

Designing Usable User Interfaces of Digital Twins: Benefits and Limitations of Applying the User Centered Design Process

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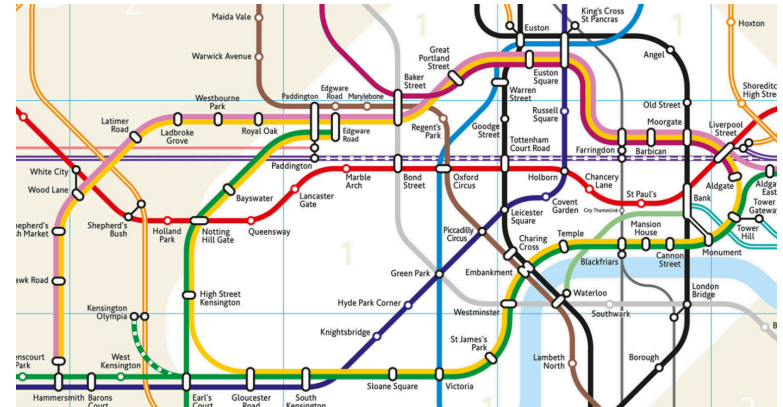
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Same system, two UIs - different tasks

Geographic view



Stylised "usable" view

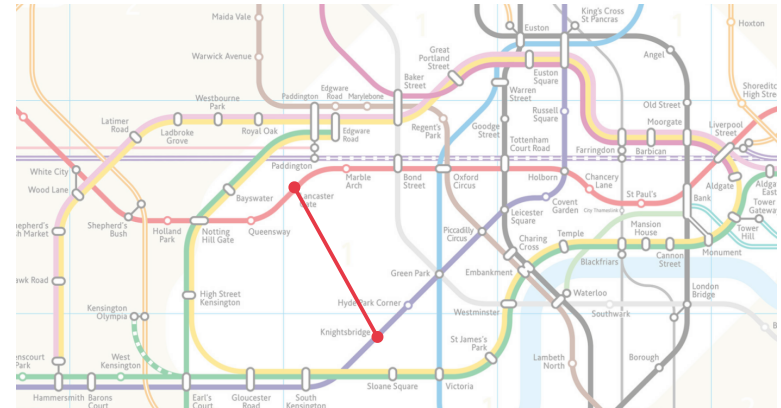


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"How close are these stations?"

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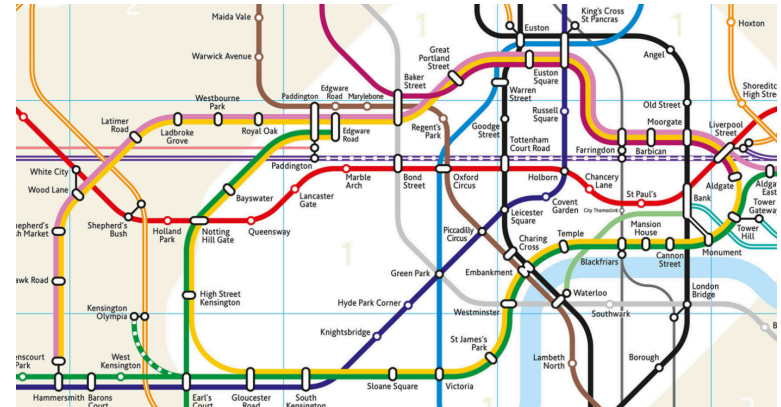
"How many stations are there between two stations?"

Same system, two UIs - different tasks

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Stylised "usable" view

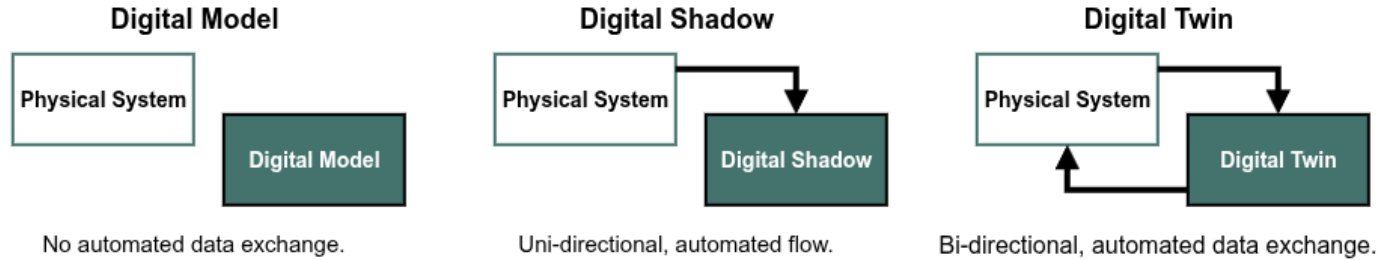


2 usable UIs for different contexts of use

The two UIs do not provide the same **Efficiency** and **Effectiveness** for all tasks.

Digital Twins

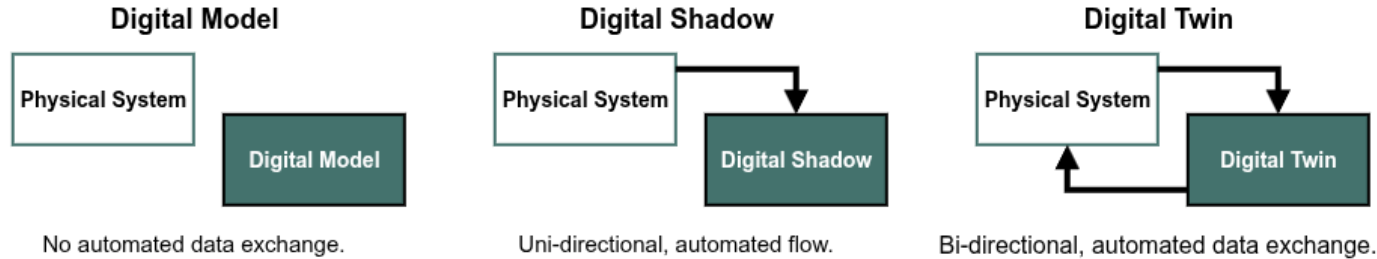
Three levels of integration¹:



¹ Kritzinger, W., Karner, M., Traar, G., Henjes, J., Sihm, W.: Digital Twin in manufacturing: A categorical literature review and classification. IFAC-PapersOnLine 51(11), 1016–1022.
<https://doi.org/10.1016/j.ifacol.2018.08.474>

Digital Twins

Three levels of integration¹:



Service oriented definition²:

"a set of models and data associated with the actual system that enables the creation of a set of services"

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² Eramo, R., Bordeleau, F., Combemale, B., Brand, M. van den, Wimmer, M., & Wortmann, A. (2022). Conceptualizing Digital Twins. IEEE Software, 39(2), 39. <https://doi.org/10.1109/MS.2021.3130755>

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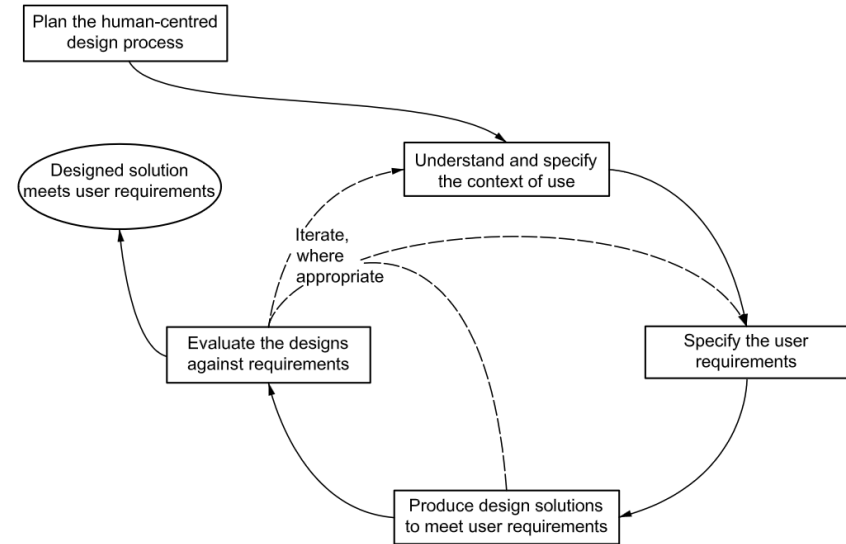
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ISO standard 9241 part 210⁴

- ✓ Well established, well tooled: field studies, personas, usability evaluations, participatory design
- ✓ Documented benefits: **Usability**

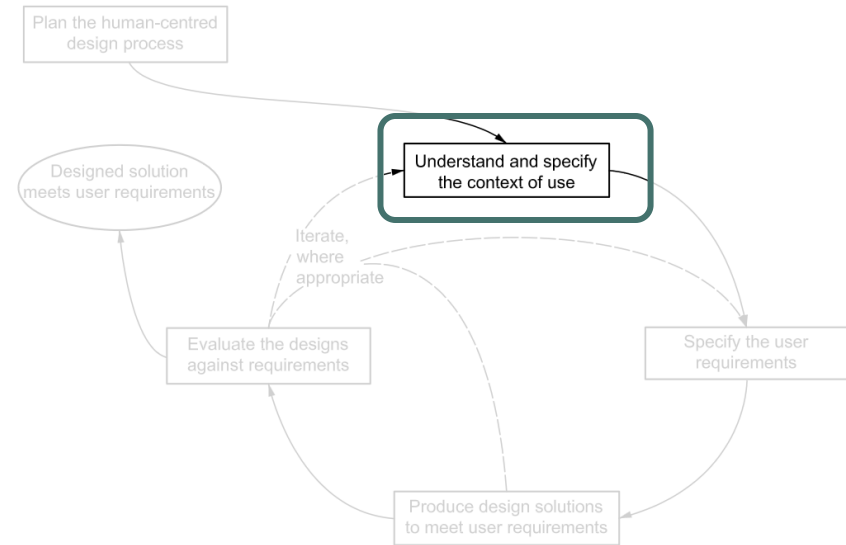


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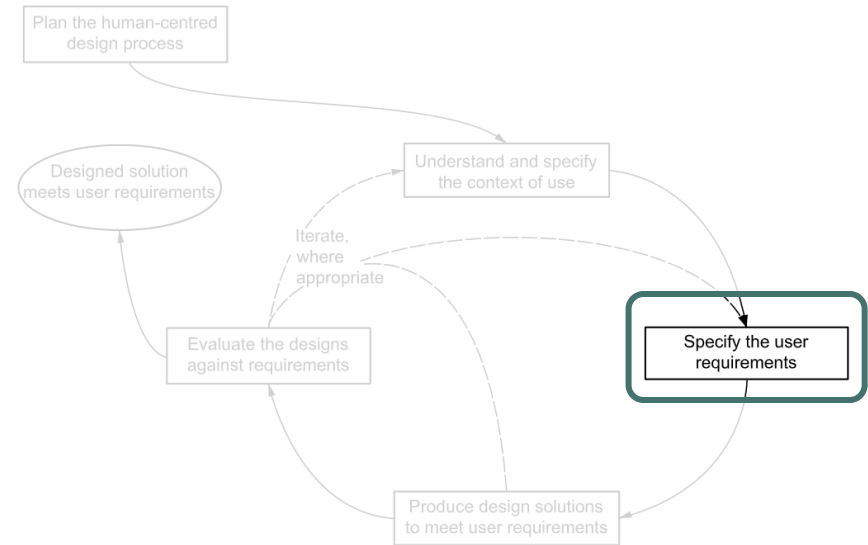


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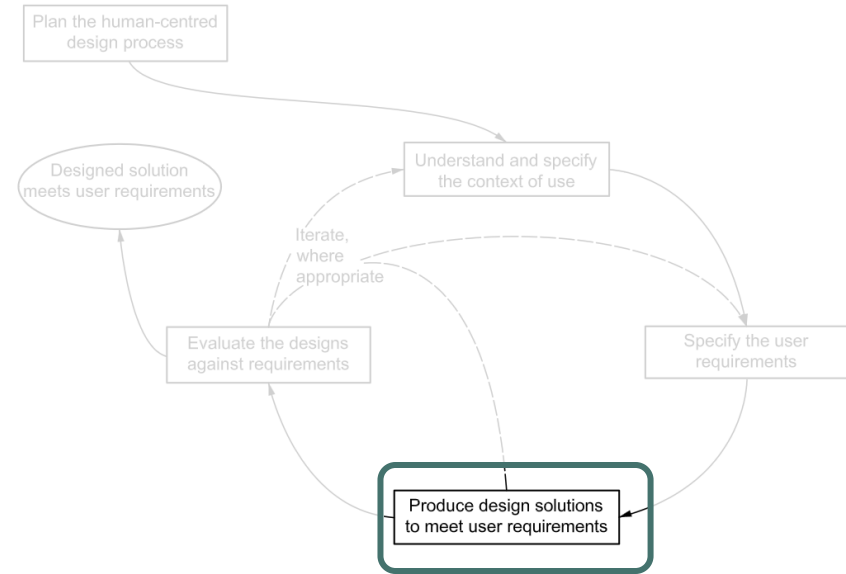


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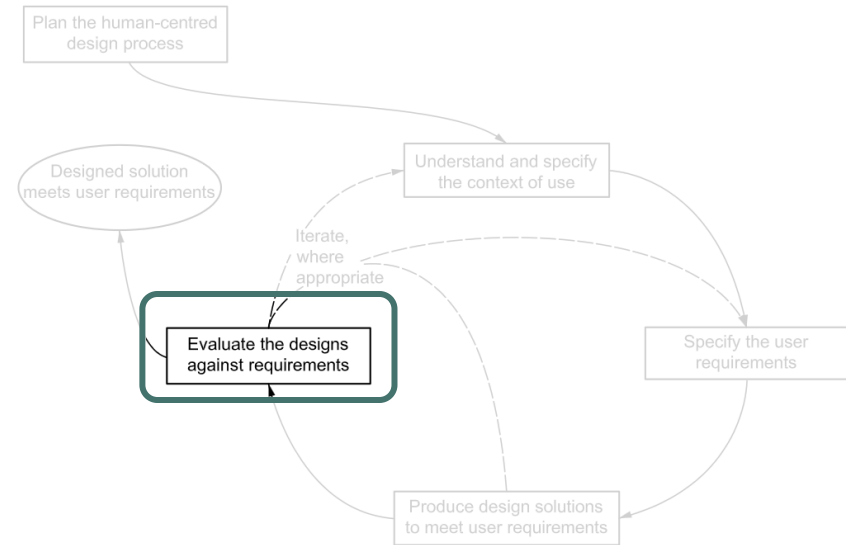


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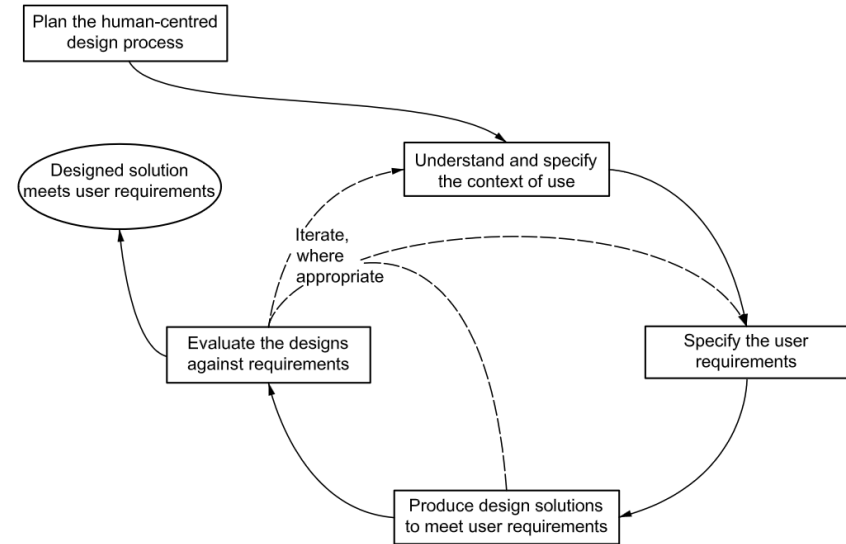


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UCD for DTs:

Needs a continuous, usage-based method to support the specification of the context of use.

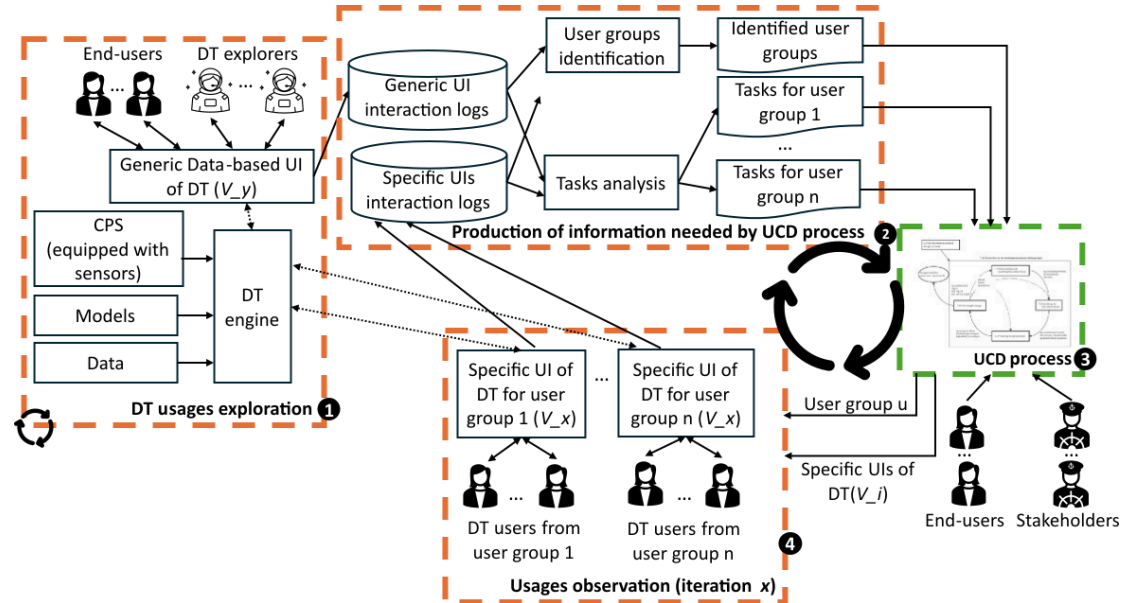
Our contribution: a tuned-for-DT UCD process

3 additional phases that produce the context of use from usage.

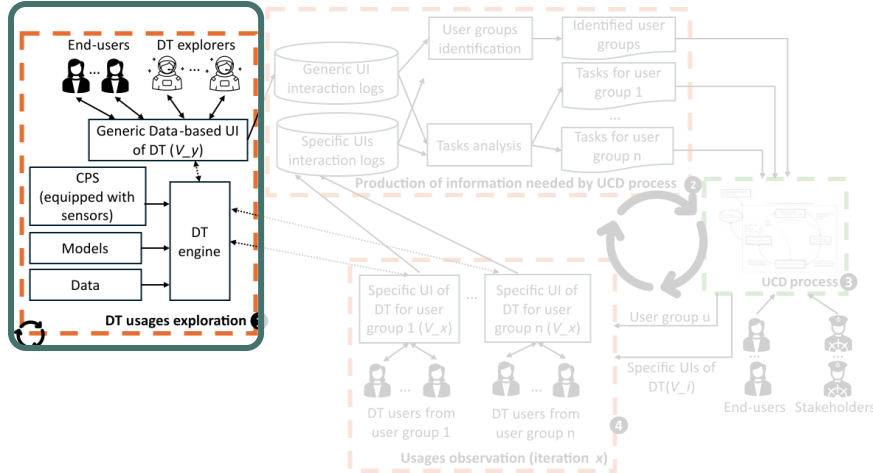
Explore → Generic UI let users compose their own tasks.

Analyse → Candidate user groups and their tasks.

Observe → Specific UIs stay instrumented; the loop allows refinement.



The tuned process, step by step



Step 1: DT Usage exploration

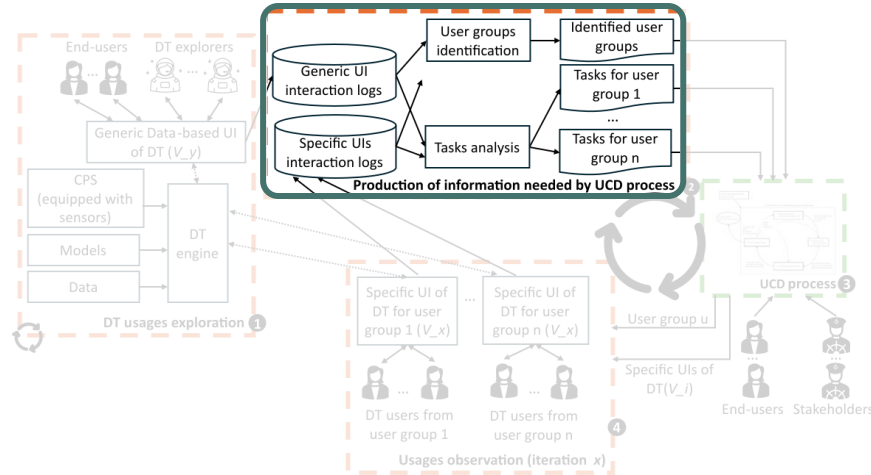
Exploration of the generic UI:

- Generic data-based tasks, e.g., dataviz, data querying
- DT model interaction, e.g., 3D model, map visualisation

Input: Generic data-centric/model-centric UI

Output: Interaction logs

The tuned process, step by step



Step 2: Producing user groups and tasks

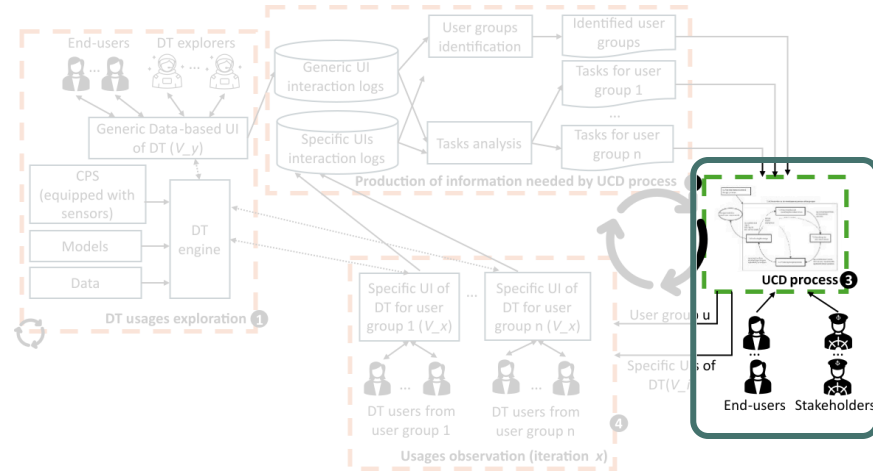
- Analysing usage → potential **user groups** + their **tasks**
- Logs give *sequences*, not *intent* → complement with interviews

Input: Usage data (interaction logs)

- from generic UI
- from specific UIs

Output: Potential user groups and associated tasks

The tuned process, step by step



Step 3: UCD process per user group

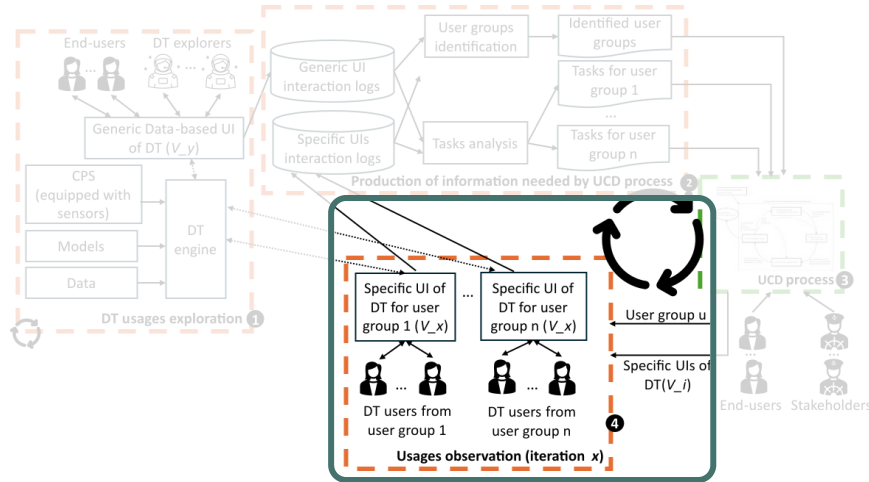
Apply the standard UCD process:

- With eager users
- Identified user group members
- Prototype evaluated with users **from the group**
- Ends when the prototypes fit user needs

Input: Identified user groups and their tasks

Output: Dedicated UIs for user groups for performing associated tasks

The tuned process, step by step



Step 4: Usage observation over user groups

Exploration of the specific UIs:

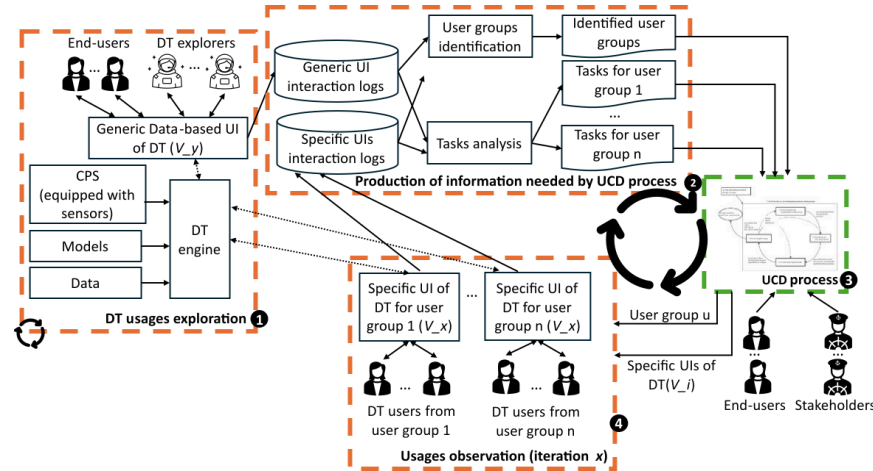
- By real operators, performing real specific tasks
- Interactions logged → back to step 2

Input:

- Specific workflow UIs
- Associated user groups

Output: Interaction logs

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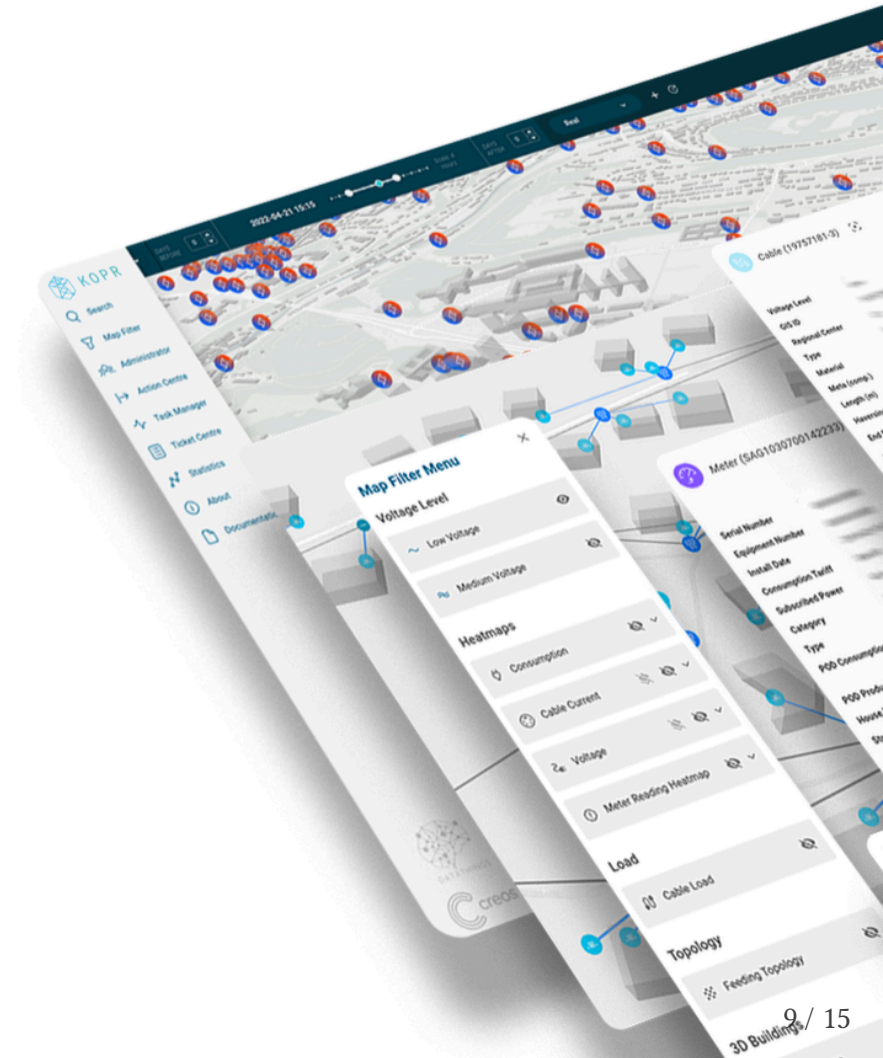
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Kopr case study

- DT for **supervision and operational analysis**
- Aggregates GIS, metering infrastructure, real-time sensors
- **> 50 billion temporal data points / year**

<https://kopr-twin.com/>



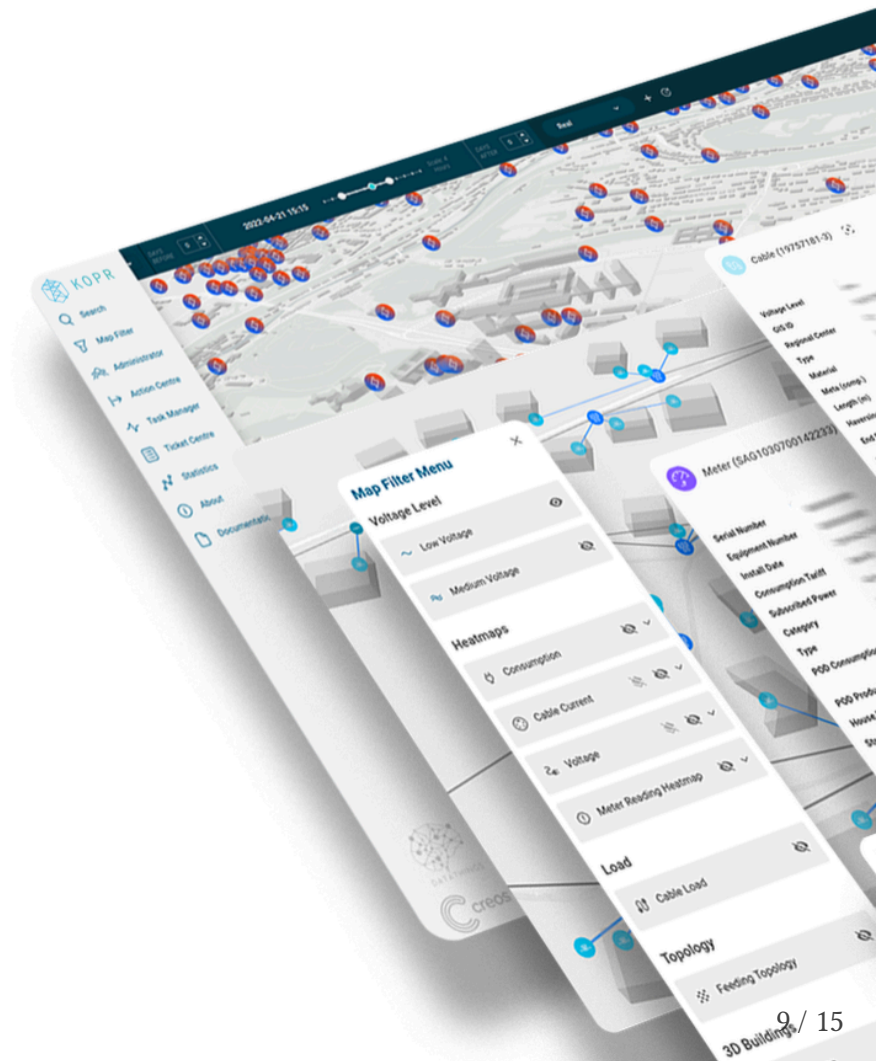
Kopr case study

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- Aggregates GIS, metering infrastructure, real-time sensors
- **> 50 billion temporal data points / year**

Context: renewable transition + rapid infrastructure growth

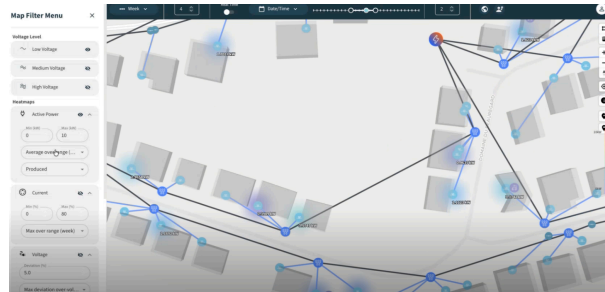
The DT's purpose keeps expanding.

<https://kopr-twin.com/>



Generic UI support multiple users' tasks

Map view



Tabular view

Element Count	Substation Power	Cable Load	Meter Power	Voltage	Transformer Load	Short Circuit
Max Loading						
72.83 %	24.46 %	100%	0	0	0	0
Sort By: Max Loading						
ID	Max load kVA	Max transformer kVA	Max loading %	Time at max	Average load kVA	
Trafo-1	408.8286 kVA	430.0000 kVA	72.83 %	2026-02-09 18:45	51.3819 kVA	
Trafo-2	408.8286 kVA	430.0000 kVA	72.83 %	2026-02-09 18:45	51.3819 kVA	
Trafo-2	227.6903 kVA	430.0000 kVA	40.89 %	2026-02-09 17:45	52.0989 kVA	
Trafo-1	227.6903 kVA	430.0000 kVA	40.89 %	2026-02-09 17:45	52.0989 kVA	
Trafo-1	97.8209 kVA	400.0000 kVA	24.46 %	2026-02-09 17:30	16.2705 kVA	
Trafo-2	97.8209 kVA	400.0000 kVA	24.46 %	2026-02-09 17:30	16.2705 kVA	
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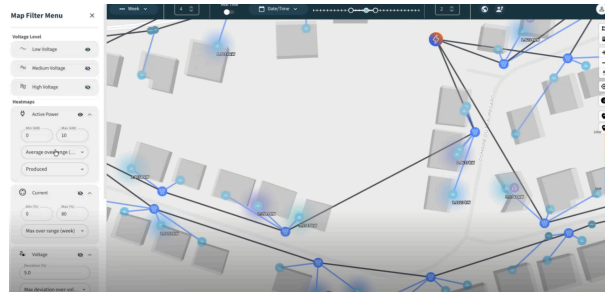
Grid planners → Evaluate risk areas on the low-voltage network

Long-term planners → Anticipate future demand in electricity

Maintenance managers → Deploy corrective actions

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Grid planners → Evaluate risk areas on the low-voltage network

Long-term planners → Anticipate future demand in electricity

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Very generic

Neither **Efficient** nor **Effective** for specialised user tasks.

Specialised workflows: PV Approval

	Before the DT	After the DT
Workflow	Manual, multi-tool: GIS → PowerFlow → load profiles → computations	Single popup, automated simulation
Duration	Weeks	Minutes
Quality	Error-prone	One-click validation

Specialised workflows: PV Approval

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Workflow	Manual, multi-tool: GIS → PowerFlow → load profiles → computations	Single popup, automated simulation
Duration	Weeks	Minutes
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Same task. From weeks of manual tool-hopping to a one-click validated decision.

Better **Efficiency** and fewer **Errors**.

What standard UCD missed here

Within the same workflow, users split into two groups with different informational needs:

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- cable type?
- safety margins?
- exact currents?
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Others prioritise higher level inspection



Colour-based percentage indicators

Loading (Before)	Loading (After)	Current (Before)
9.0607 %	19.6042 %	0.0111 kA

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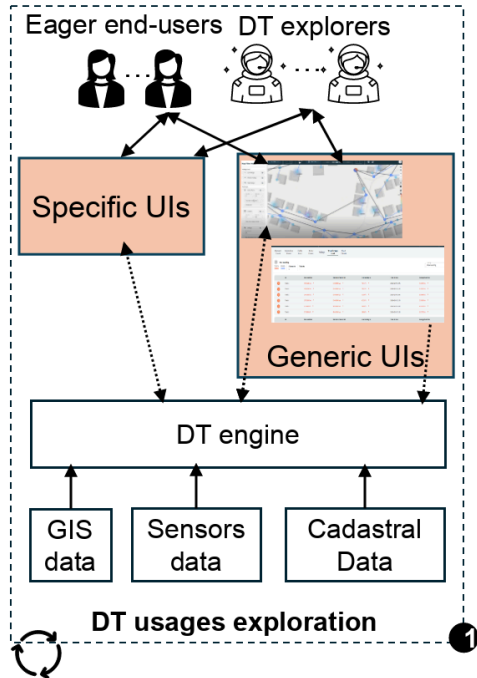
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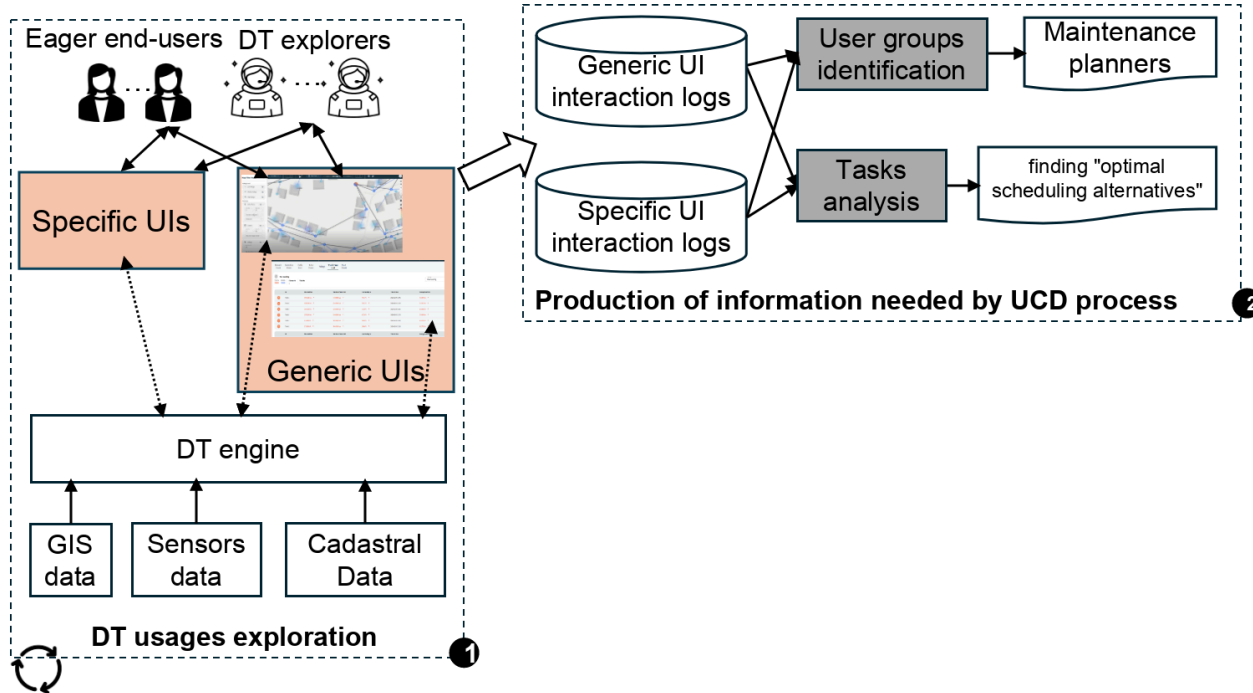
Why?

UCD treats roles as fixed entities, not evolving groups, and so did not identify diverging needs.

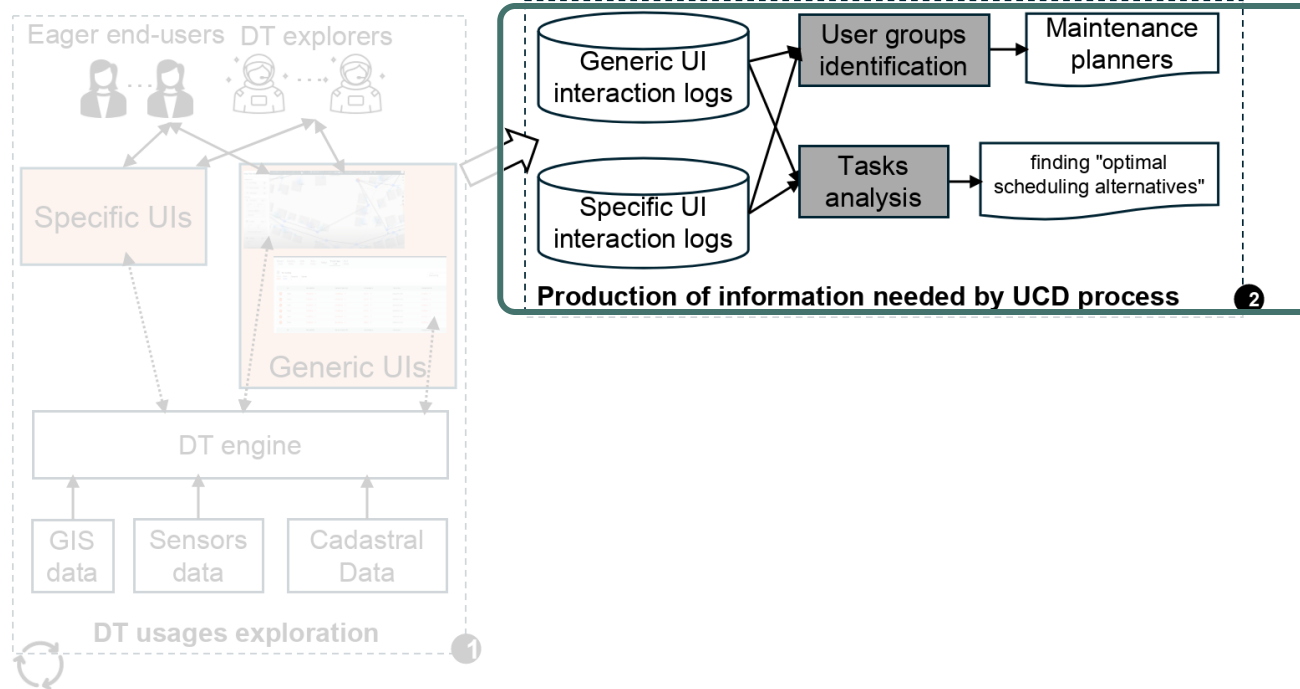
The tuned process applied: Maintenance Planning



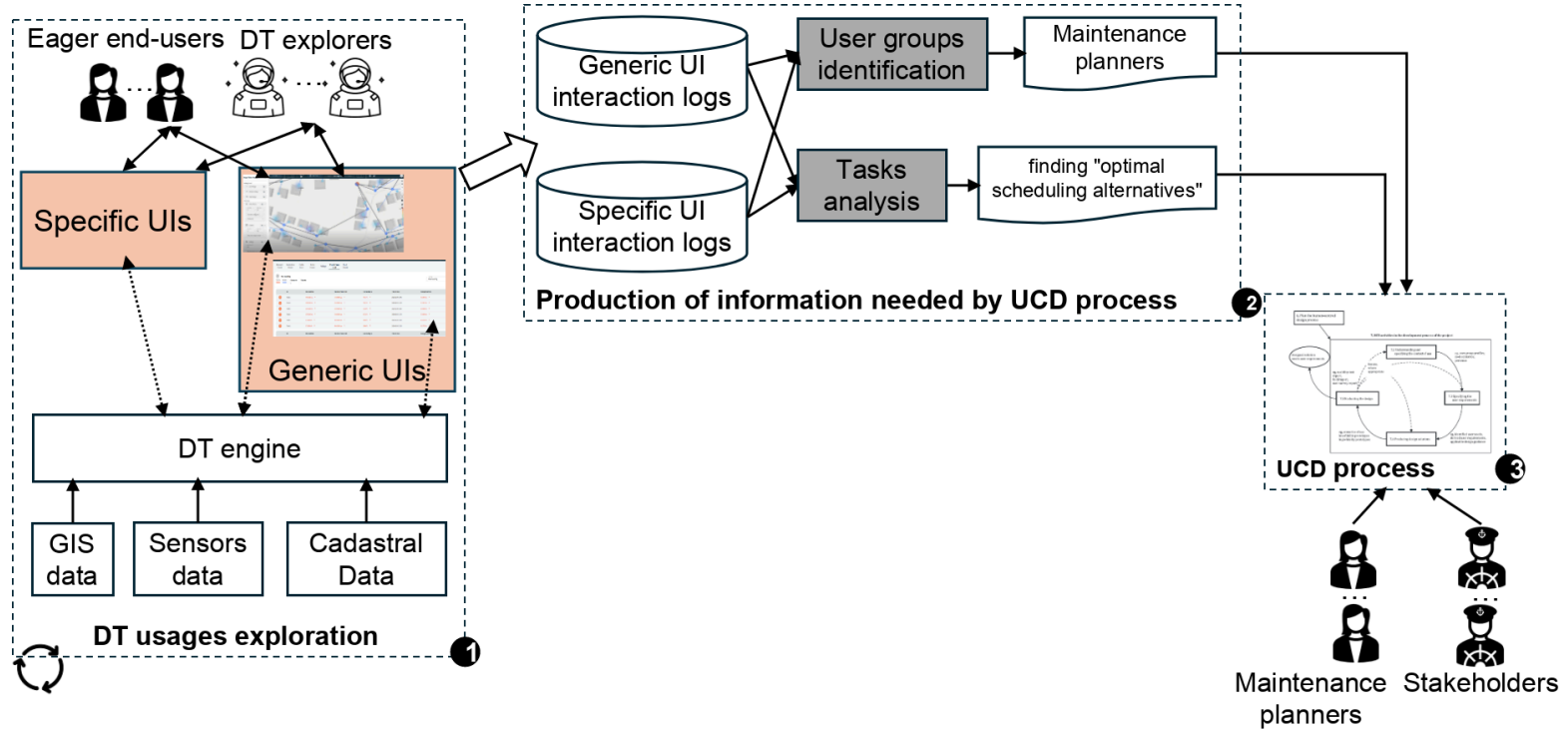
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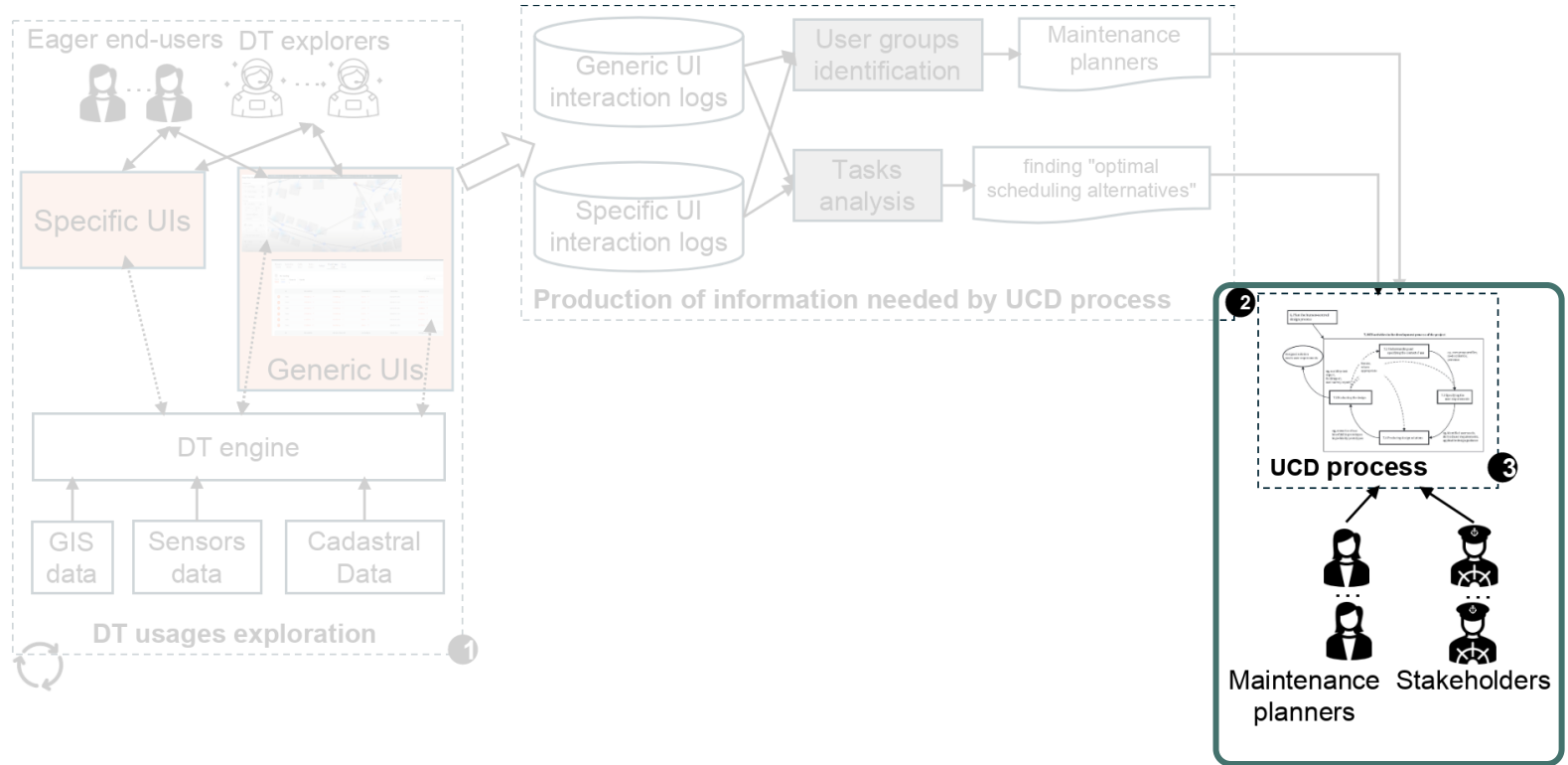
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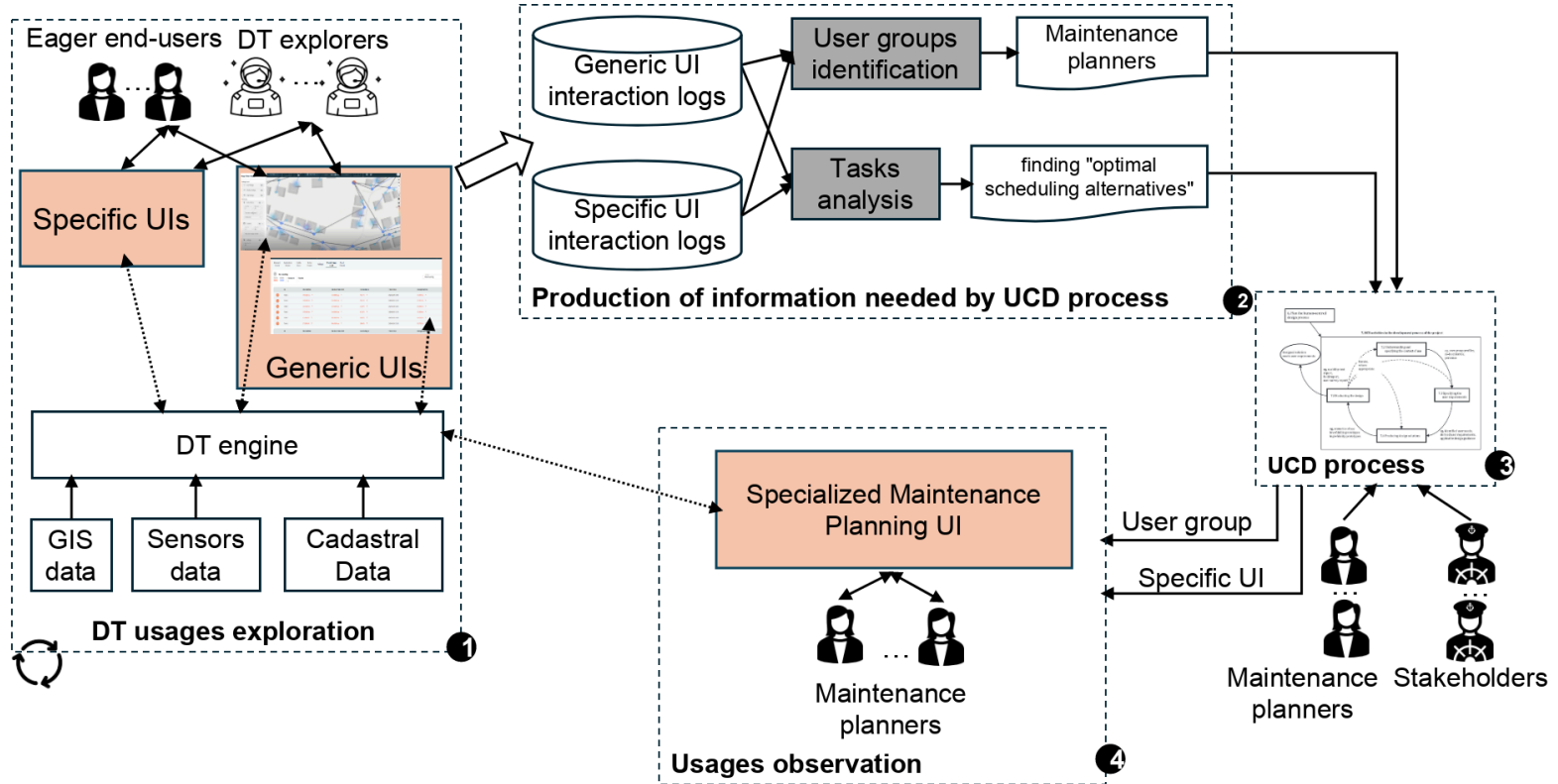
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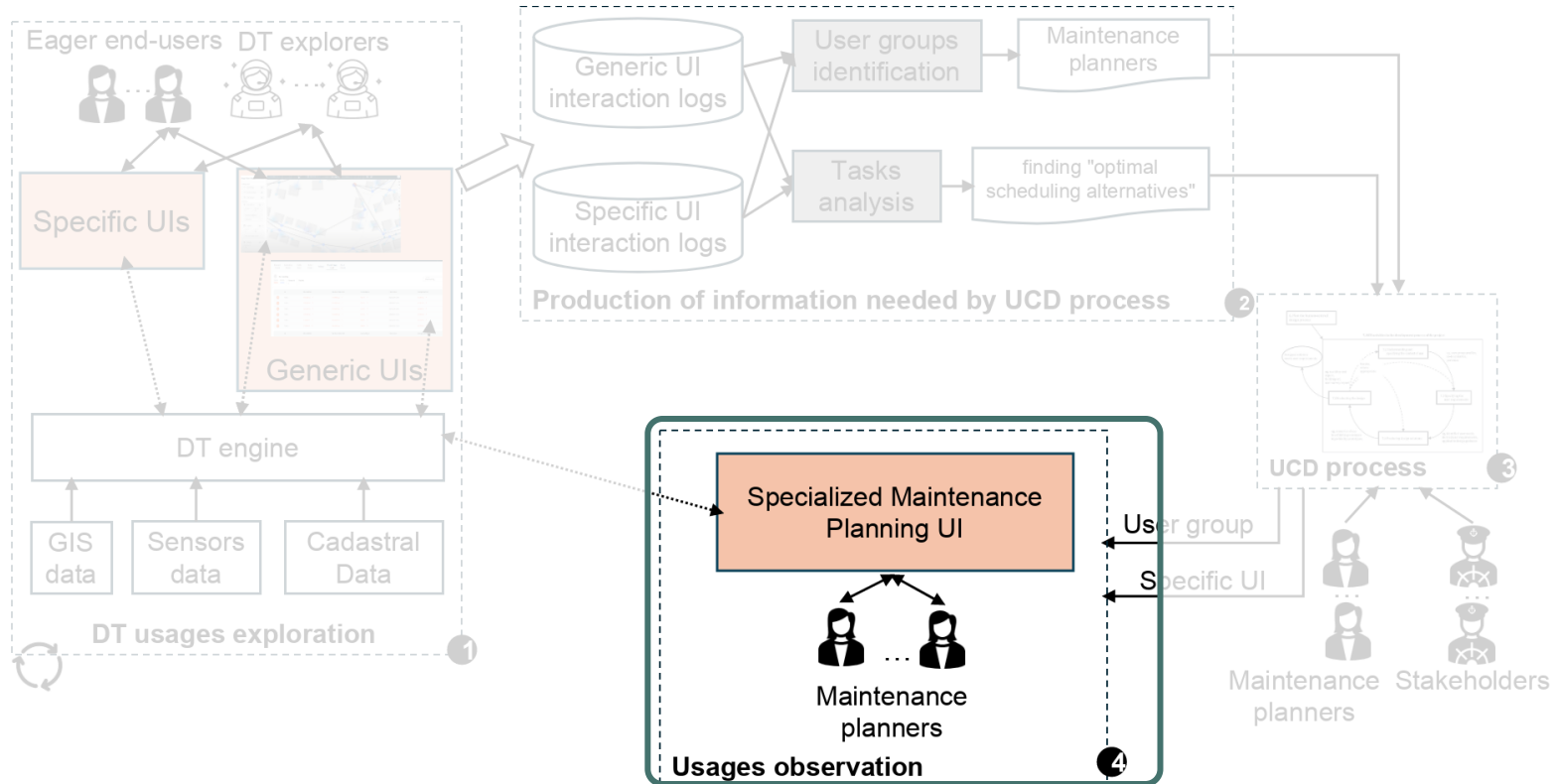
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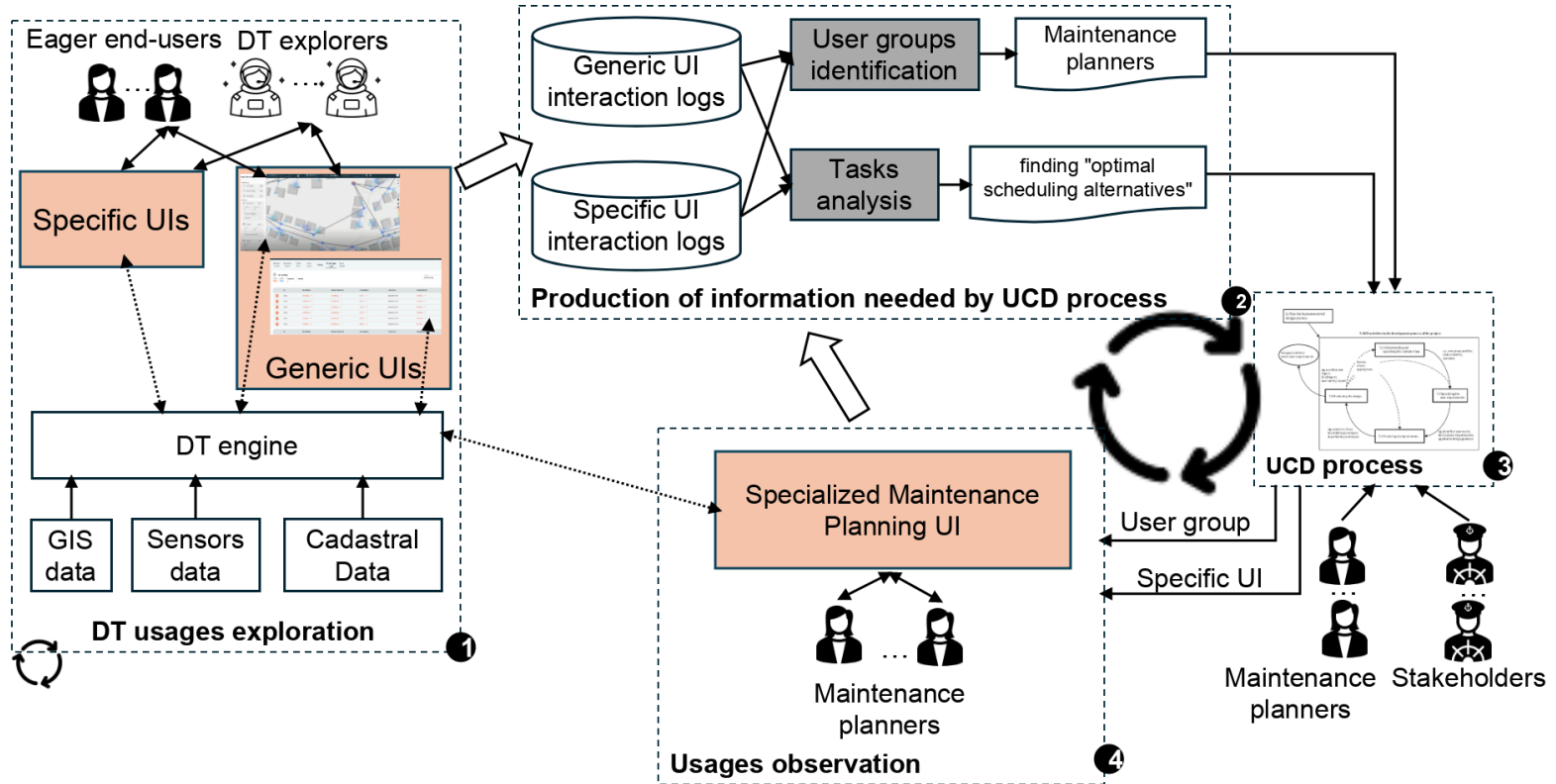
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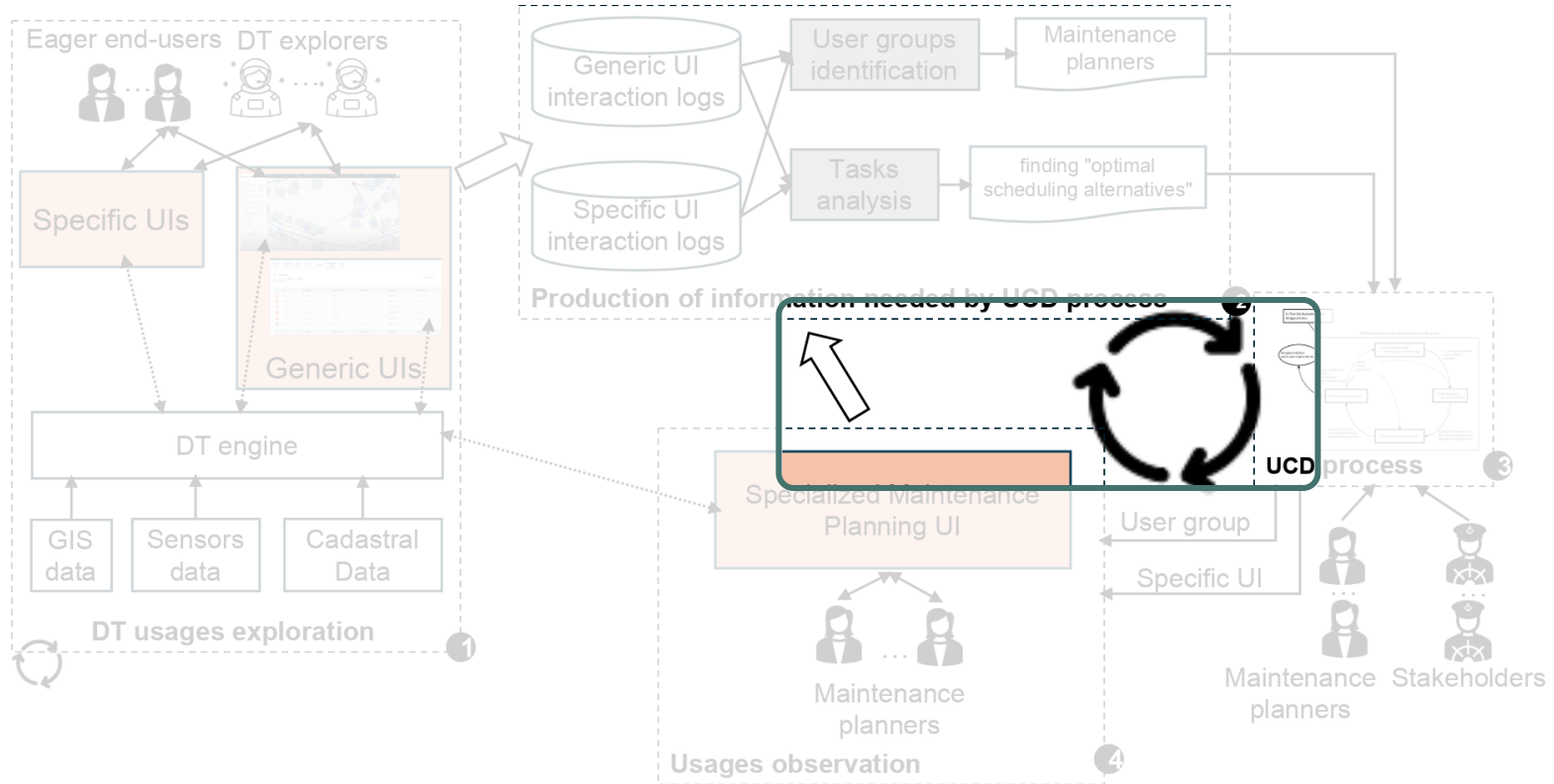
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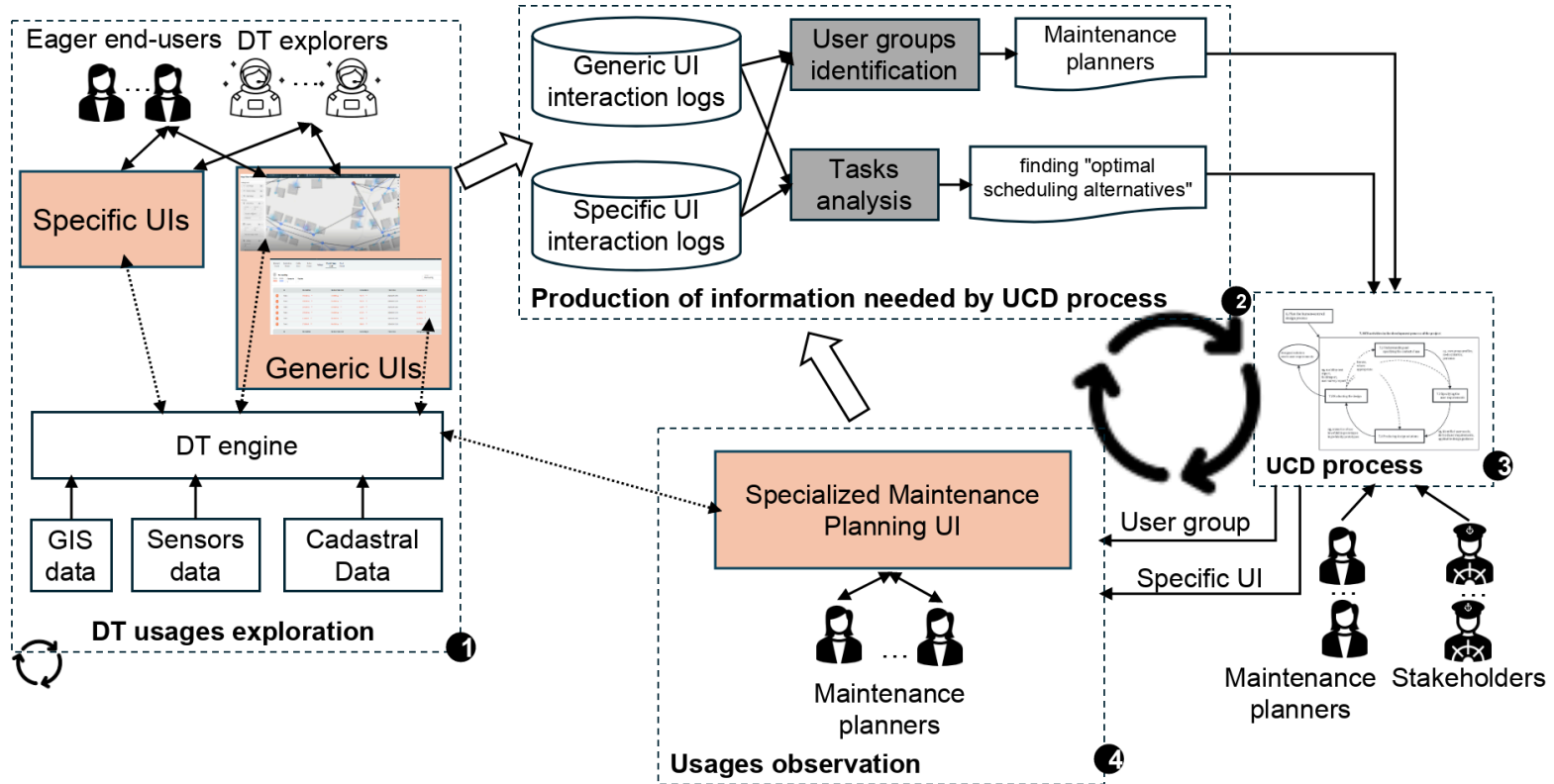
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Conclusion and future work

Problem:

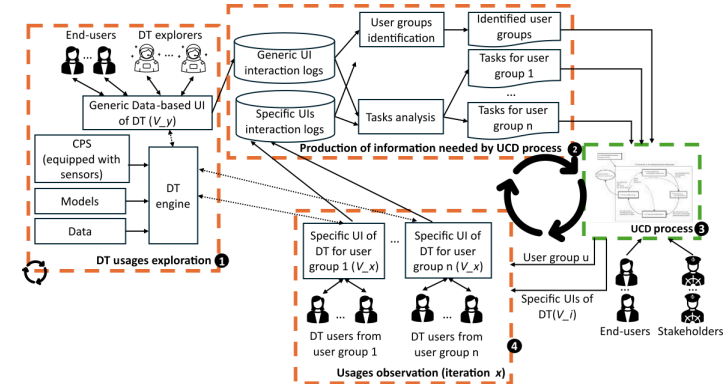
- DTs' UIs require dedicated methods to deal with the evolution of user needs and tasks.
- UCD methods do not support identifying tasks that are not known by users at design time.



Paper: [hal-05701147](https://hal.archives-ouvertes.fr/hal-05701147)

Contribution: A tuned-for-DT UCD process:

- **Explore** → generic UI, instrumented
- **Analyse** → patterns become user groups and tasks
- **Observe** → specific UIs stay instrumented



Future work:

- Develop tool to support the specification of context of use,
- Apply this tuned-for-DT approach to more use-cases.

Thank you

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- philippe.palanque@irit.fr
- arnaud.blouin@irisa.fr
- benoit.combemale@irisa.fr
- francois.fouquet@datathings.com

Kopr: <https://kopr-twin.com/>



[Paper: hal-05701147](#)

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