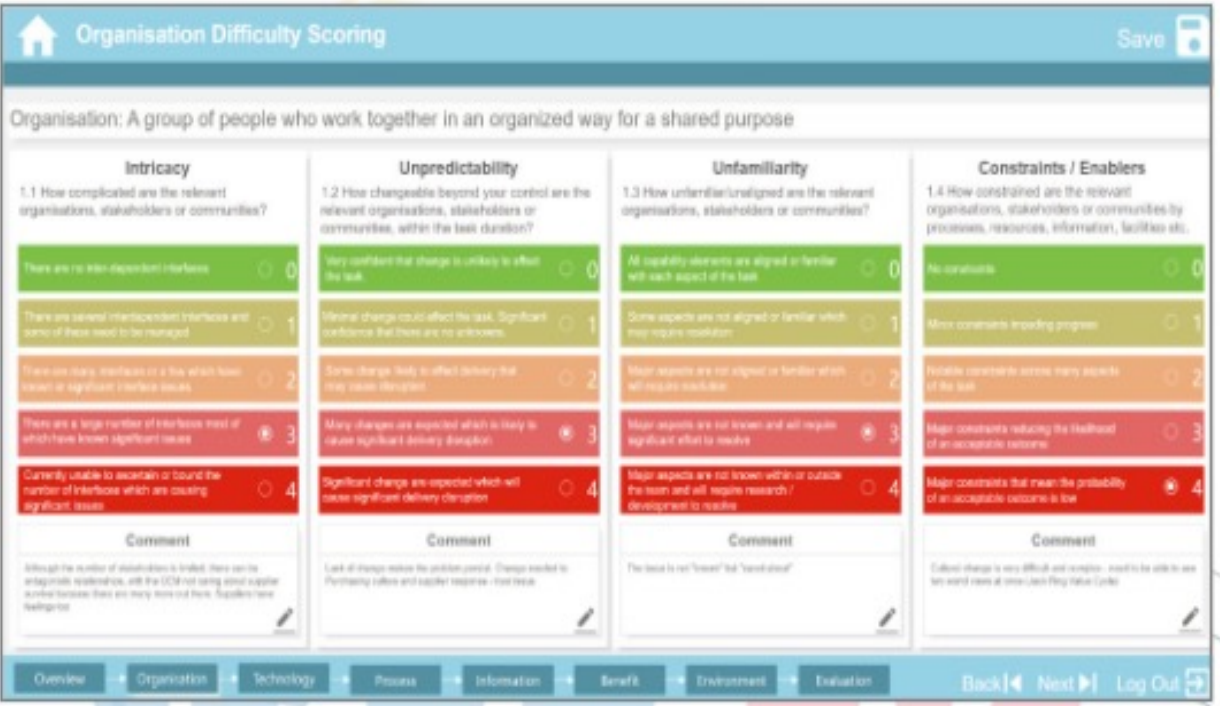

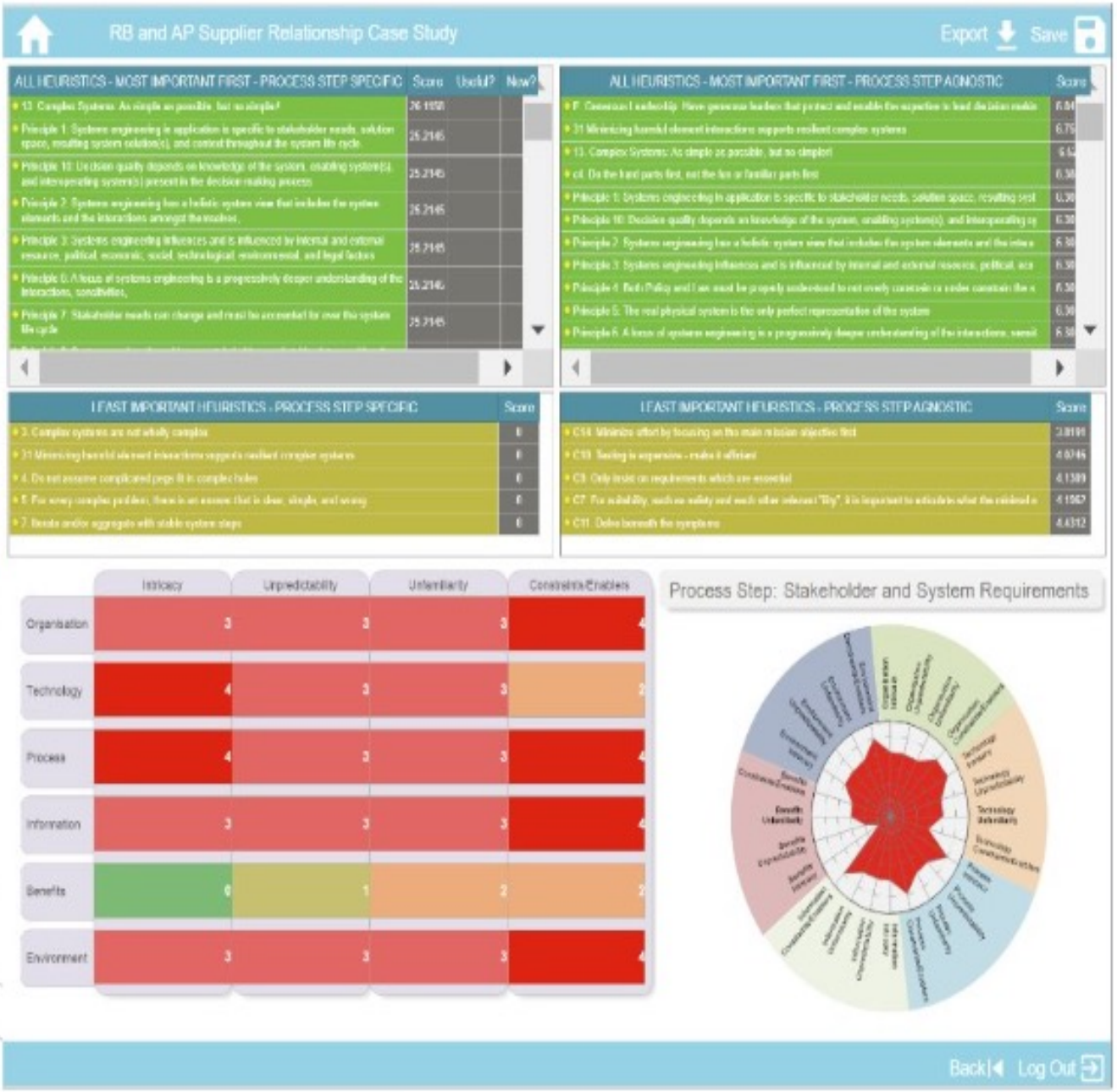

Benefits

Approach:

Environment

Leadership style

Manage Methodology

Governance Structure

and

Team Mix

And the Discussion!!!

Methodology

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Methodology

Q. Can we use the indicate which heuristics are useful?

- Selected quality heuristics from 600+
  - 41 Complexity 10 Complicated
- Scored what type of problems they are suitable for (Using DAT)
- Used matching algorithm to identify what Heuristics most applicable to problem

The Problem characterization

	Intricacy	Unpredictability	Unfamiliarity	Constraints/Enablers
Organisation	3	1	1	3
Technology	0	0	0	0
Process	2	0	0	1
Information	2	2	1	2
Benefits	2	2	1	3
Environment	2	1	1	1

The Heuristic characterization

Methodology

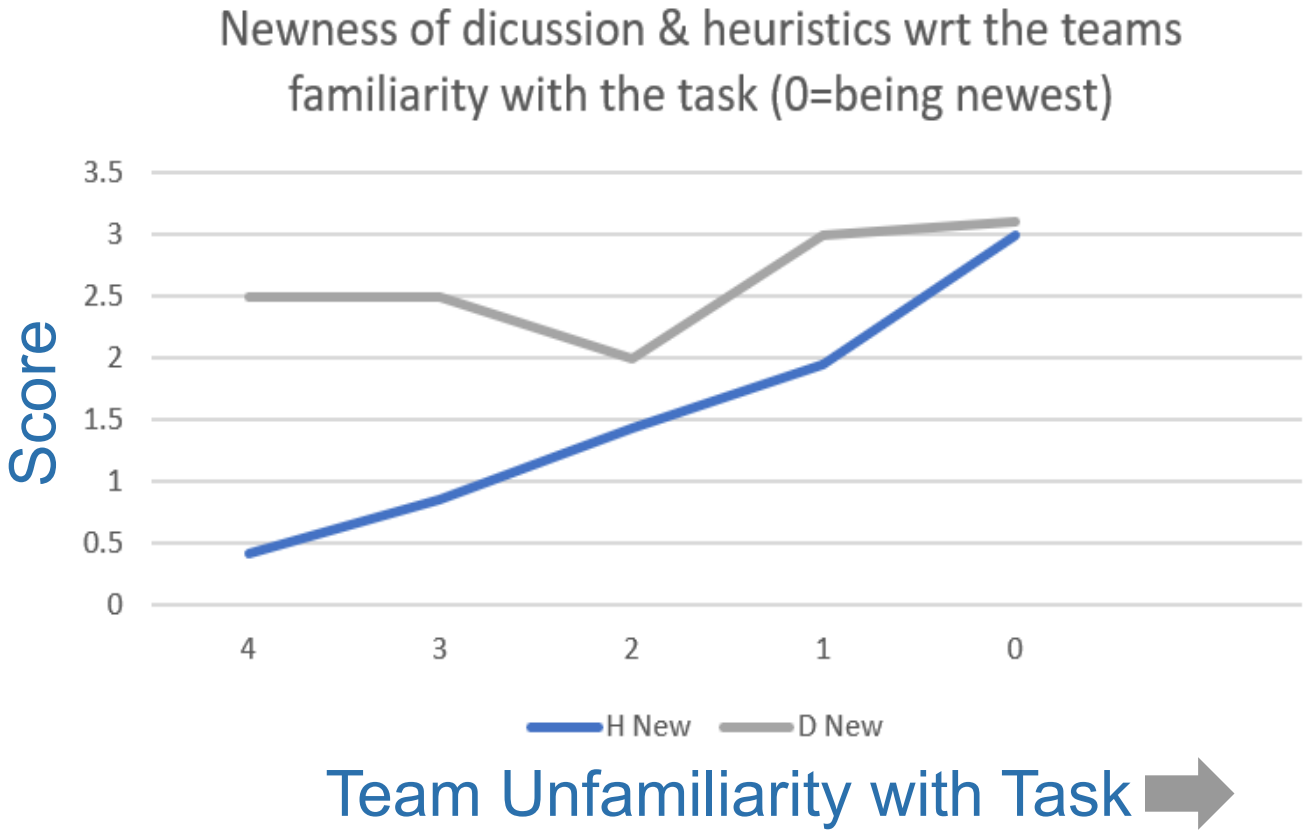
- Are these heuristics useful
  - Useful= Relevant to problem* Newness

    0= Not
    1= A bit
    2= Somewhat
    3= A lot
    4= Significant
- How useful is this compared to discussion and Delivery Advice ELMGaTe. (already proven)
- Small number of responses (19)

Results

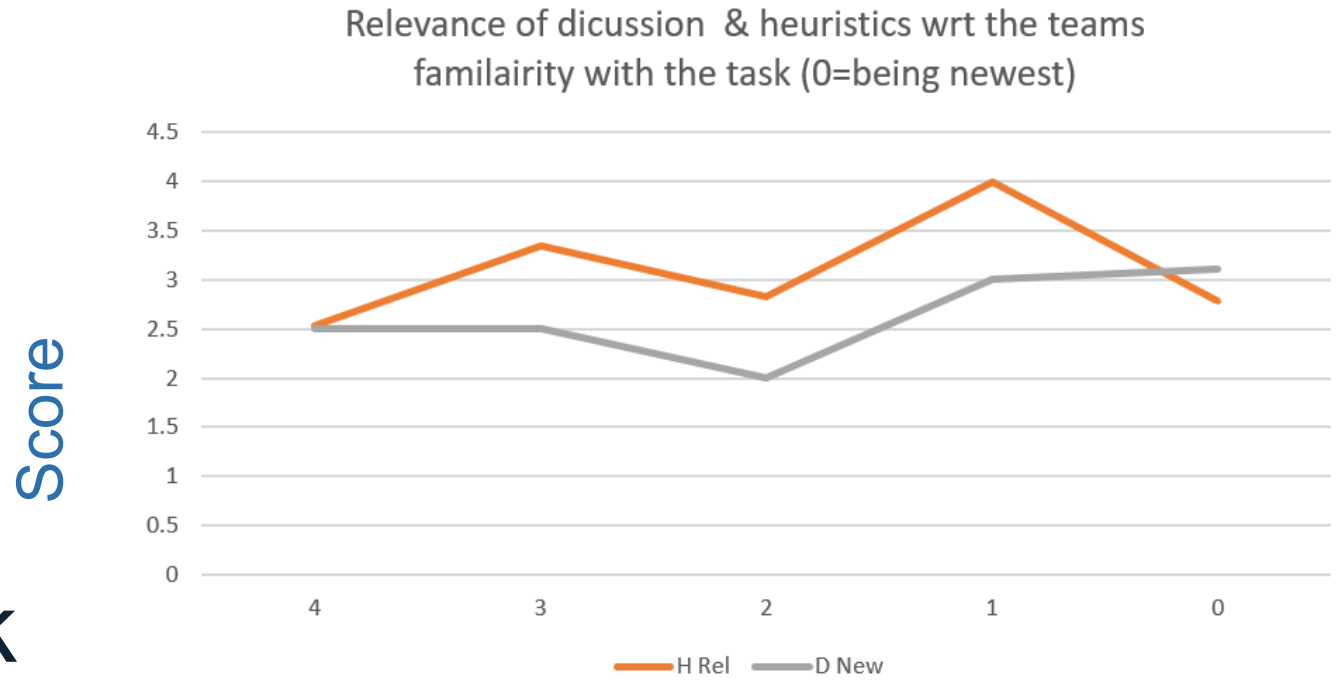
Newness

- Discussion always Valuable
- Heuristics value dependent on unfamiliarity with task
- ELMGaTe scored 1.65 on newness



Relevance

- Discussion value Valuable
- Heuristics value dependent on unfamiliarity with task
- ELMGaTe scored 3.5



0= Not
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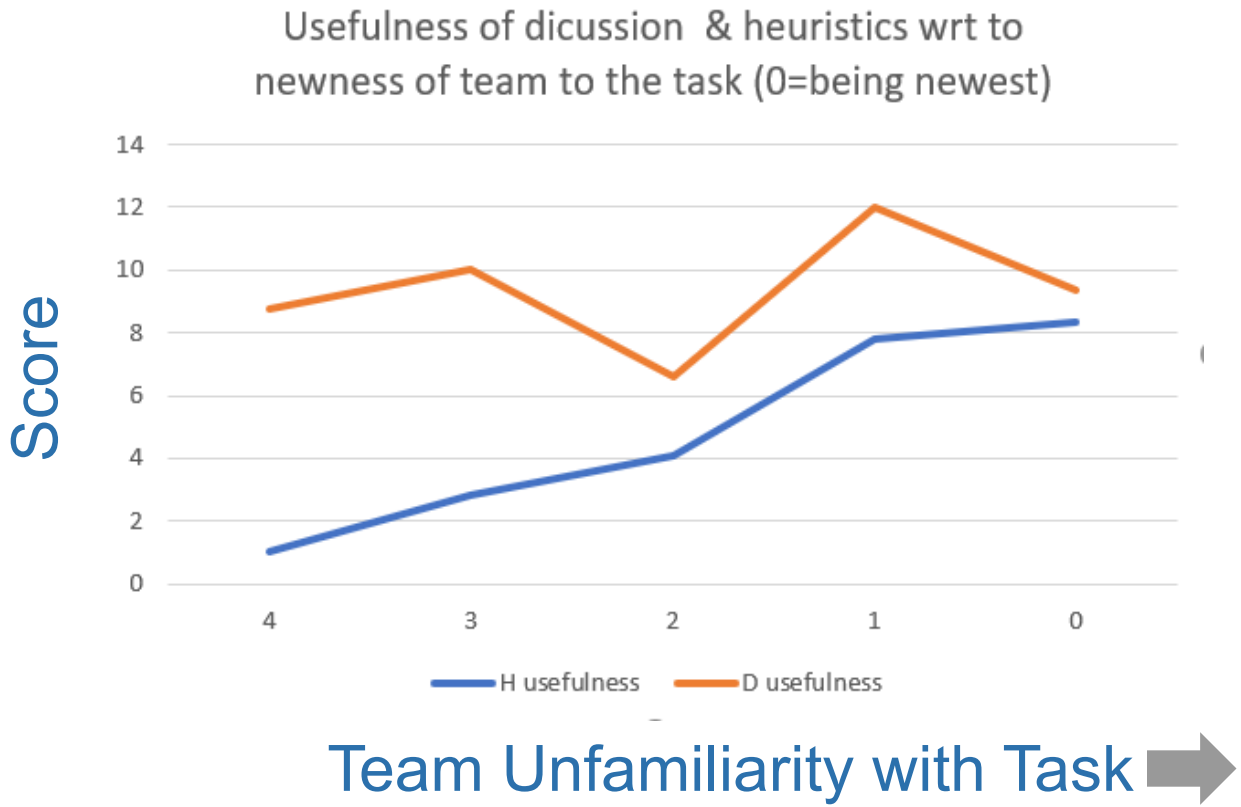
Usefulness

- Relevance * Newness
- Newness dominates usefulness curve



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Heuristic Mapping

The mapping worked effectively ….according to the Engineers.

But test group scored all Heuristics provided highly.

Most likely as we pre-selected the best Heuristics from the 600.

Need to repeat without pre-selection

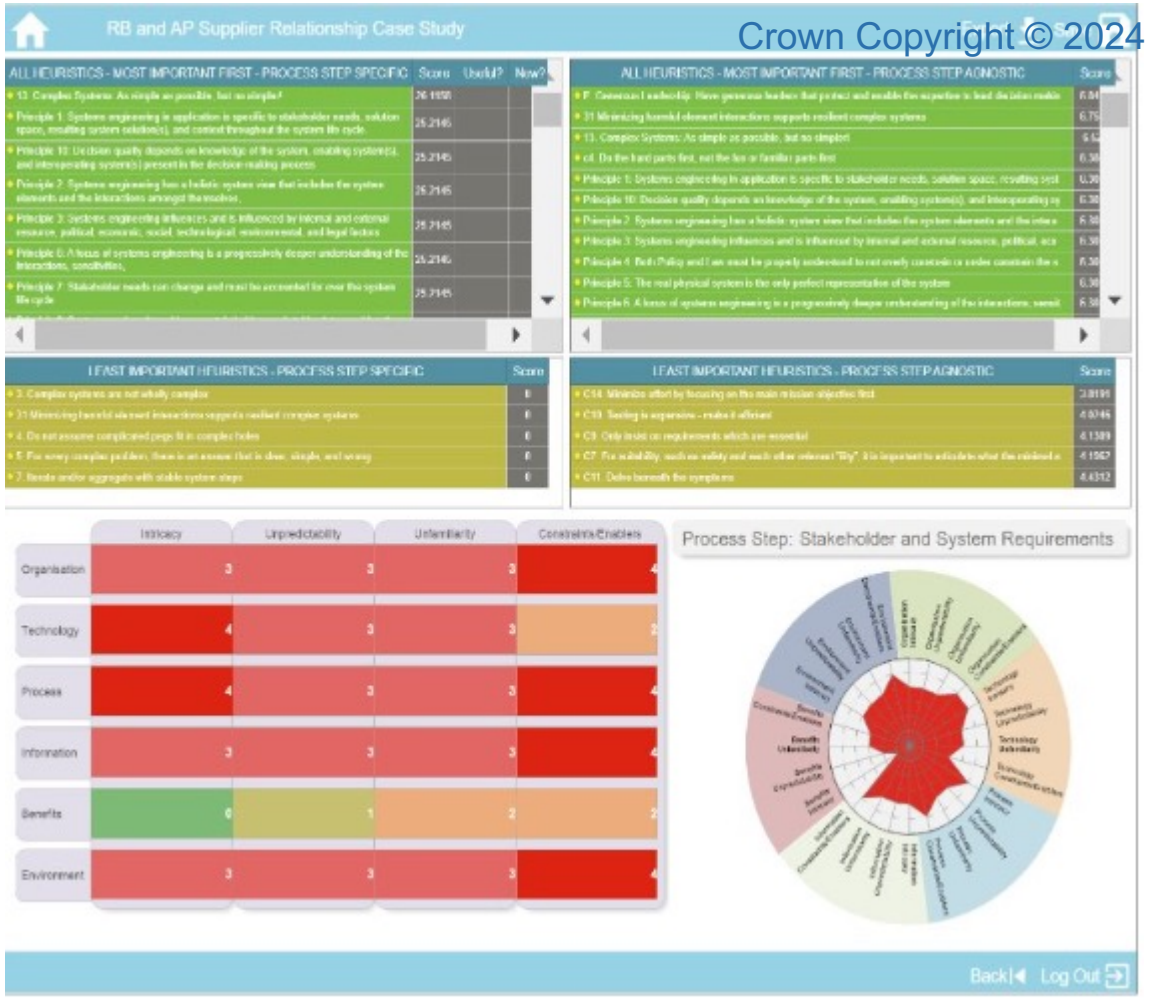
The Problem characterization

	Intricacy	Unpredictability	Unfamiliarity	Constraints/Enablers
Organisation	3	1	1	3
Technology	0	0	0	0
Process	2	0	0	1
Information	2	2	1	2
Benefits	2	2	1	3
Environment	2	1	1	1

The Heuristic characterization

Discussion/summary

- Discussion from using DAT always useful
- Heuristics really useful for new teams
- ELMGaTe results similarly useful if new
- 71% of practicing SE's found something significantly useful
- 100% of Trainee team got significant useful advice



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CACI MooD outcomes delivered.

Next Steps

Can we simplify?
Can we create a field guide? to

1. Help new SE
2. Broaden experienced SE's
    1. Heuristics
    2. Tool/ Methods used

Focused on understanding the situation: Task and its ECO system:

Then mapping to the many advice types that might help that situation (referencing out advice)

Advice types

- Heuristics
- Tactics
- Mindset – Leadership style
- Methodology
- …….

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