Decision Support for Planning the Activities of Remote Robot Fleets

Some examples and illustrated ideas from XAI (eXplainable AI)

Nika Beriachvili Rebecca Eifler Arthur Bit-Monnot Félix Ingrand

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LAAS-CNRS, Toulouse

PhD Keywords

Explainable AI

Task Planning

Constraint Satisfaction

Human-Robot(s) Collaboration

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In this presentation:
Some examples and illustrated ideas from Explainable AI planning.

Oversubscribed problems and *iterative planning*

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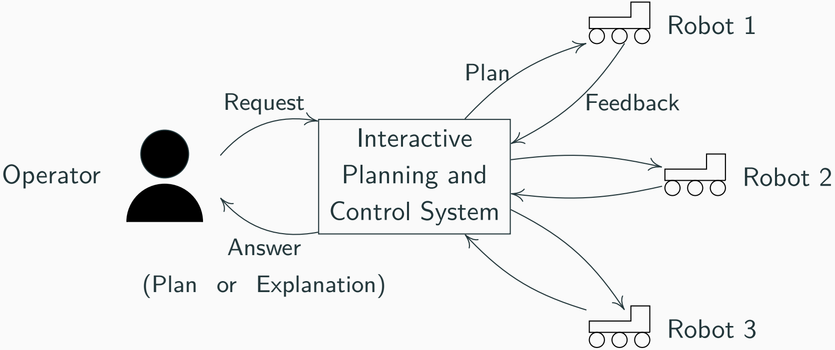
Iterative planning approach

$\rightarrow$ Address oversubscribed problems with a **step-by-step negotiation process** between the user and the planning system.

Example: Motivating multi-agent scenario



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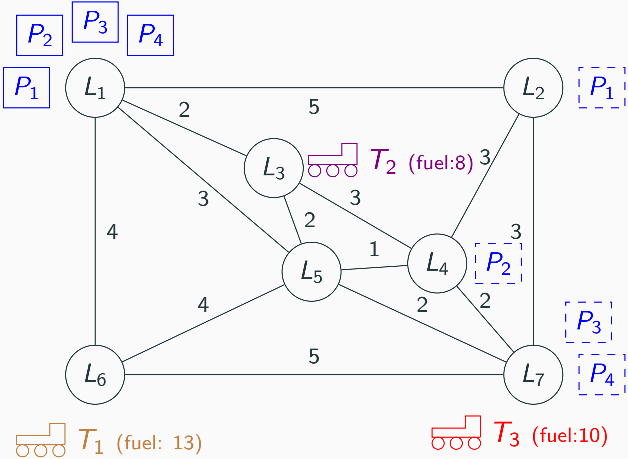

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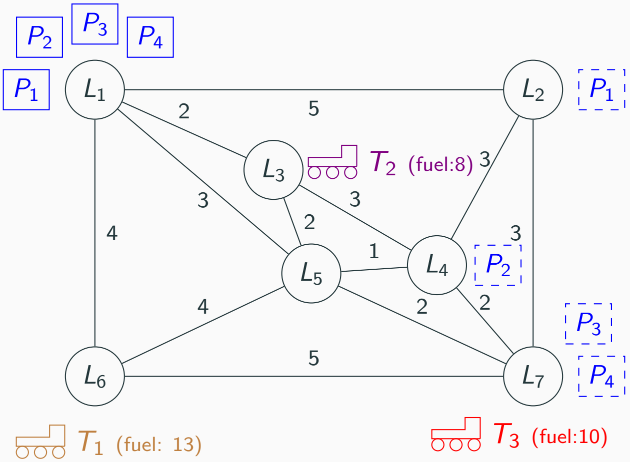

- **Operator**: Can you deliver packages P_1, P_2, P_3, P_4 to L_2, L_4, L_7, L_7 using only truck T_1 ?
- **System**: No. Because neither { P_1, P_2, P_3 } nor { P_1, P_2, P_4 } can be delivered with the given amount of fuel for T_1.

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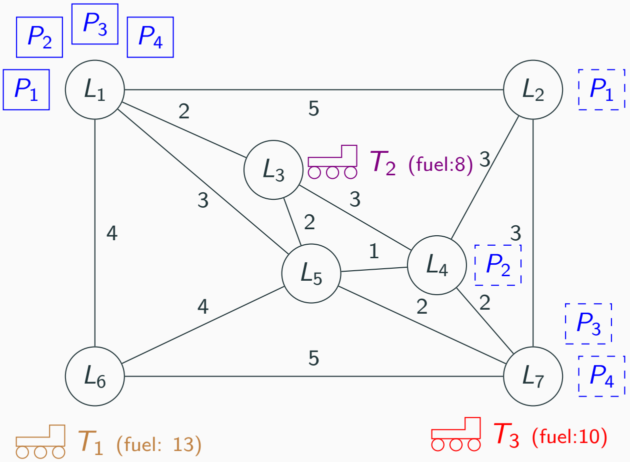

- **Operator**: Can you deliver P_1, P_2, P_3, P_4 to L_2, L_4, L_7, L_7 using only trucks T_1 and T_3 ?
- **System**: Yes. Here's a plan achieving that.

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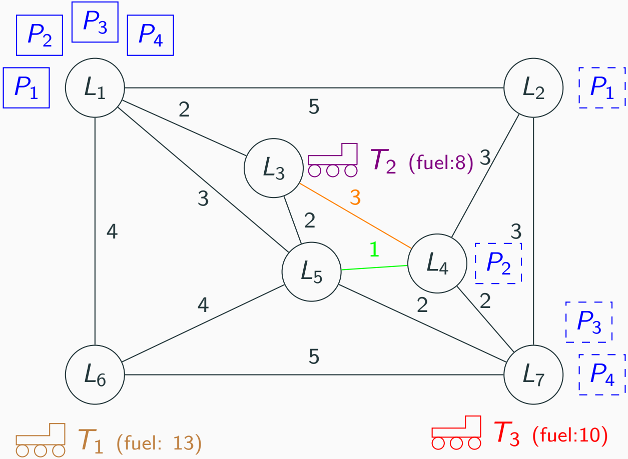

- **Operator**: In this plan, why does T_3 take road L_5L_4 rather than road L_3L_4 ?
- **System**: Because T_3 taking road L_3L_4 would result in more fuel being used than T_3 taking road L_5L_4 (10 instead of 9).

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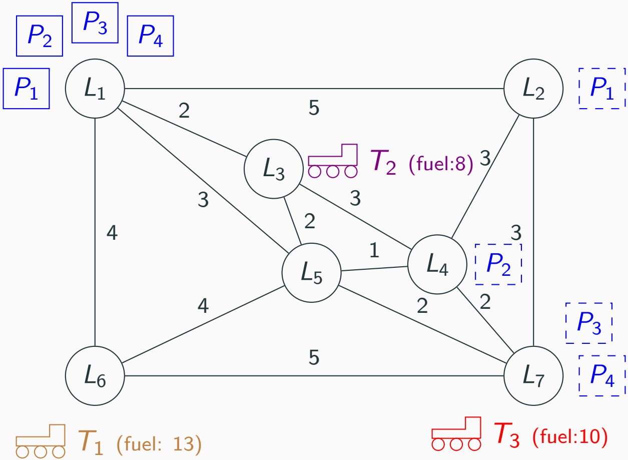

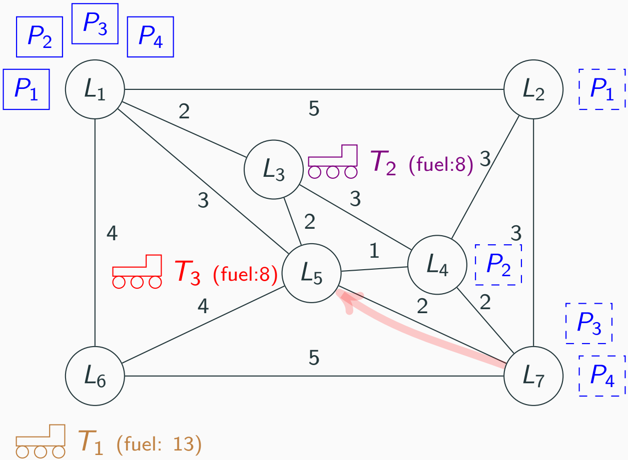
P2
P3
P4
P1
L1
L2
P1
5
2
L3
T2 (fuel:8)
3
3
3
4
2
3
1
T3 (fuel:8)
L5
L4
P2
4
2
2
P3
5
L6
L7
P4
T1 (fuel: 13)

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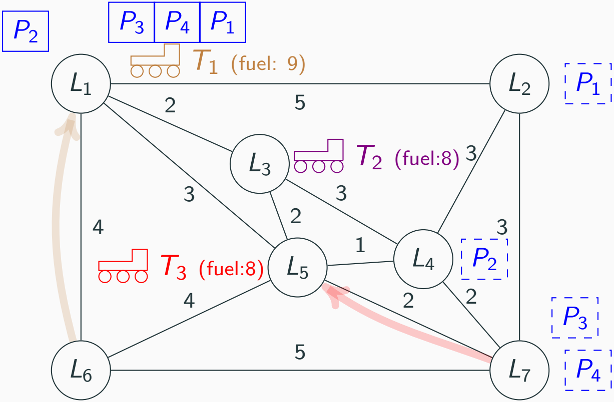

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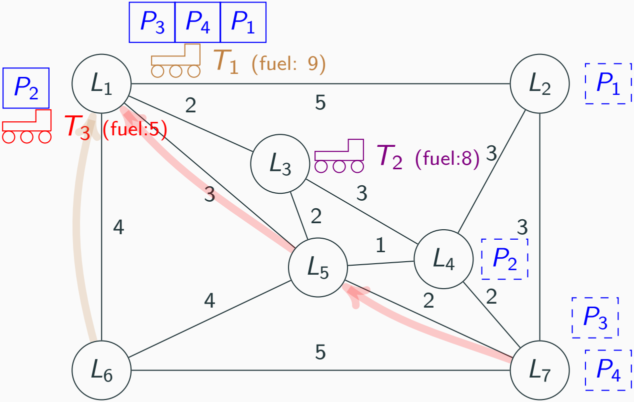

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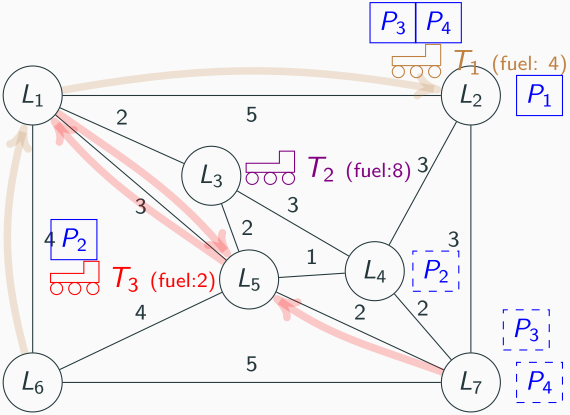

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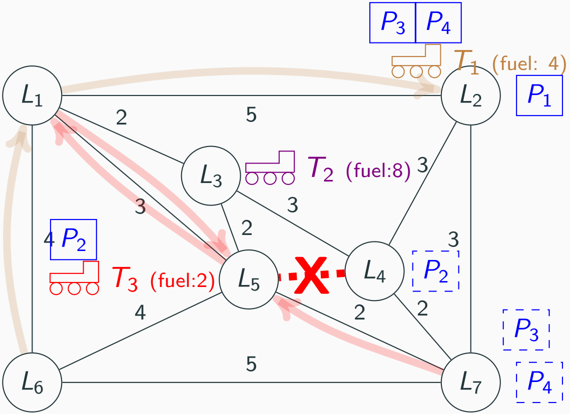

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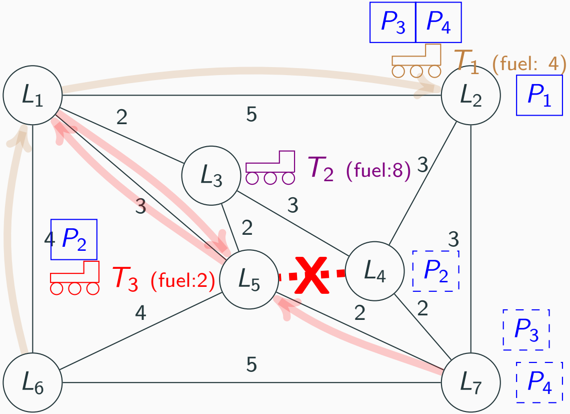

During execution, when T_3 is at L_5 and T_1 is at L_2, road L_5L_4 is suddenly blocked

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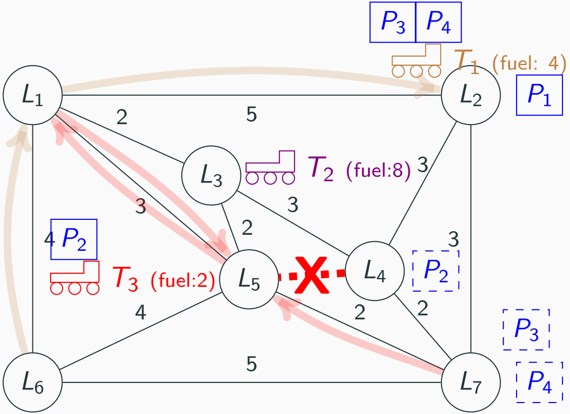

- **System**: The plan is not achievable anymore as $L_5 L_4$ is now blocked.

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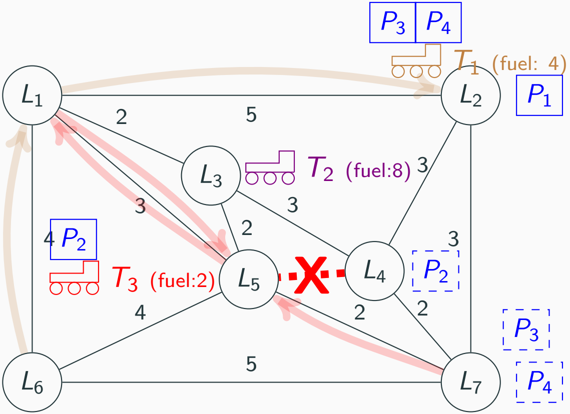

- **Operator**: Is there another plan still satisfying our requirements ?
- **System**: No. Because P_2 cannot be delivered to L_4 without using T_2, as T_1 and T_3 do not have enough fuel remaining.

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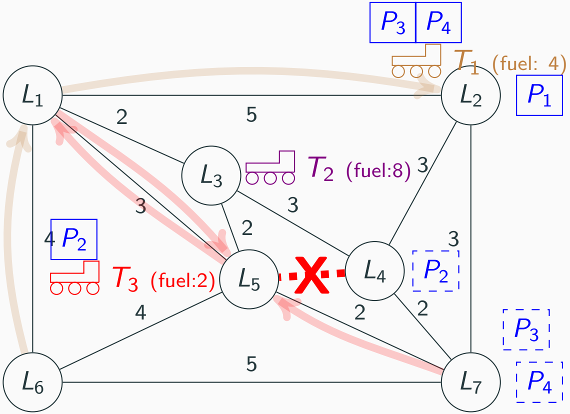

- **Operator**: Then find a plan that uses truck T_2.
- **System**: Here's a plan achieving that.

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In the example: explanations given in **natural language**.

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Ex: $\{P_1, P_2, \underline{P_3}, T_1, \mathit{fuel}_0(T_1) \leq 13\}$ and $\{P_1, P_2, \underline{P_4}, T_1, \mathit{fuel}_0(T_1) \leq 13\}$ are two MUSes for $\{P_1, P_2, P_3, P_4, T_1, \mathit{fuel}_0(T_1) \leq 13\}$

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Ex: $\{fuel_0(T_1) \leq 13\}$ and $\{P_3, P_4\}$ are two MCSes.
Corollary: *an MCS is trivial feasible relaxation.*

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Ex: $\{\mathit{fuel}_0(T_1) \leq 13\}$ and $\{P_3, P_4\}$ are two MCSes.
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*MUSes and MCSes are **minimal hitting sets** of each other.*

Explanation structure

Computing explanations boils down to:

$\rightarrow$ **Finding MUSes** (or MCSes/relaxations) of some **infeasible problem(s)**.

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Rack system to slide jigs between "Beluga" and "factory" sides of the site. ↖

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Possible incompatibilities between unload/load/deliver tasks, preferences...
→ **Explain by finding their MUSes !**

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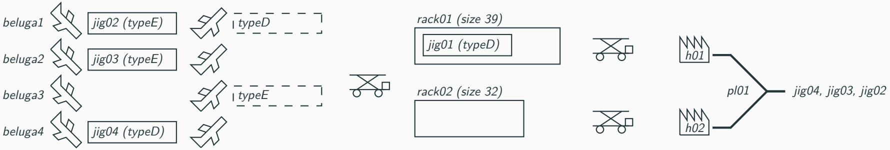

(Initially, *jig01* is on *rack01* and is empty)

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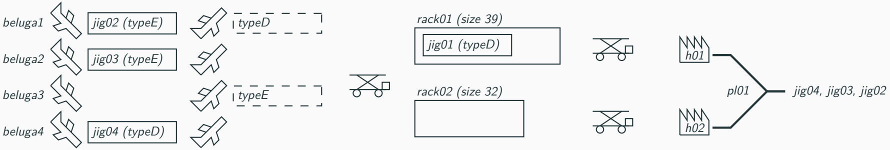

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Goals / preferences:

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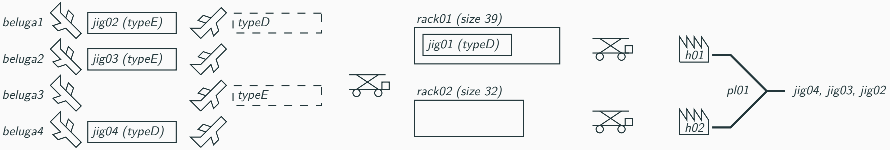

(Initially, *jig01* is on *rack01* and is empty)

Goals / preferences:

- Unload *jig02* from *beluga1*, *jig03* from *beluga2*, *jig04* from *beluga4*

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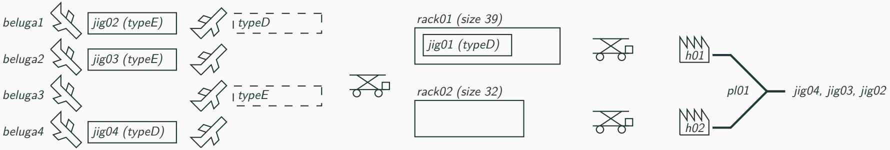

(Initially, *jig01* is on *rack01* and is empty)

Goals / preferences:

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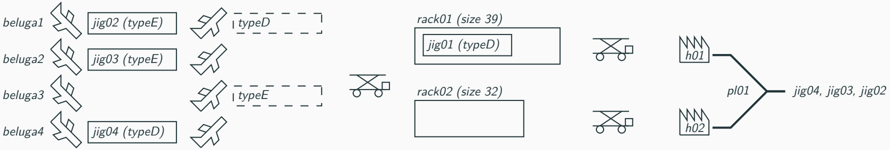

(Initially, *jig01* is on *rack01* and is empty)

Goals / preferences:

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- Deliver *jig04*, *jig03*, *jig02* to production line *pl01*

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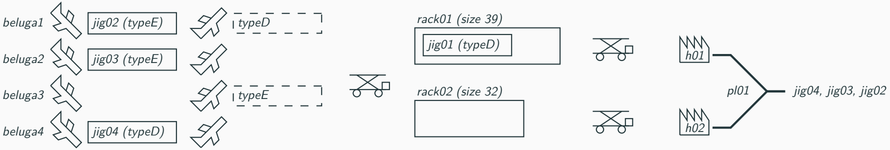

(Initially, *jig01* is on *rack01* and is empty)

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MUSes (only one):

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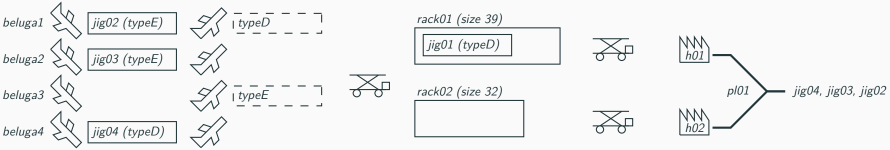

(Initially, *jig01* is on *rack01* and is empty)

Goals / preferences:

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- Deliver *jig04*, *jig03*, *jig02* to production line *pl01*

MUSes (only one):

- { Load a *typeE* jig into *beluga3*, Deliver *jig04* to production line *pl01* }

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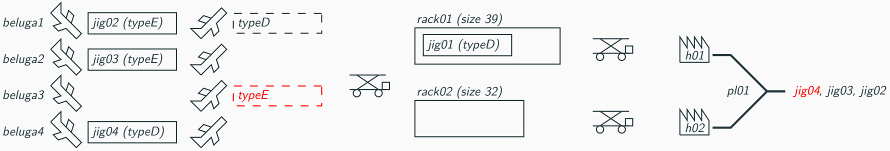

(Initially, *jig01* is on *rack01* and is empty)

Goals / preferences:

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- Load a *TypeD* jig into *beluga1*, a *typeE* jig into *beluga3*
- Deliver *jig04*, *jig03*, *jig02* to production line *pl01*

MUSes (only one):

- { Load a *typeE* jig into *beluga3*, Deliver *jig04* to production line *pl01* }

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- More details ?

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Goals MUS: { Load a *typeE* jig into *beluga3*, Deliver *jig04* to production line *pl01* }

- More details ? ***Why exactly*** is this a MUS ?

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Goals MUS: { Load a *typeE* jig into *beluga3*, Deliver *jig04* to production line *pl01* }

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*Particularly interesting for **singleton** goal / preference MUSes.*

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  "Because Beluga3 leaves before jig04 is unloaded"
  preferred over *"Not enough empty typeE jigs on site"*

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  Ex: "Why do you do close the door [rather than the window] ?"
  surprise about the window not being closed

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  (Future work... Lots of logical shenanigans involved !)

Thank you ! Questions ?

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