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

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adding an autonomous tug

• Without a human onboard
• What prioritization strategy should be used to resolve potential conflicts between two tugs?
soliciting atco input
Revue / Review

Veuillez 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: ____________________

Veuillez 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
online exercise

- 73 scenarios
- 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
cues used during test

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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
design of experiments

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

1. Empty tugs operate at a constant velocity

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

1. Empty tugs operate at a constant velocity
2. Tugs are equipped with data link (no radio)
3. Stopping a tug requires tablet interaction
4. Data link transfer is instantaneous

• None of these situations occur near the runway
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cue usage

\[ y = \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_5 x_5 + \beta_{12}(x_1 \vee x_2) + \beta_{45}(x_4 \vee x_5) \]
- All cues except PathAfter are significant
- Primary cue is relative position of each tug to intersection
  - Secondary cue used is either NAC or ETA
**cue usage**

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- Primary cue is relative position of each tug to intersection.
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**Use of ETA cue**
- Delay to tug+ETA2 greater impact than tug+ETA10.
- Perhaps still accounting for airport location.
cue usage by airport, exp, country

ETA: +2
TaxiPrior: -10

ATCo from larger airports more likely to choose tug with low values
cue usage by airport, exp, country

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HFES Annual Meeting 2015 (Los Angeles, LA, USA)
cue usage by airport, exp, country

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

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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
• 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
questions?

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• Neuroergonomics group at ISAE-SUPAERO

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