



Self-Managing Conflict Resolution for Autonomous Taxiing Tugs: An Initial Survey

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Image: <http://www.decideursenregion.fr/Loire-Centre/Innover-En-Region/entreprises/technologies/TaxiBot-le-tracteur-pour-avions-revolutionnaire-concu-par-TLD>

adding an autonomous tug

- Without a human onboard
- What prioritization strategy should be used to resolve potential conflicts between two tugs ?



Image: <http://www.decideursenregion.fr/Loire-Centre/Innover-En-Region/entreprises/technologies/TaxiBot-le-tracteur-pour-avions-revolutionnaire-concu-par-TLD>

soliciting atco input



Training: TaxiBots
TB : Example # 4

73 scenarios

Revue / Review

Veillez choisir l'option qui correspond le mieux à votre choix de priorité entre les taxibots.
Please select the option that best matches your prioritization approach for the taxibots.

- ☐ J'ai regardé les critères de chaque taxibot et choisi celui qui semblait être globalement "le meilleur" / Looked at the criteria of each aircraft and picked the taxibot that seemed to be globally "better"
- ☐ Je n'ai utilisé a priori qu'un seul critère ; si jamais le critère était identique entre les avions, j'ai utilisé un second critère et ainsi de suite / Chose between aircraft based on one criterion, if they were equal, used another criterion until I found one "better" than the other
- ☐ Other:

Veillez choisir les critères que vous avez utilisés. Si vos critères ne sont pas dans cette liste, écrivez-les dessous, séparés par une virgule.
Please choose the criteria that you used. If your criteria are not in the list, write them below, separated by a comma.

- ☐ Temps de roulage avant / Time called prior
- ☐ Temps d'arrivée prévue / ETA
- ☐ Trajet prévu / Predicted trajectory

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☐ J'ai regardé les critères de chaque taxibot et choisi celui qui semblait être globalement "le meilleur" / Looked at the criteria of each aircraft and picked the taxibot that seemed to be globally "better"

☐ Je n'ai utilisé a priori critère et ainsi de suite / until I found one "better"

☐ Other:

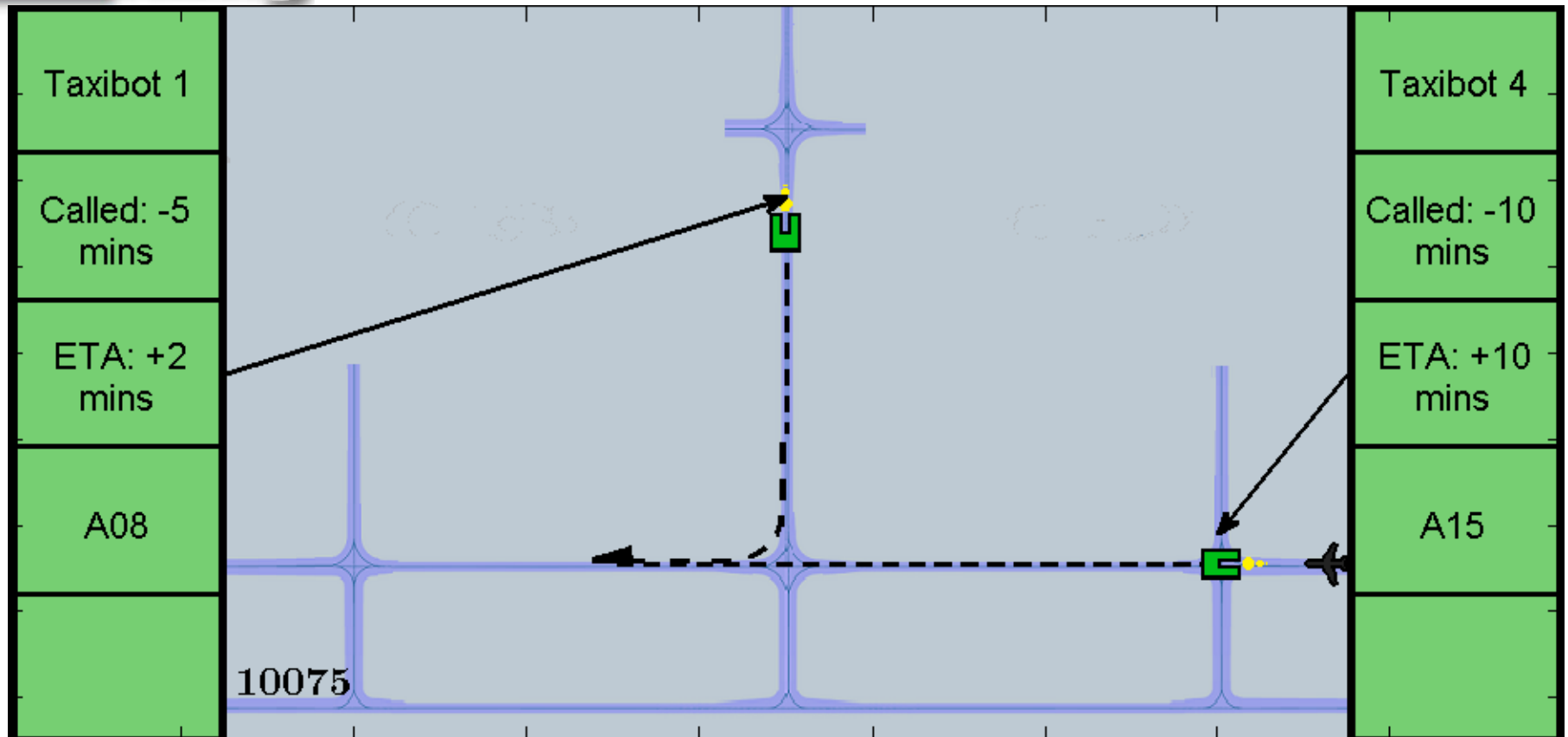
Veillez choisir les critères suivants, séparés par un espace.
Please choose the criteria below, separated by a space.

☐ Temps de roulage avant l'atterrissage / Taxi time before landing

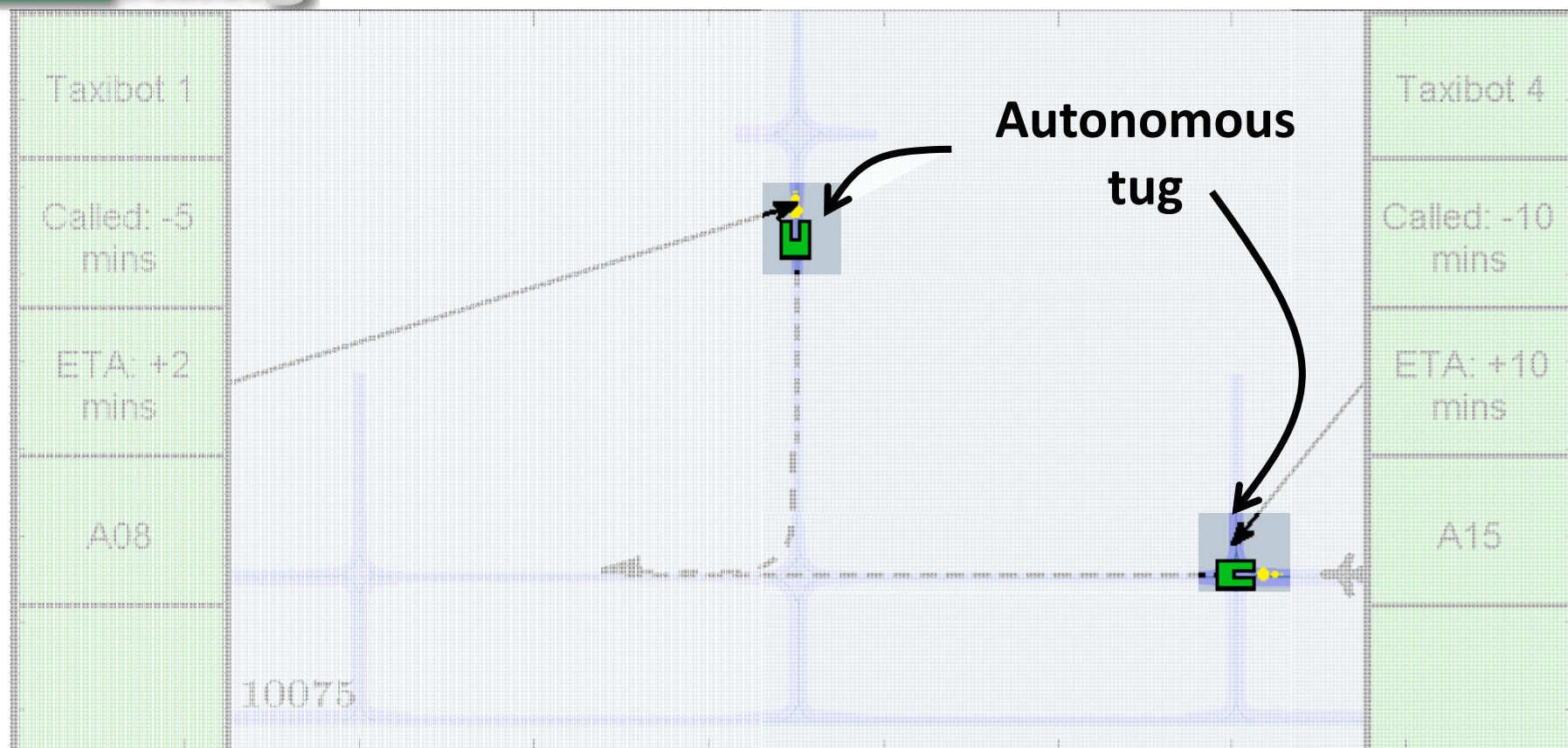
☐ Temps d'arrivée prévu / Expected arrival time

☐ Trajet prévu / Predicted route

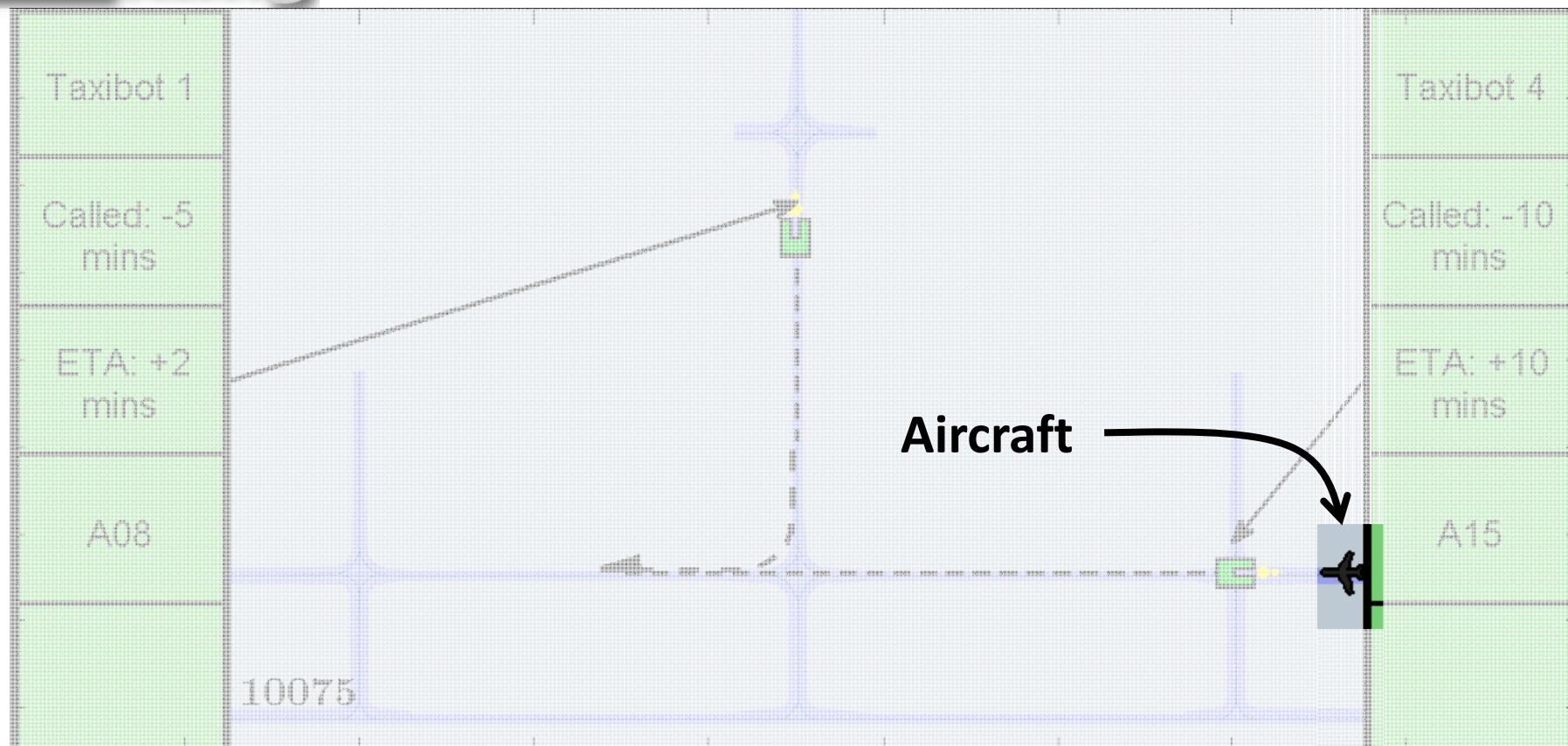
- 17 participants (11 airports represented; France, Spain, Turkey, USA)
- Analysis:
 - Linear multivariate regression model with logical variables
 - One-way Kruskal-Wallis ANOVA
 - Mann-Whitney Wilcoxon rank-sum test



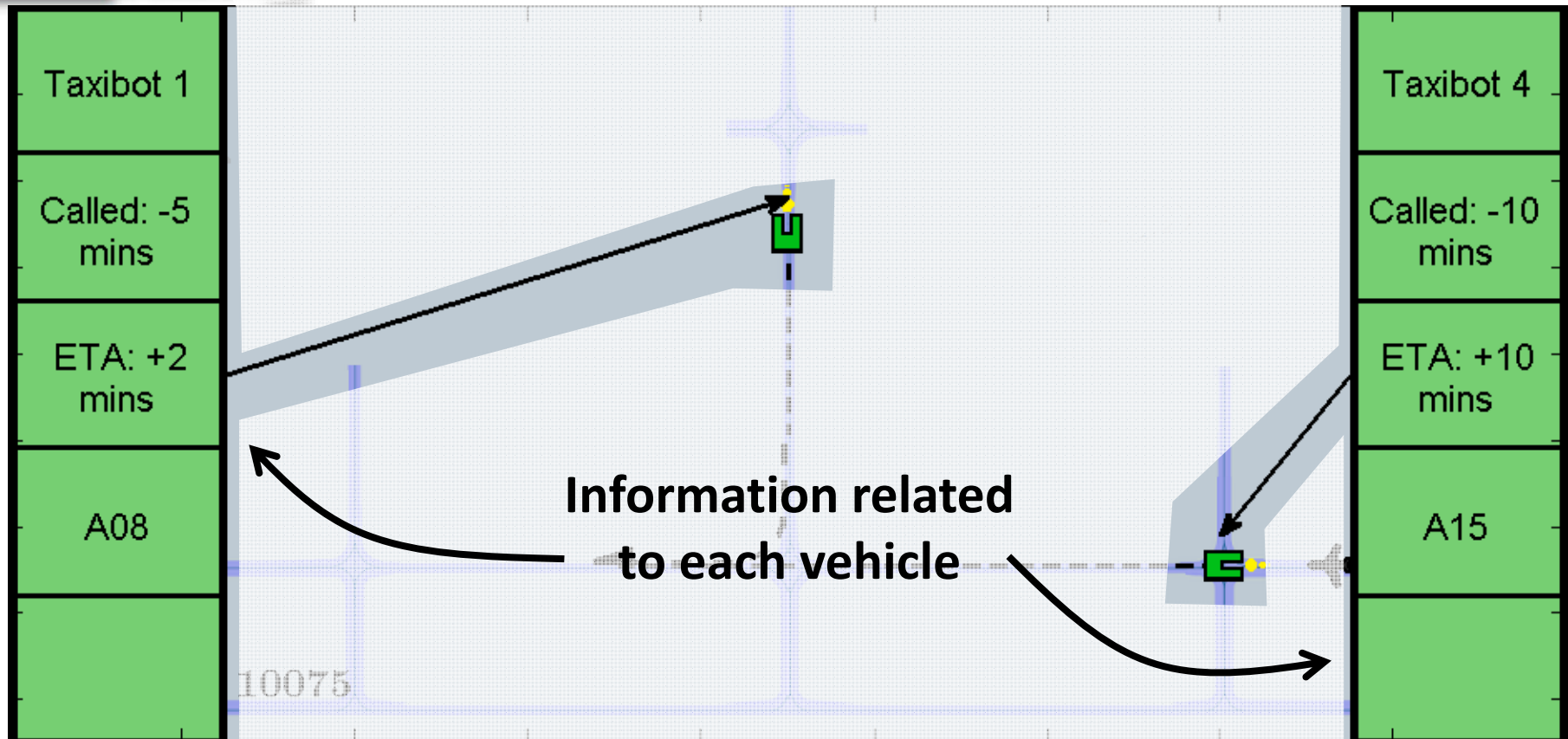
- Radar image of generic intersection at generic airport



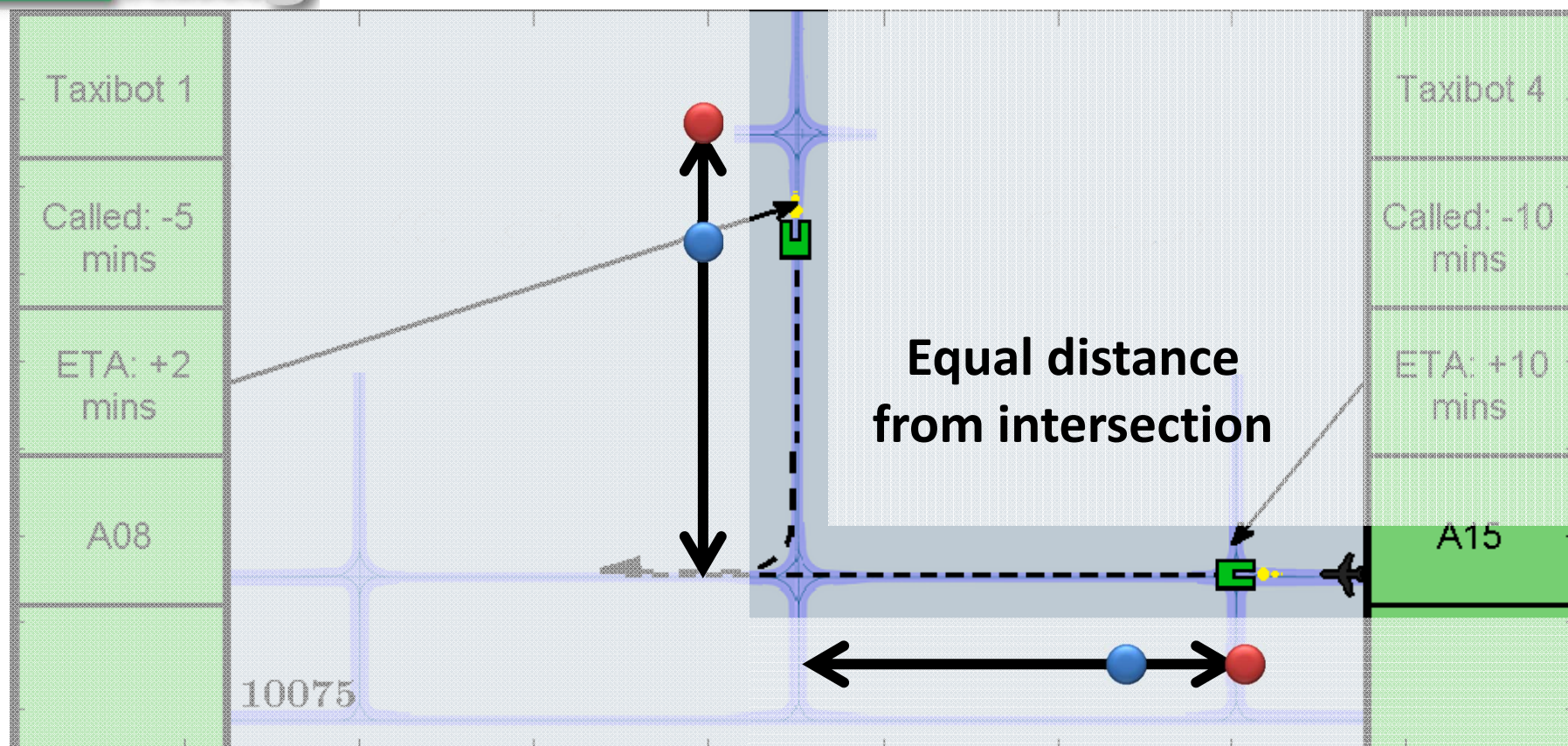
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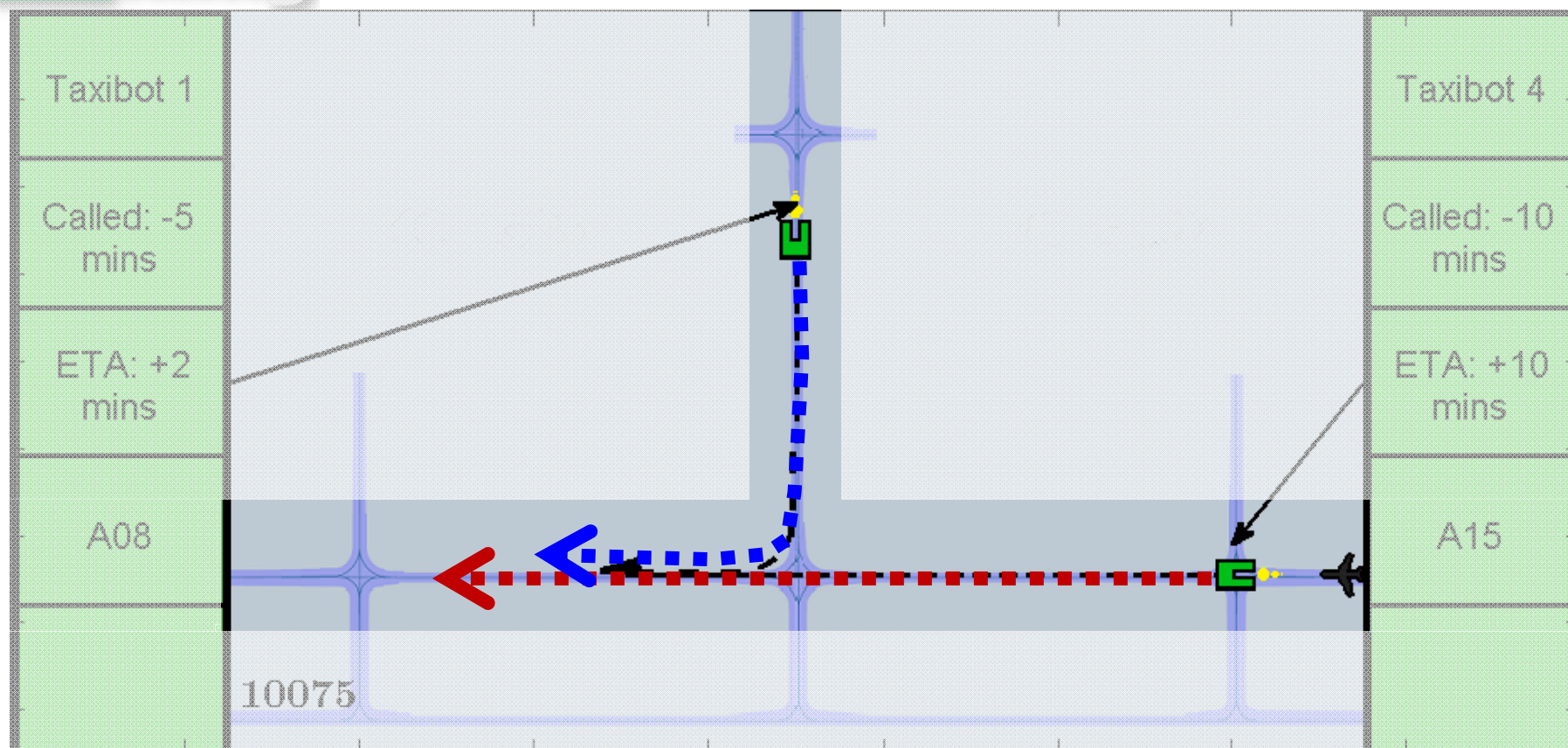
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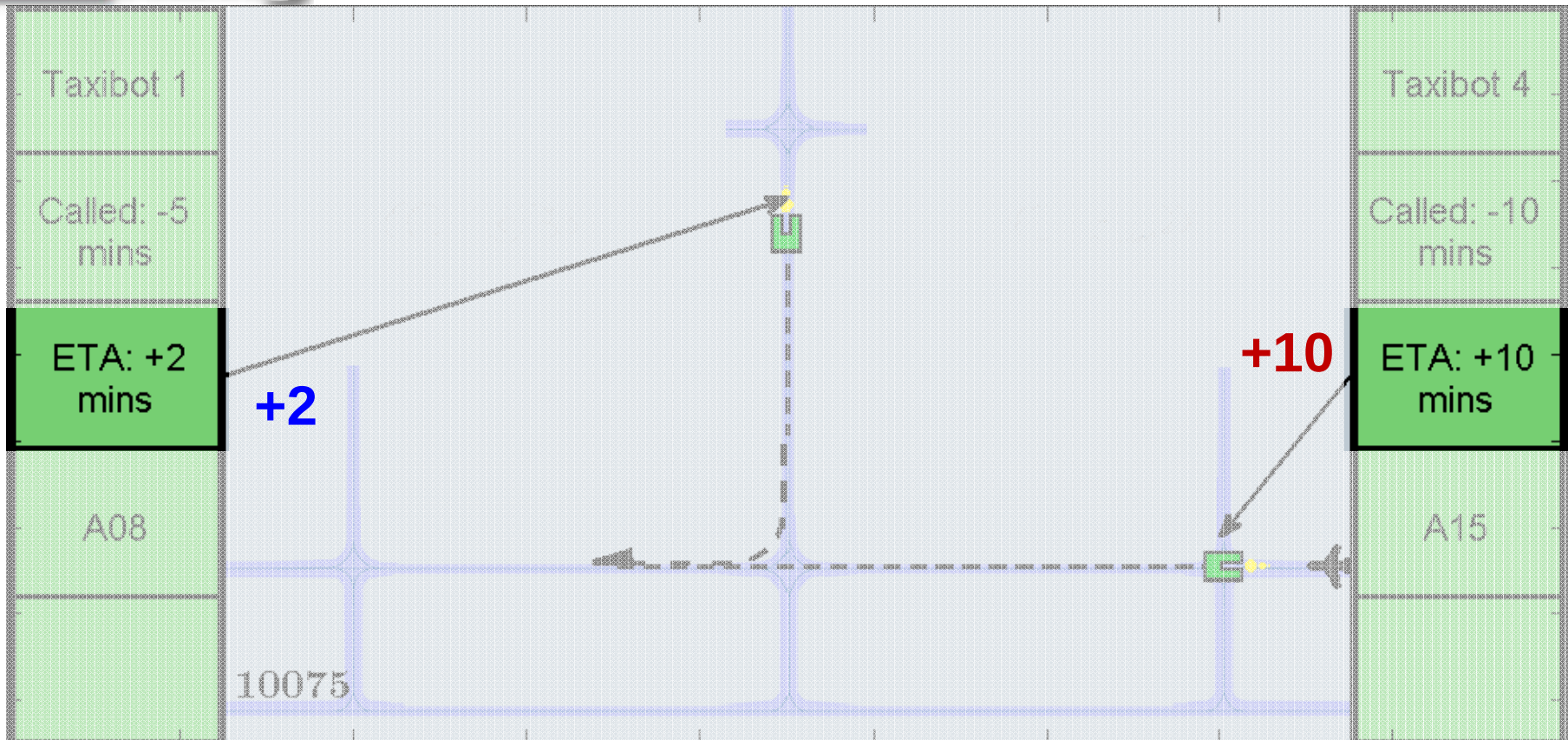
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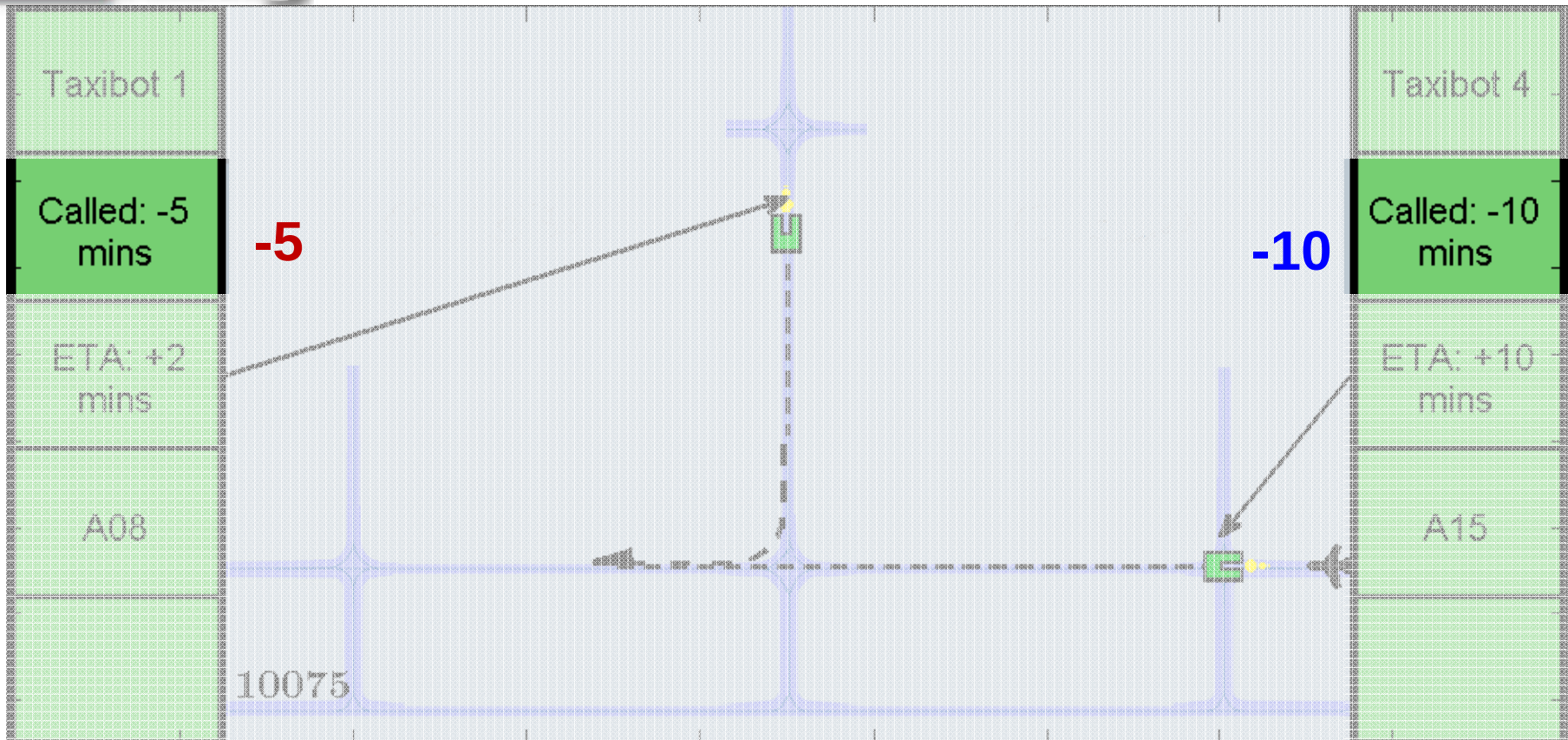
- Position relative to the intersection (PosRel; Closer, Farther)



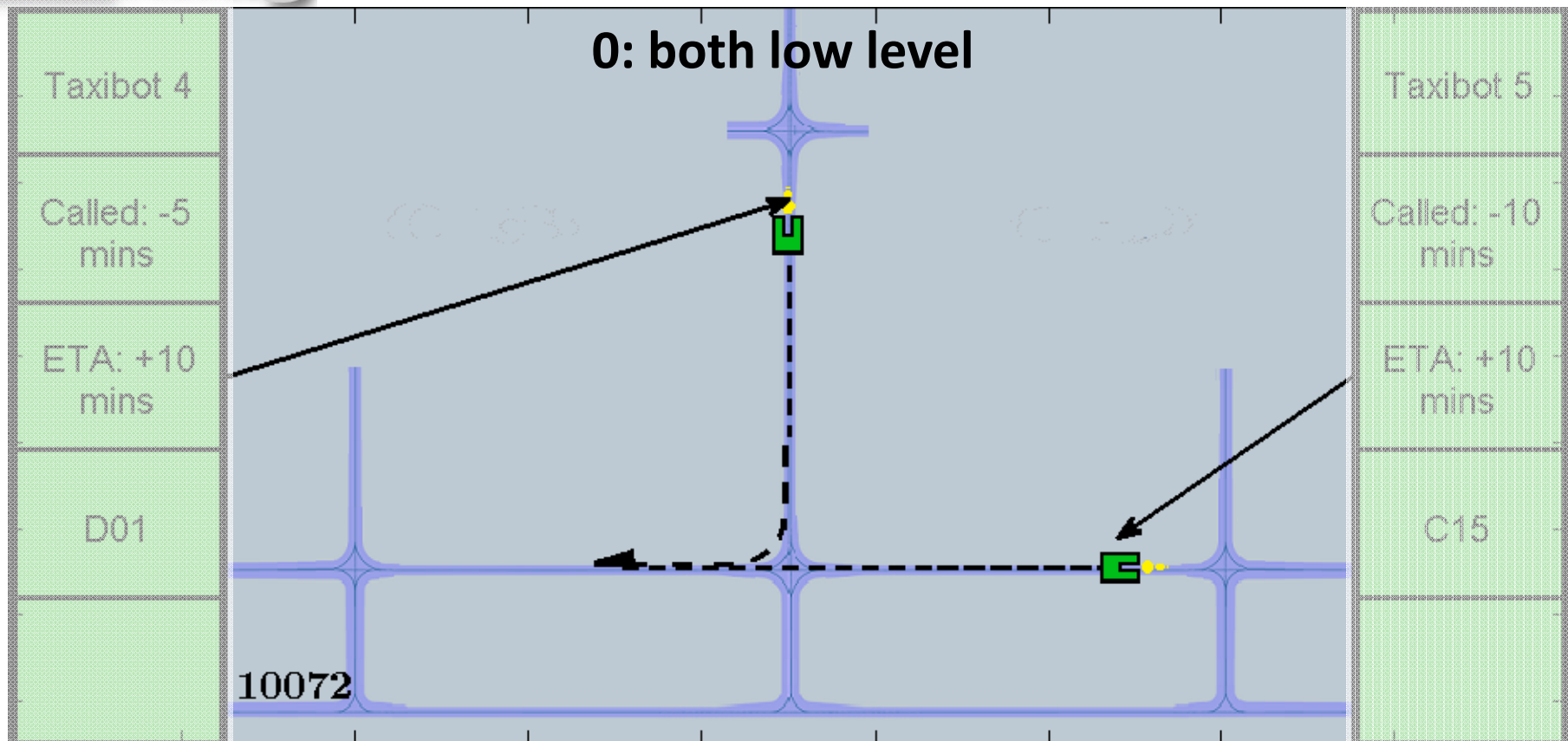
- Path after intersection (PathAfter; Turn, Straight)



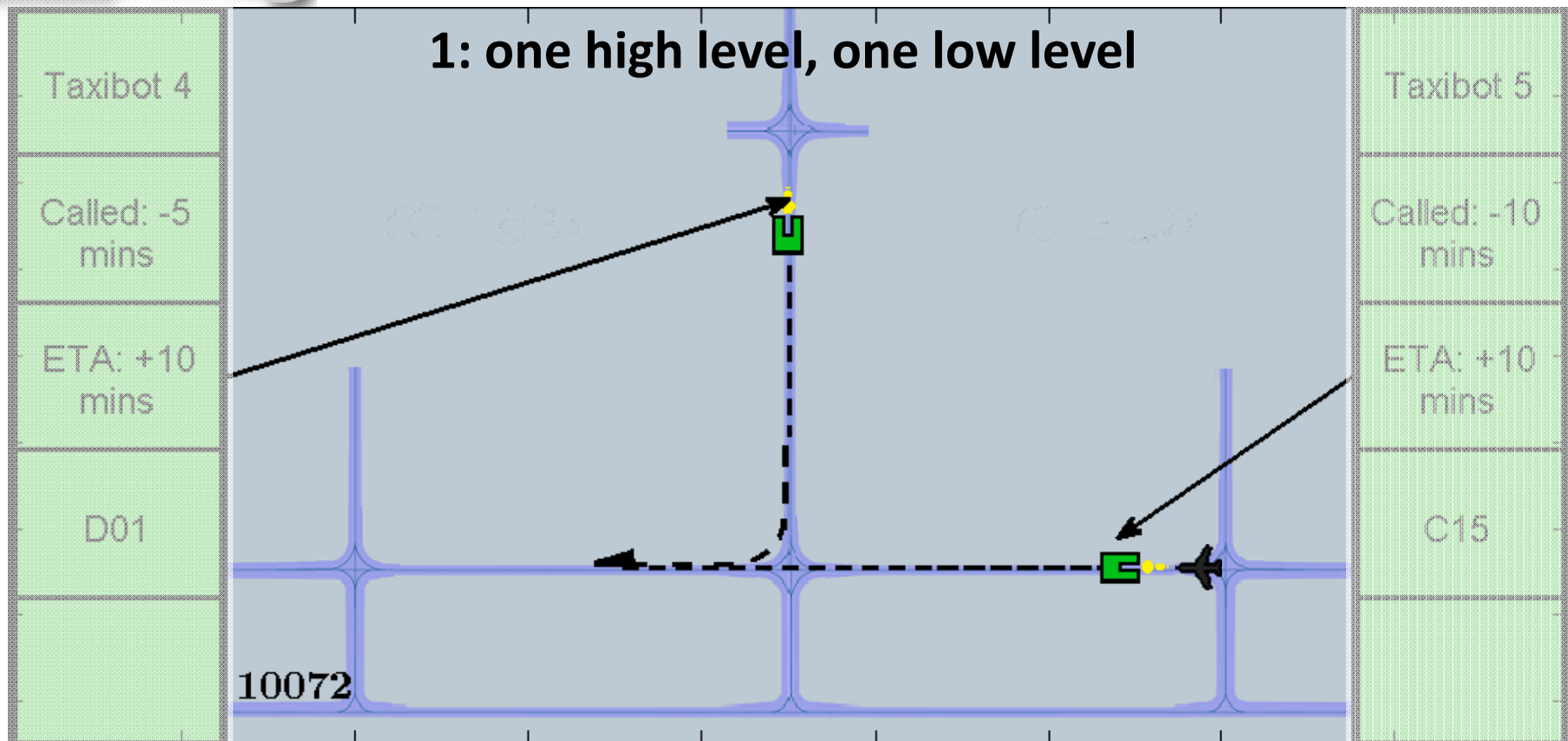
- Estimated time of arrival at Destination (ETA; **+2 mins**, **+10**)
- Visual representation of non-quantified information



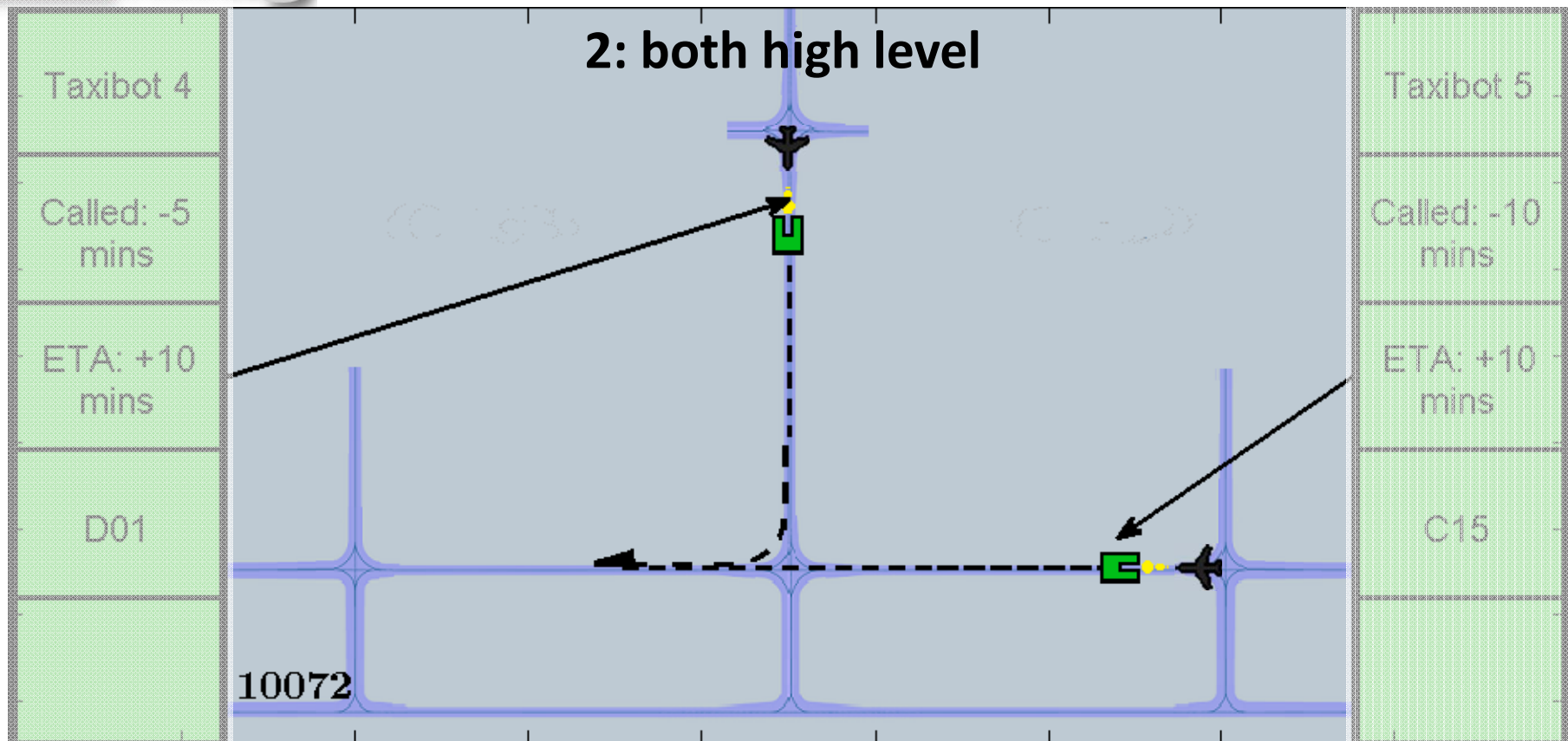
- Taxi time prior to intersection (TaxiPrior: **-10 mins**, **-5**)
- Visual representation of non-quantified information



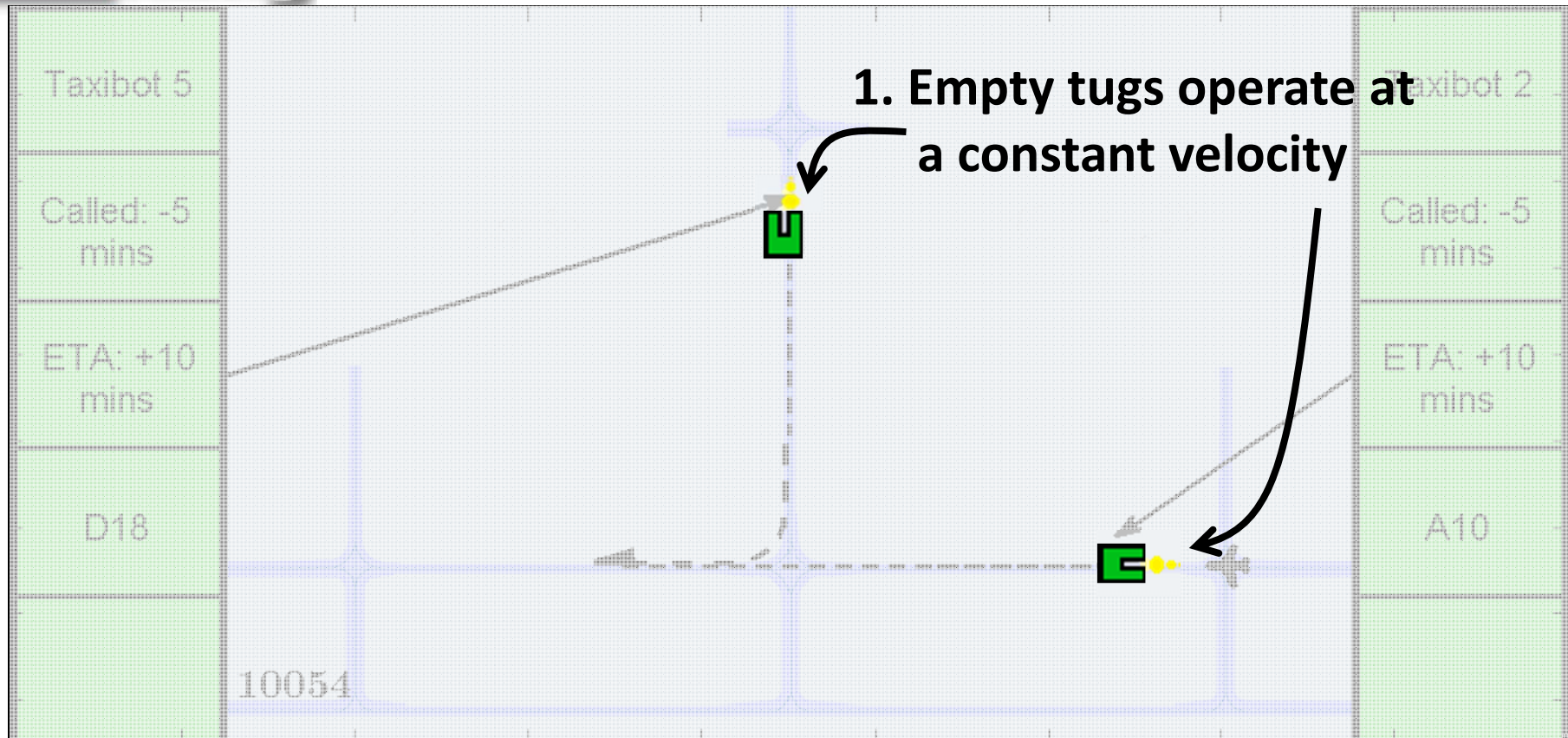
- 3^{5-1} fractional factorial design (Xu 2004) – 81 runs, three levels
- Example: with NAC cue



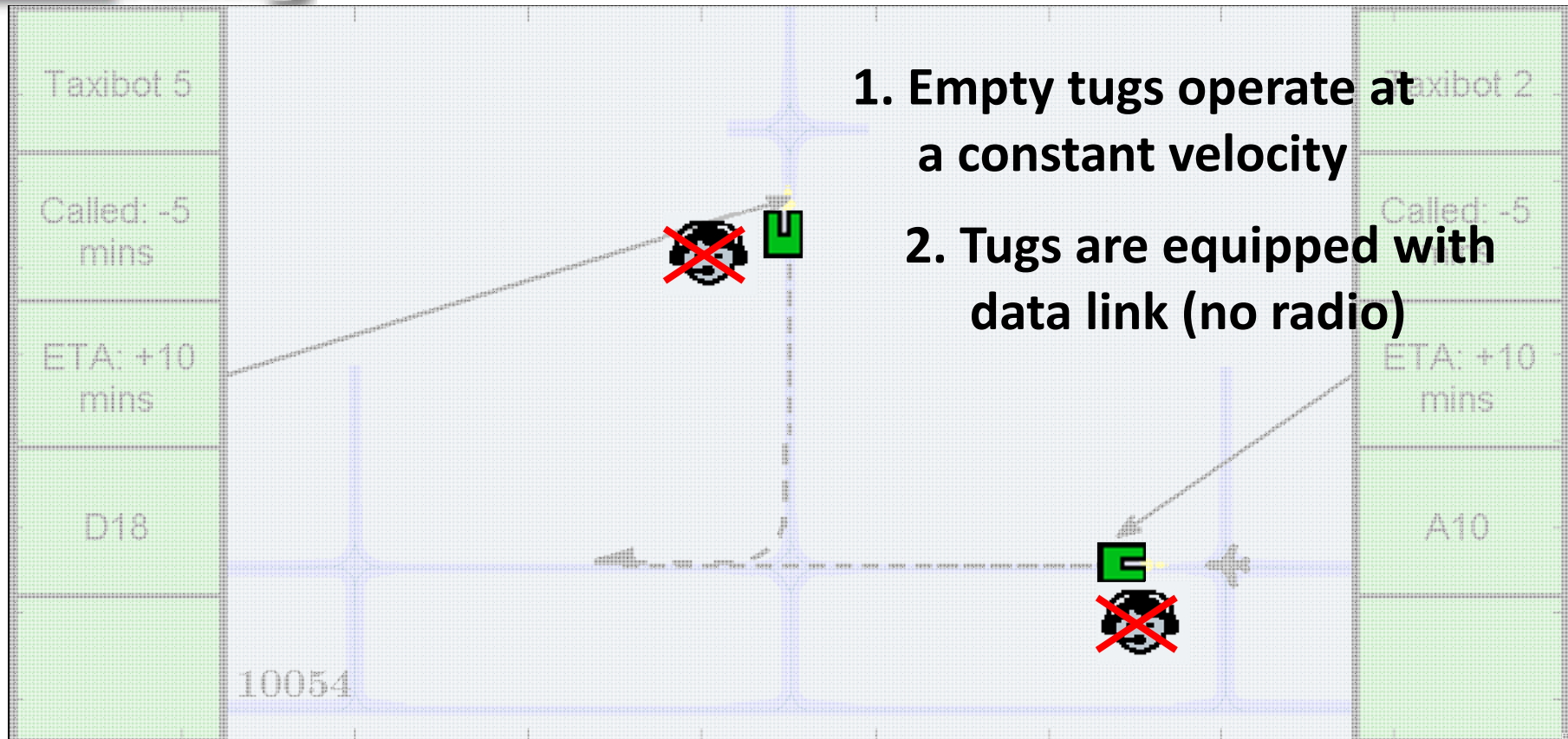
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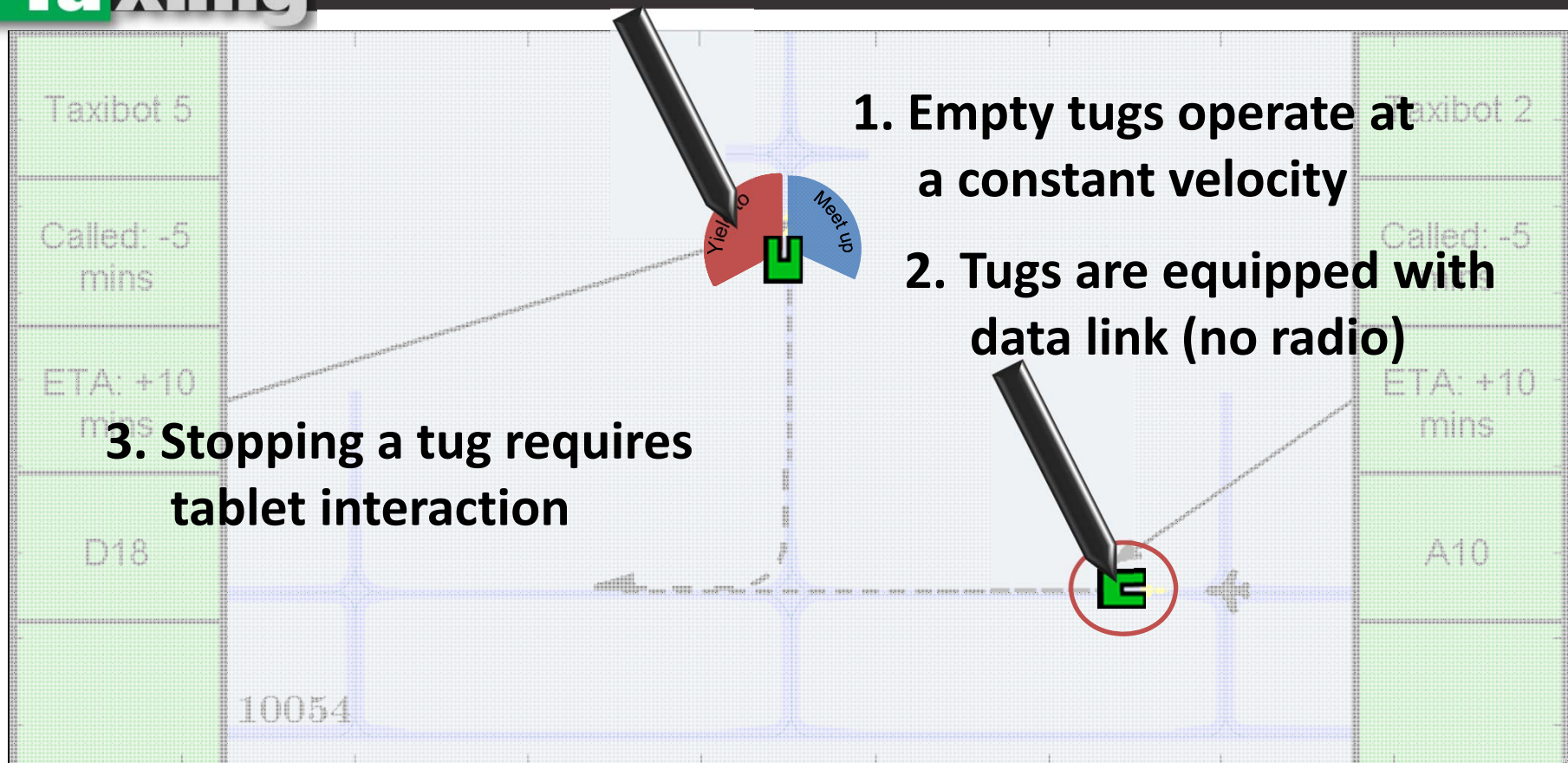
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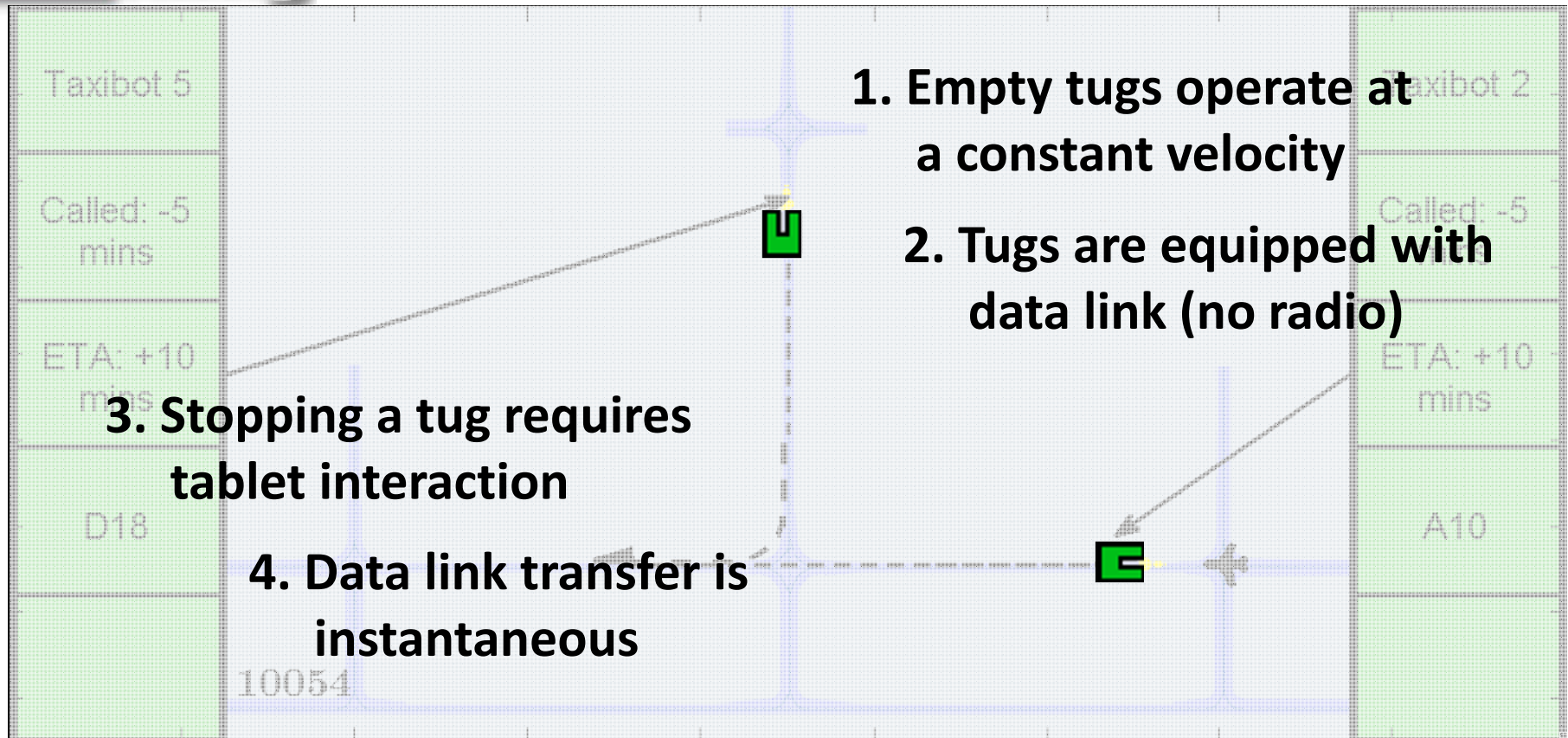
- None of these situations occur near the runway
- Participants asked to respond in 5s or less



- None of these situations occur near the runway
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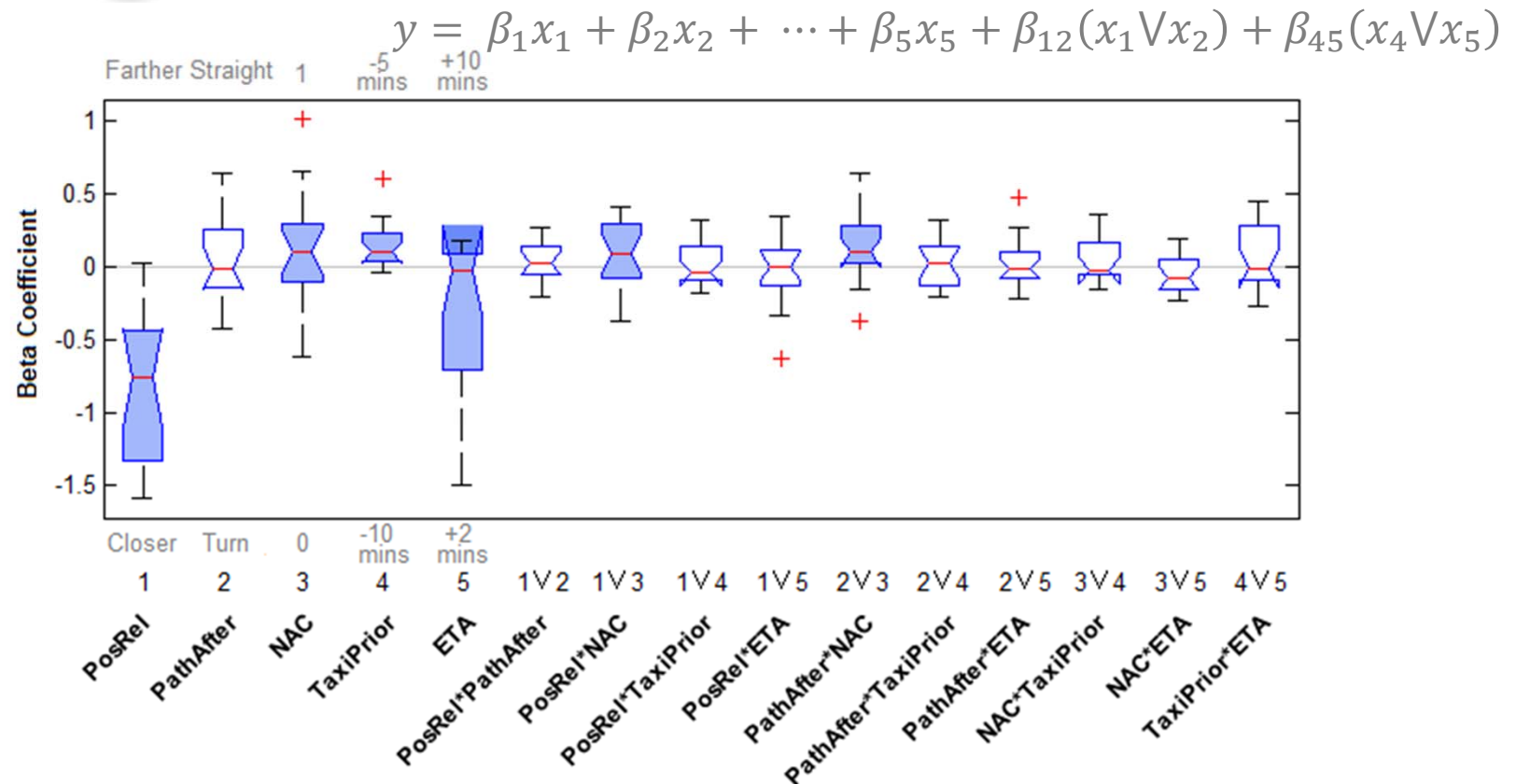


- None of these situations occur near the runway
- Participants asked to respond in 5s or less



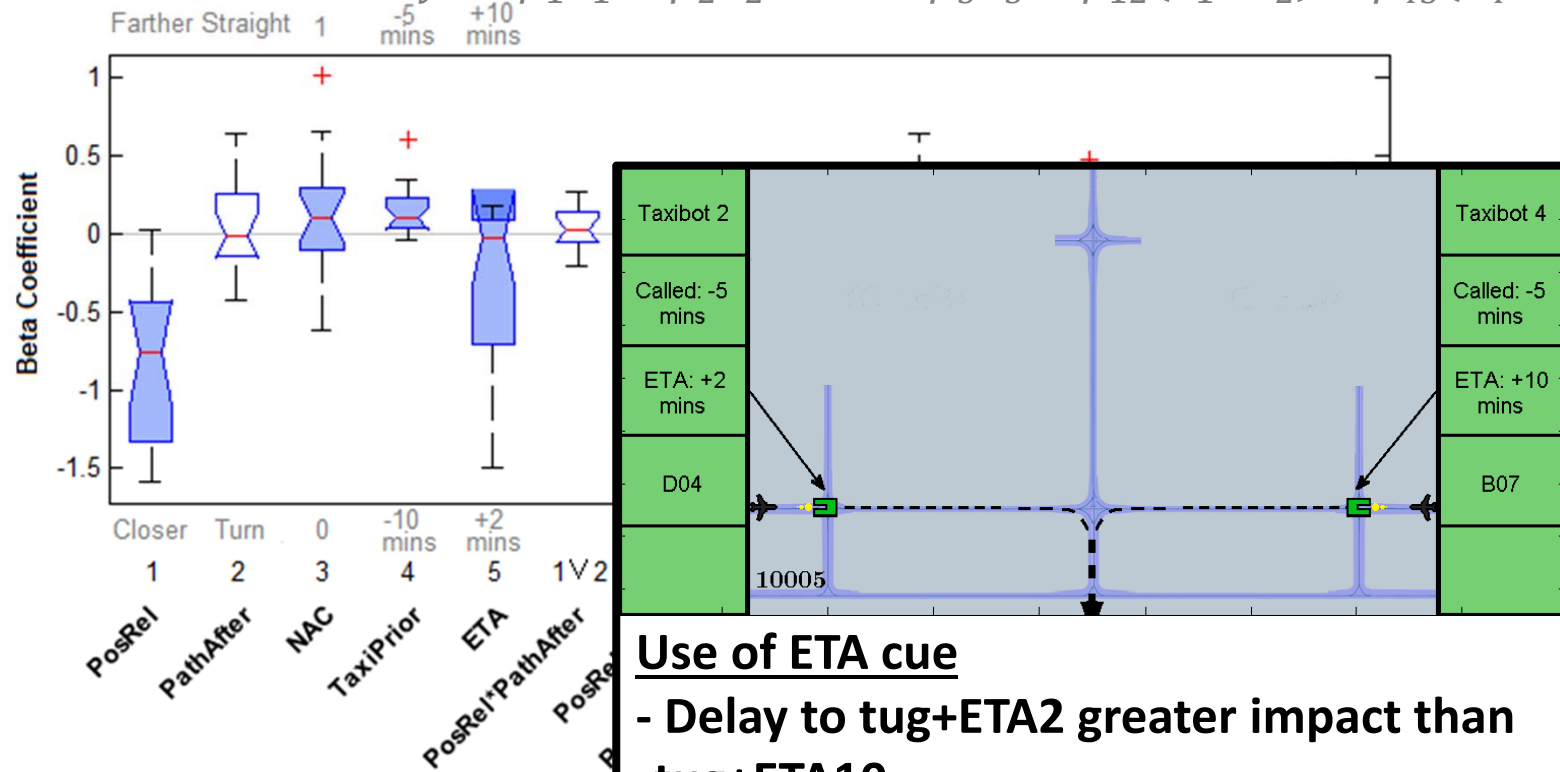
- None of these situations occur near the runway
- Participants asked to respond in 5s or less

$$y = \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_5 x_5 + \beta_{12}(x_1 \vee x_2) + \beta_{45}(x_4 \vee x_5)$$



- All cues except PathAfter are significant
- Primary cue is relative position of each tug to intersection
 - Secondary cue used is either NAC or ETA

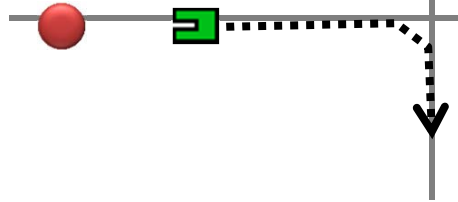
$$y = \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_5 x_5 + \beta_{12} (x_1 \vee x_2) + \beta_{45} (x_4 \vee x_5)$$



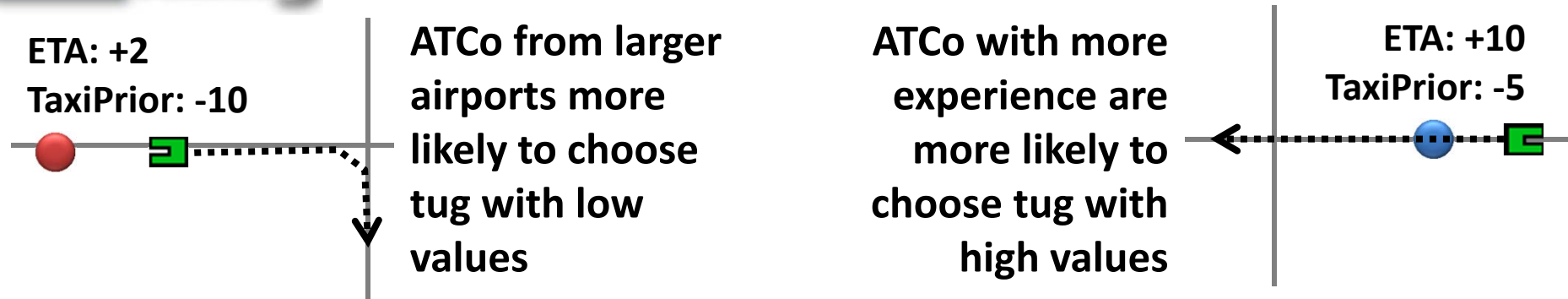
- All cues except PathAfter are used
- Primary cue is relative position
 - Secondary cue used is either NAC or ETA

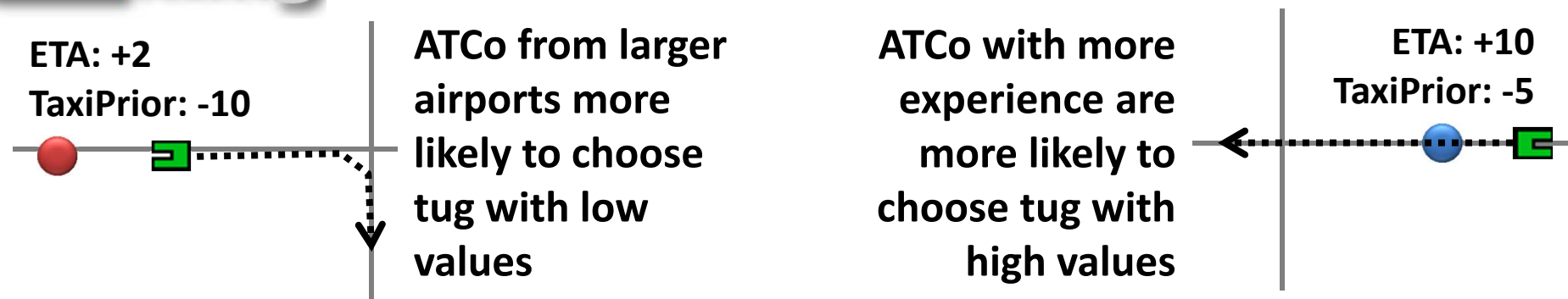
ETA: +2

TaxiPrior: -10

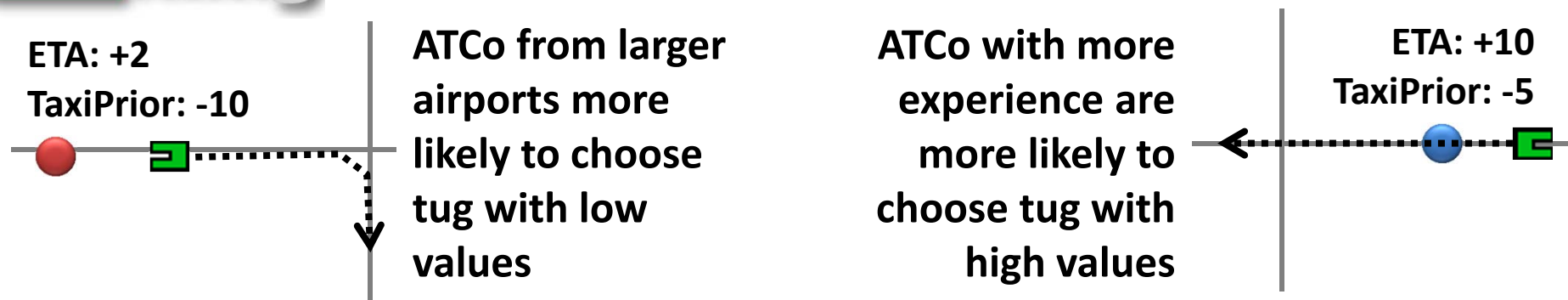


ATCo from larger
airports more
likely to choose
tug with low
values

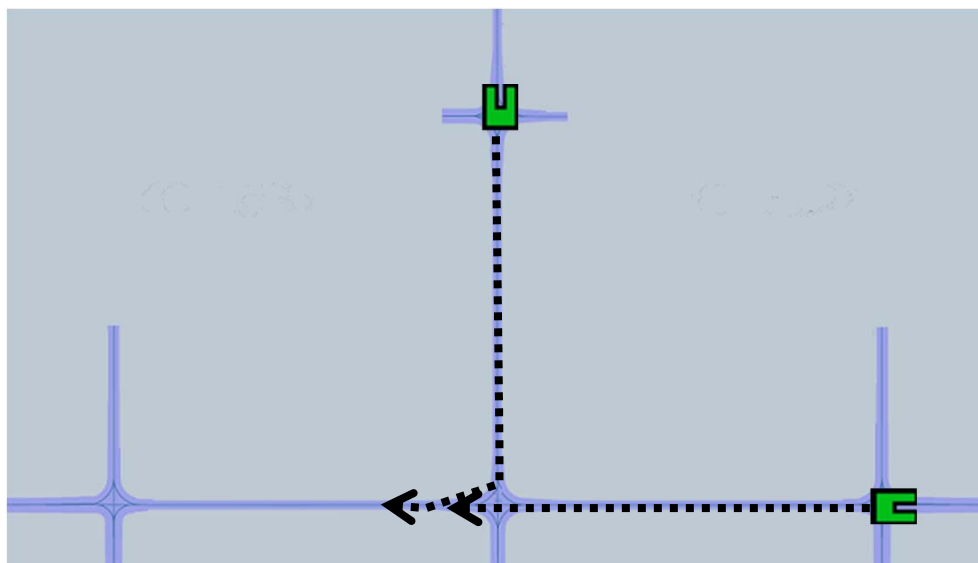




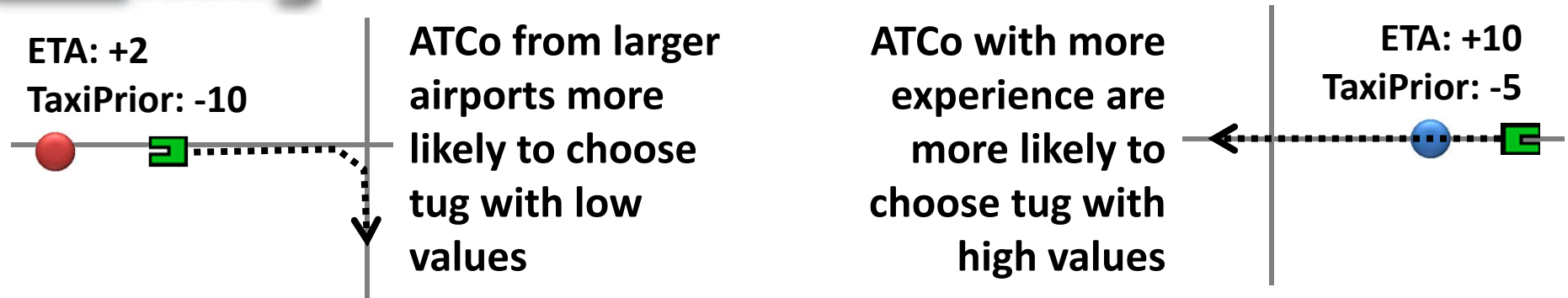
However this effect is very minor and dominated by the environmental cues. No changes in cue usage due to these variables.



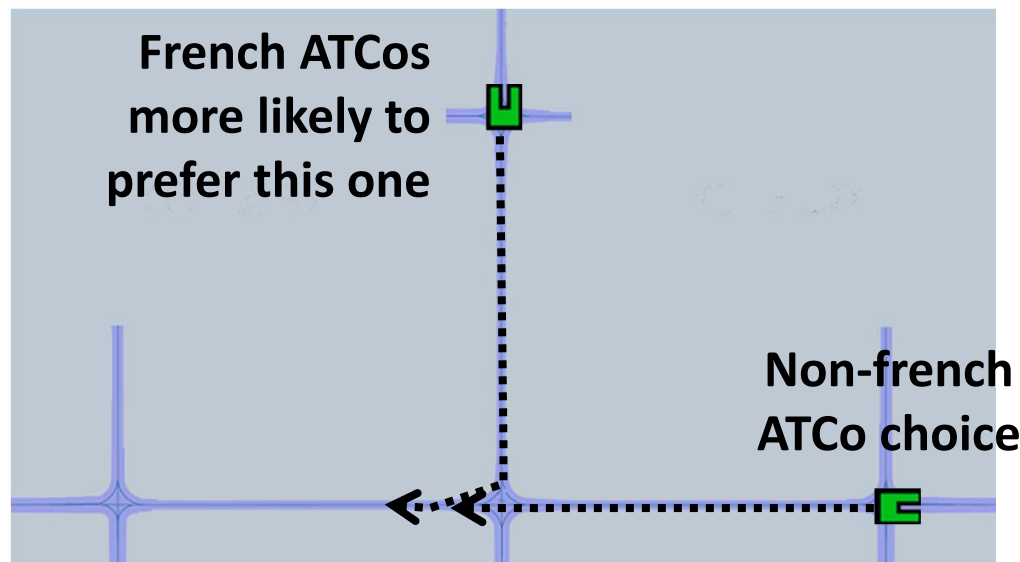
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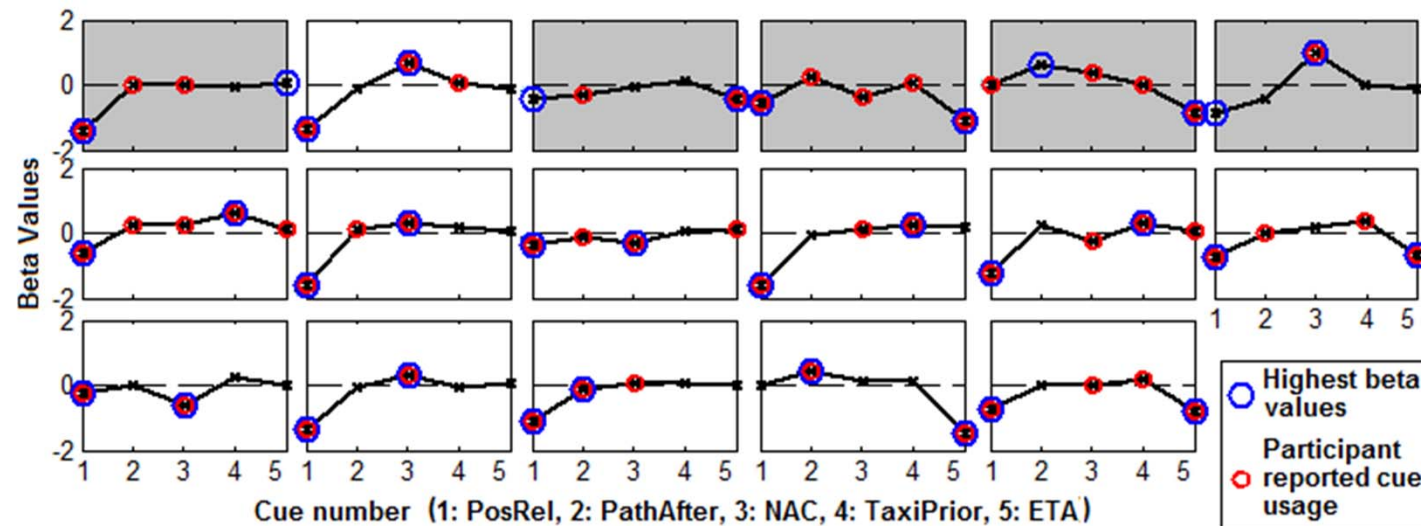


cue usage by airport, exp, country

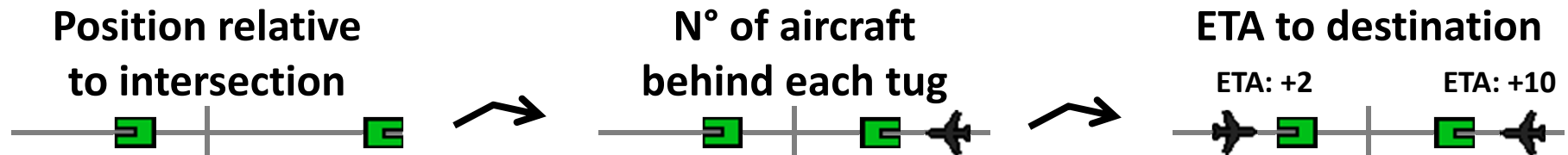


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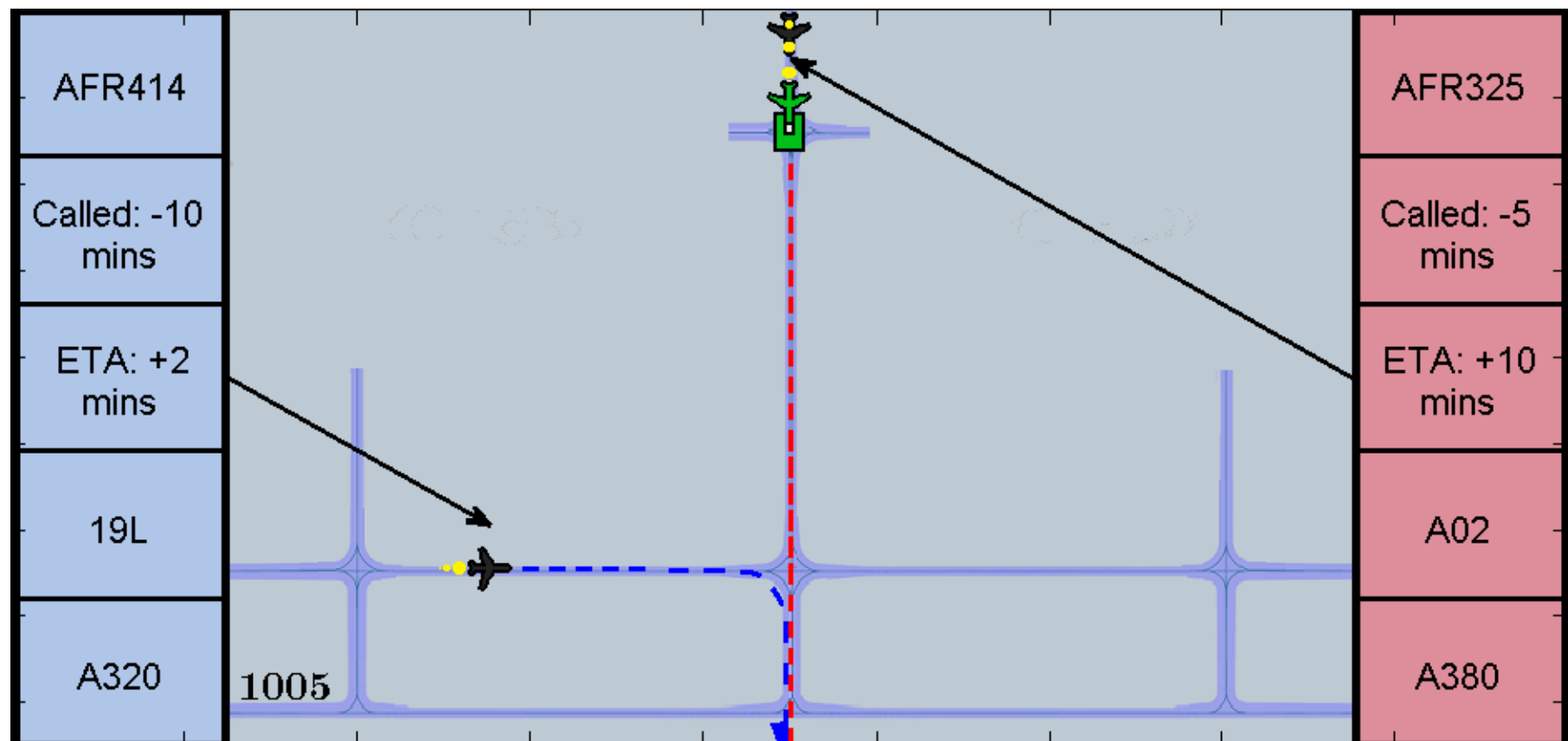
- **Two highest beta values** plotted against **self-reported cue usage**
- Almost **1/3 mismatch** (5 out of 17 participants)
- Cannot always rely on participant qualitative feedback



- Physical study limitations – information not presented similar to real working conditions
- Small sample of different cue values (e.g. different results if followed by another tug ? Different high/low ETA values ?)
- Only one type of decision making strategy (Take the Best)
- No information regarding their charges (e.g. departure manager, airport flight duty period)
- Future end game: operational requirements (based on detailed use studies)

Effect of Technology on Vehicle Airport Taxiing Prioritization (Part 2)

January – February 2016



conclusion

- Initial investigation into autonomous tug conflict resolution strategies
- Online international study with static scenarios
- Closest to intersection
 - Number of aircraft behind tug
 - Estimated time to destination
- Additional follow-up study planned

DISCUS 07:15:33	
EVEILLES	ACTIVES
CSN850 A320 07:15:33 07:15:33 07:15:33	AFR4560 A320 07:15:33 07:15:33 07:15:33
AFR163 A320 07:15:33 07:15:33 07:15:33	DALE67 A320 07:15:33 07:15:33 07:15:33
AFR612 A320 07:15:33 07:15:33 07:15:33	SWR211 A320 07:15:33 07:15:33 07:15:33
EZ7942G A320 07:15:33 07:15:33 07:15:33	AFR8772 A320 07:15:33 07:15:33 07:15:33
LBT457 A320 07:15:33 07:15:33 07:15:33	AFR213 A320 07:15:33 07:15:33 07:15:33
AFR1659 A320 07:15:33 07:15:33 07:15:33	AFR7185 A320 07:15:33 07:15:33 07:15:33
AFR4512 A320 07:15:33 07:15:33 07:15:33	XLF017 A320 07:15:33 07:15:33 07:15:33
AF902QW A320 07:15:33 07:15:33 07:15:33	FIN845B A320 07:15:33 07:15:33 07:15:33
AFR904V A320 07:15:33 07:15:33 07:15:33	AFR1083 A320 07:15:33 07:15:33 07:15:33
AA151 A320 07:15:33 07:15:33 07:15:33	





ATCo and want to participate ? Or work with ATCos ? Contact me (zarrin.chua@gmail.com) for study online link !

questions ?

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Acknowledgements

- G. Durantin, F. Lancelot, M. Cousy, F. André
- Anonymous air traffic controller participants
- Neuroergonomics group at ISAE-SUPAERO

EVEILLES		ACTIVES	
CSN850	07:15:33	AFR456	07:15:33
AFR163	07:15:33	DALE7	07:15:33
AFR612	07:15:33	SWR211	07:15:33
EZ7942G	07:15:33	AFR772	07:15:33
LB7457	07:15:33	AFR213	07:15:33
AFR1659	07:15:33	AFR7185	07:15:33
AFR4512	07:15:33	XL7017	07:15:33
AF902QW	07:15:33	FIN845B	07:15:33
AFR904V	07:15:33	AFR1083	07:15:33
AA151	07:15:33		

