Utrecht University

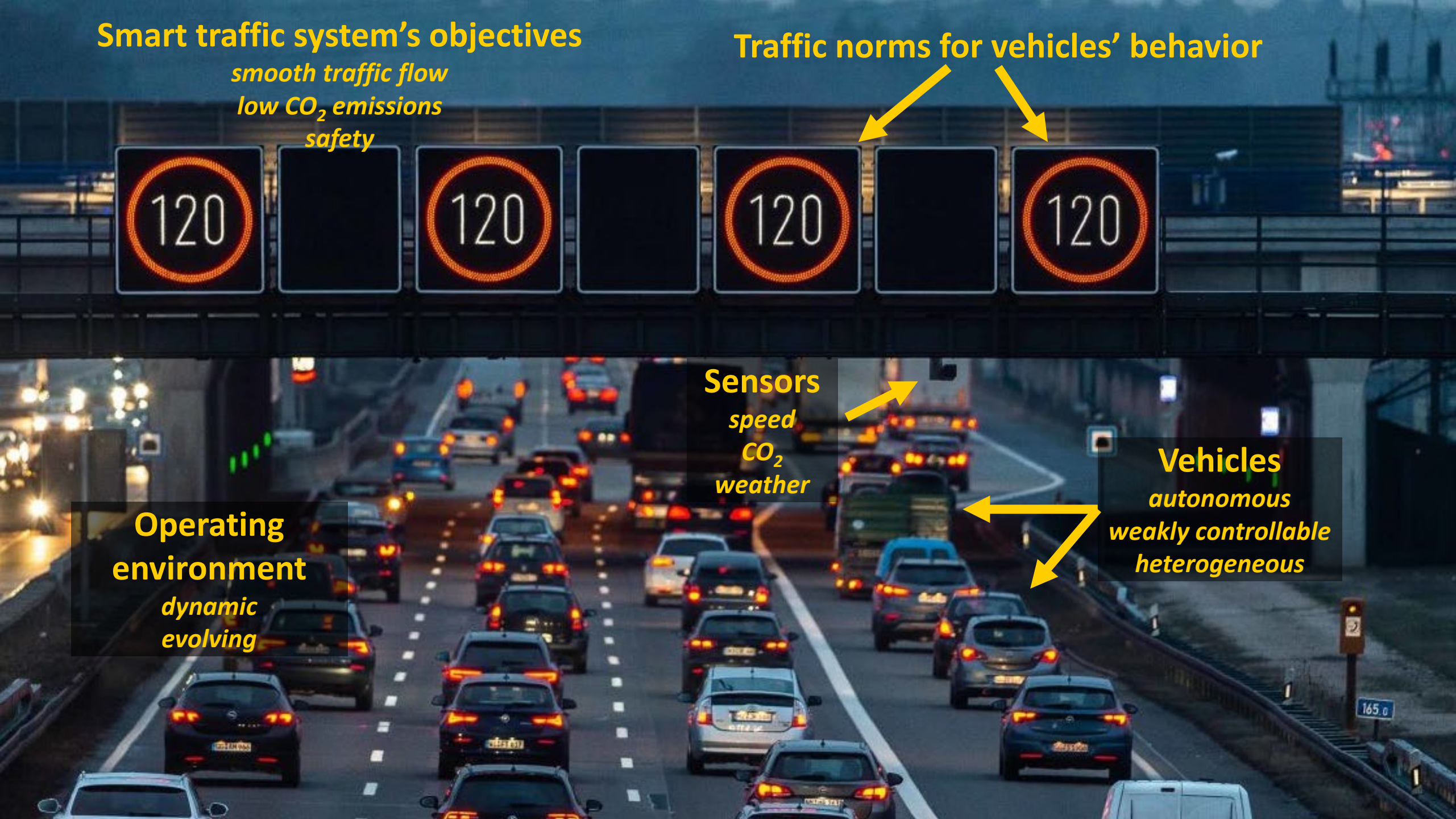
IJCAI 2023

*Data-Driven Revision of Conditional Norms in Multi-Agent Systems (Extended Abstract)**

Davide Dell'Anna

Natasha Alechina, Fabiano Dalpiaz, Mehdi Dastani, Brian Logan

* *Full paper:*
Journal of Artificial Intelligence Research 75 (2022) 1549–1593
https://doi.org/10.1613/jair.1.13683


Smart traffic system's objectives
smooth traffic flow
low CO_2 emissions
safety
Traffic norms for vehicles' behavior
120
120
120
120
Sensors
speed
CO_2
weather
Vehicles
autonomous
weakly controllable
heterogeneous
Operating environment
dynamic
evolving

Utrecht University

When the system's objectives change,

the norms need to change too

Dutch government cuts speed limit to 100km/h to reduce air pollution

Netherlands takes 'rotten measure' of reducing 130km/h limit to protect nature reserves

▲ The new limit will be introduced in 2020 and will be the joint lowest in the EU along with Cyprus. Photograph: Vincent Jannink/EPA

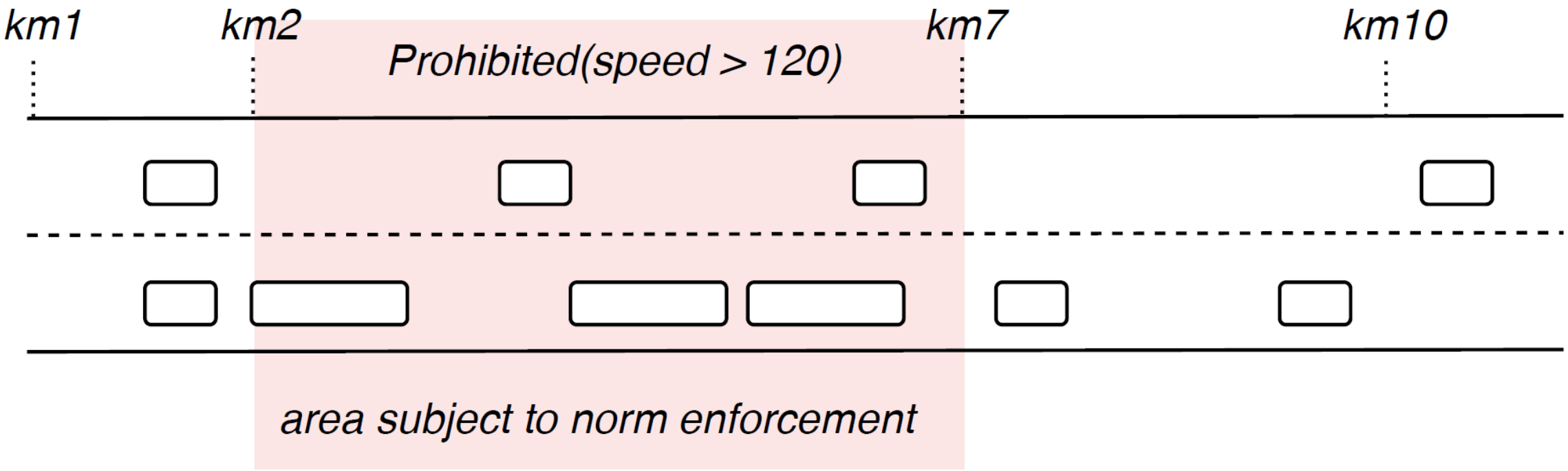
The Dutch prime minister, Mark Rutte, has taken what he has described as the "rotten measure" of cutting the maximum speed limit on roads in the Netherlands to 100km/h (62mph) after being ordered by the courts to cut pollution.

How to automatically revise norms to align them with the new system's objectives?

Conditional norms with deadlines

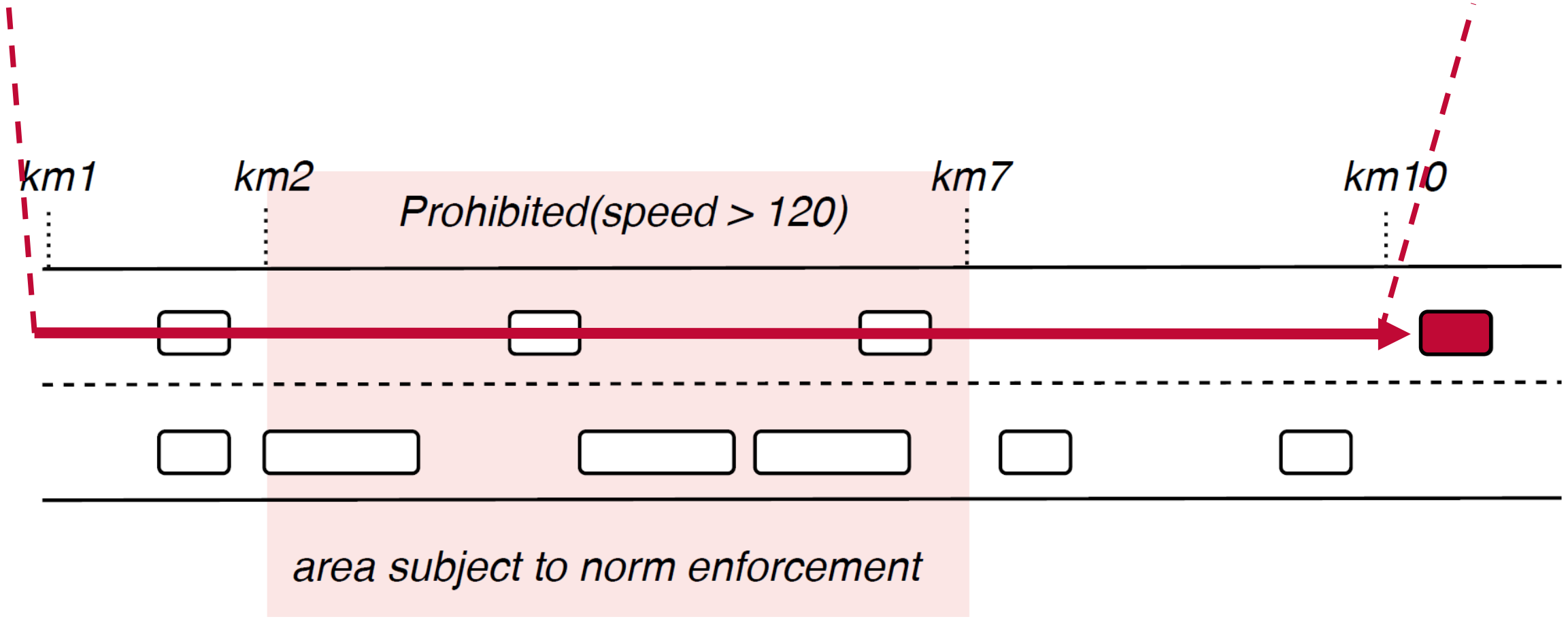
"*Each vehicle entering the 2nd km of the highway* is *prohibited from driving faster than 120 km/h until it reaches the 7th km*"

(*km2*; *P*(*sp*$_{120}$); *km7*)



Vehicles' behaviors are execution traces

$$(\{km_1, sp_{30}, car\}, \{km_2, sp_{22}, car\}, \{km_3, sp_7, car\}, \{km_4, sp_{32}, car\}, \{km_5, sp_7, car\},$$
$$\{km_6, sp_{18}, car\}, \{km_7, sp_{32}, car\}, \{km_8, sp_7, car\}, \{km_9, sp_{18}, car\}, \{km_{10}, sp_{14}, car\})$$



Norms and system's objectives classify execution traces

$$(\{km_1, sp_{30}, car\}, \{km_2, sp_{22}, car\}, \{km_3, sp_7, car\}, \{km_4, sp_{32}, car\}, \{km_5, sp_7, car\},$$
$$\{km_6, sp_{18}, car\}, \{km_7, sp_{32}, car\}, \{km_8, sp_7, car\}, \{km_9, sp_{18}, car\}, \{km_{10}, sp_{14}, car\})$$

compliant with the norm

does not satistfy system's objectives

(*km2*; *P*(sp_{120}); *km7*)

Max CO_2 emitted < 100 g/s & Travel Time < 450s

violating the norm

satisfies system's objectives

sp_{130}

$$(\{km_1, sp_{30}, car\}, \{km_2, sp_{22}, car\}, \{km_3, sp_7, car\}, \{km_4, sp_{32}, car\}, \{km_5, \cancel{sp_7}, car\},$$
$$\{km_6, sp_{18}, car\}, \{km_7, sp_{32}, car\}, \{km_8, sp_7, car\}, \{km_9, sp_{18}, car\}, \{km_{10}, sp_{14}, car\})$$

Norms and system's objectives classify execution traces

Our current classification of behaviors

The correct/desired classification of behaviors

DATASET Γ

Trace	n	Objectives	Type
ρ_1	compliant	true	True Positive
ρ_2	compliant	false	False Positive
ρ_3	violating	true	False Negative
ρ_4	violating	false	True Negative

…

We do not want these

Given a dataset Γ and a norm n = (ϕ_C; P(ϕ_P); ϕ_D)

Question:

is there n'= (ϕ_C'; P(ϕ_P'); ϕ_D') s.t.

- all False Negatives are no longer prohibited
- all False Positives are no longer allowed ?

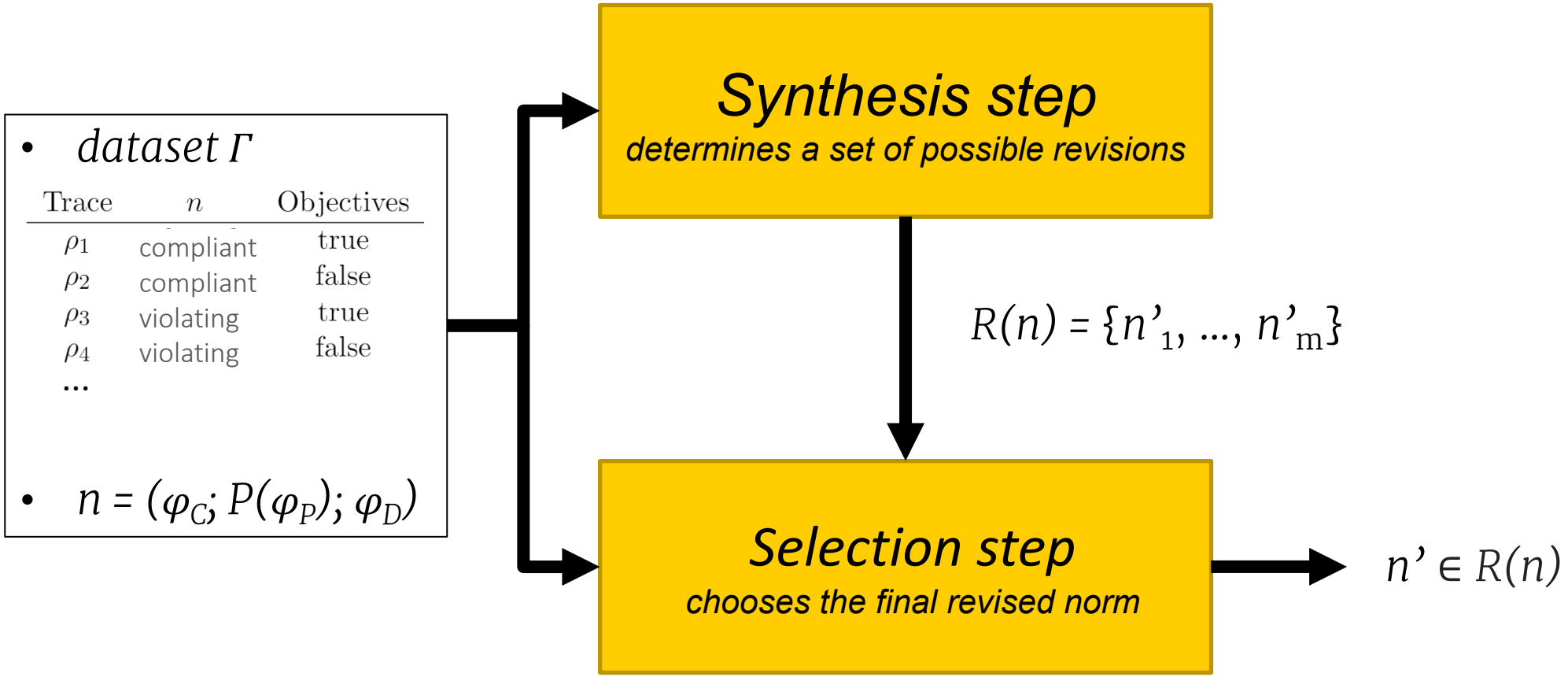
NP-complete problem

The Complexity of Norm Synthesis and Revision

Davide Dell'Anna[1(✉)], Natasha Alechina[2], Fabiano Dalpiaz[2], Mehdi Dastani[2], Maarten Löffler[2], and Brian Logan[2,3]

In *Proceedings of the 15th International Workshop on Coordination, Organizations, Institutions, Norms, and Ethics for Governance of Multi-Agent Systems, COINE@AAMAS 2022, 2022.*
https://doi.org/10.1007/978-3-031-20845-4_3

A 2-steps Heuristic Approach for Approximate Revision



Synthesis step

The set of new norms R(n)

	New conditions	New prohibited states	New deadlines
More specific	MSC *n' detaches in less states*	MSP *n' prohibits less states*	MSD *n' expires in less states*
Less specific	LSC n' detaches in more states	LSP *n' prohibits more states*	LSD *n' expires in more states*

How to determine these?

We can characterize different types of revisions

Alterations of n

$\{n' = (\varphi_C'; P(\varphi_P'); \varphi_D')$
s.t.
$\varphi_C' \in$ MSC U LSC,
$\varphi_P' \in$ MSP U LSP,
$\varphi_D' \in$ MSD U LSD$\}$

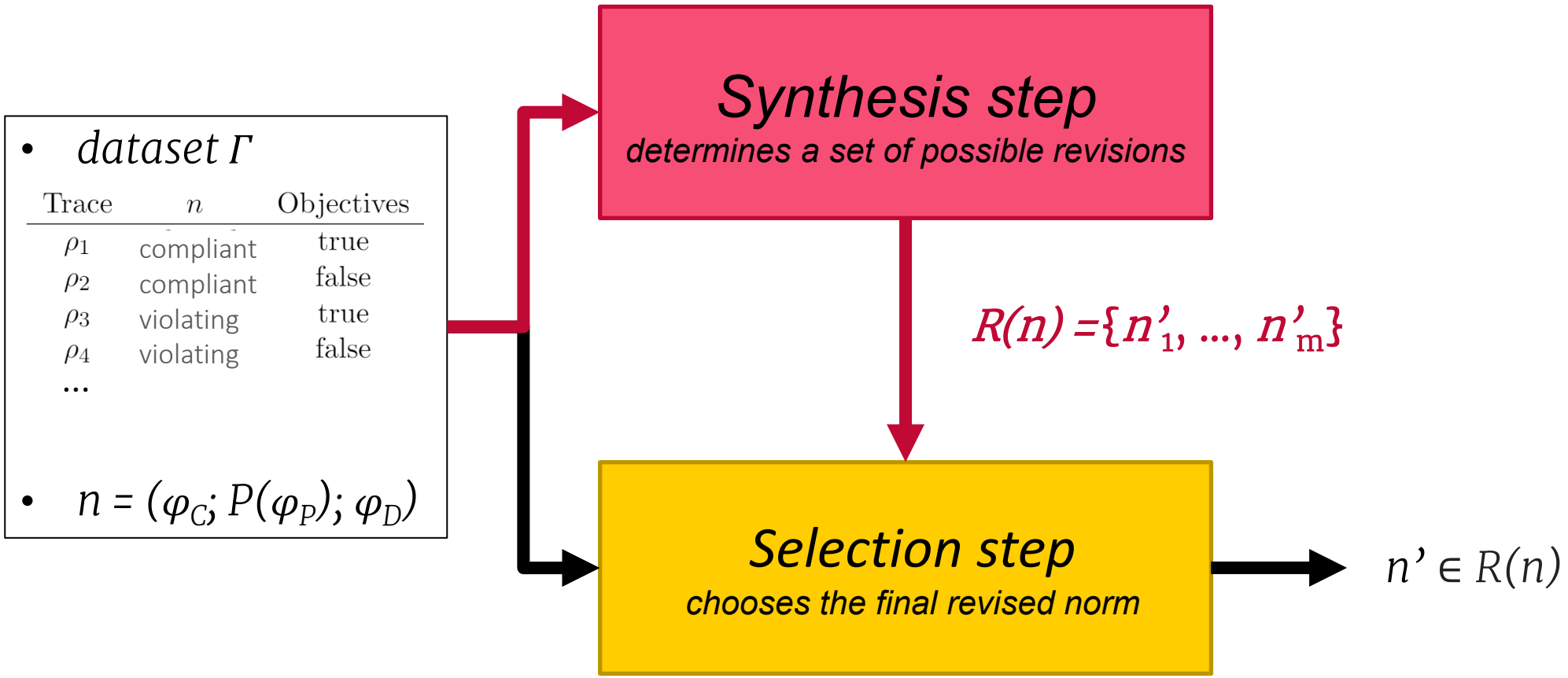
Weaker than n

$\{n' = (\varphi_C'; P(\varphi_P'); \varphi_D')$
s.t.
$\varphi_C' \in$ MSC,
$\varphi_P' \in$ MSP,
$\varphi_D' \in$ LSD$\}$

More strict than n

$\{n' = (\varphi_C'; P(\varphi_P'); \varphi_D')$
s.t.
$\varphi_C' \in$ LSC,
$\varphi_P' \in$ LSP,
$\varphi_D' \in$ MSD$\}$

A 2-steps Heuristic Approach for Approximate Revision

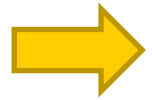


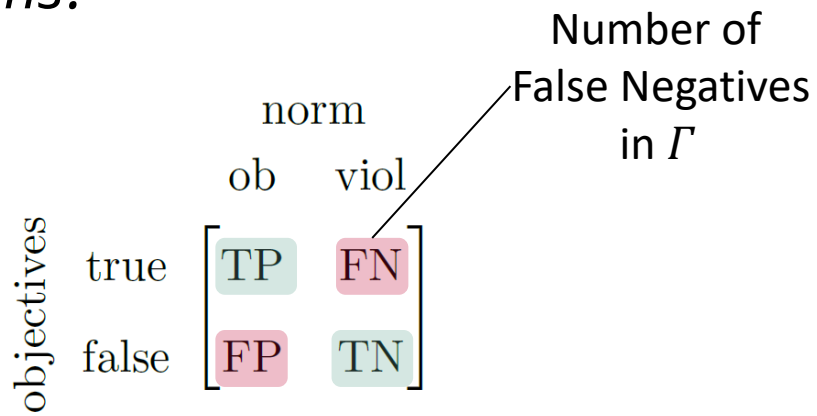
Selection step

How to compare different norms?

Dataset Γ

Trace	n	Objectives	Type
ρ_1	compliant	true	True Positive
ρ_2	compliant	false	False Positive
ρ_3	violating	true	False Negative
ρ_4	violating	false	True Negative
...			

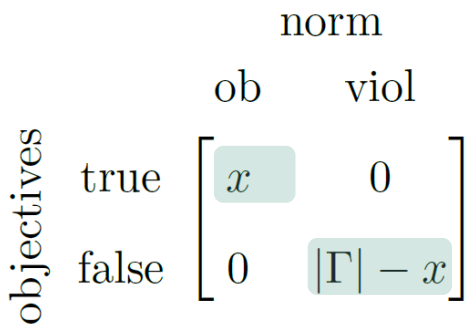




We want a norm that is aligned with the objectives

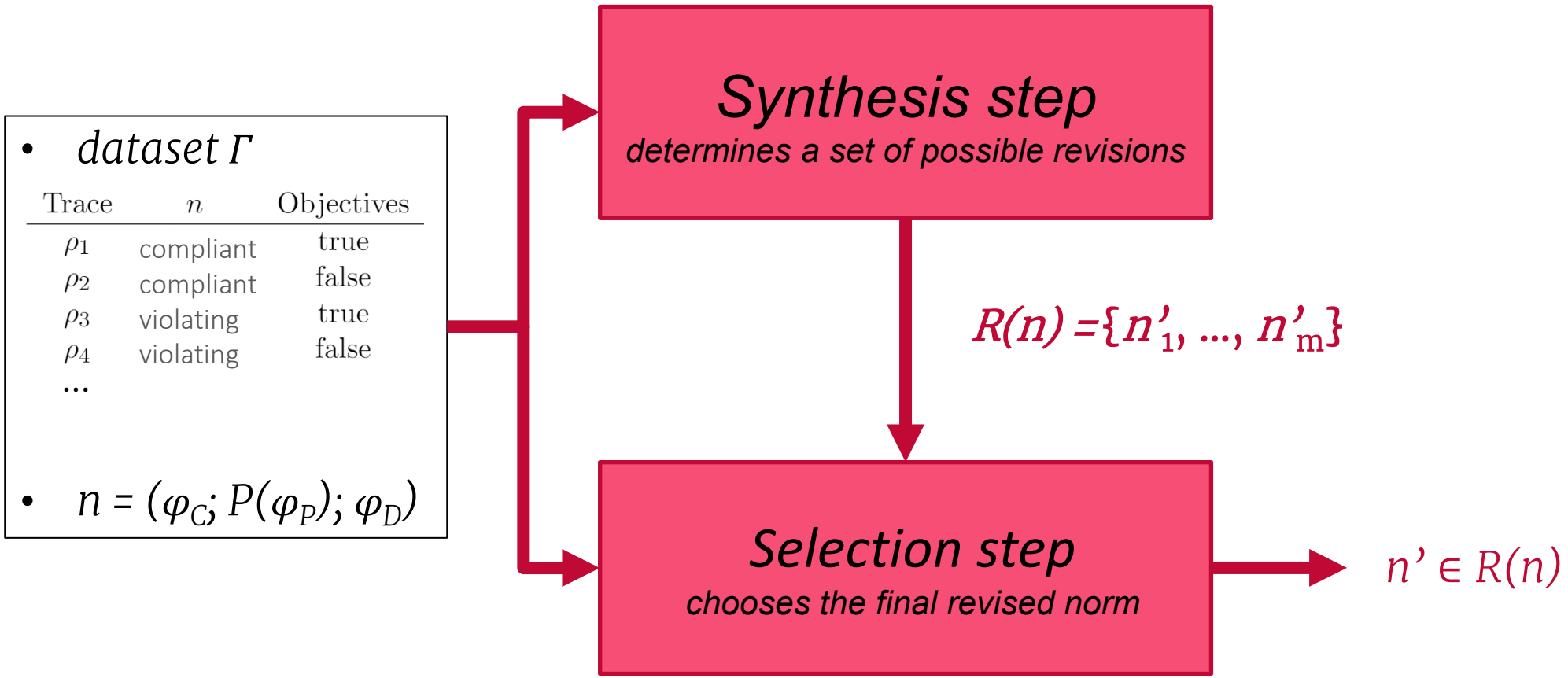
i.e., an accurate norm.

IDEAL CASE:



Accuracy = TP+TN / |Γ|

A 2-steps Heuristic Approach for Approximate Revision



Experiments

Are the revised norms better aligned with the objectives?

Norms:
100 different initial speed limit norms

Traces:
100 datasets (1 per norm)
each with 1500 traces (1 per vehicle)
labeled w.r.t to norms and objectives

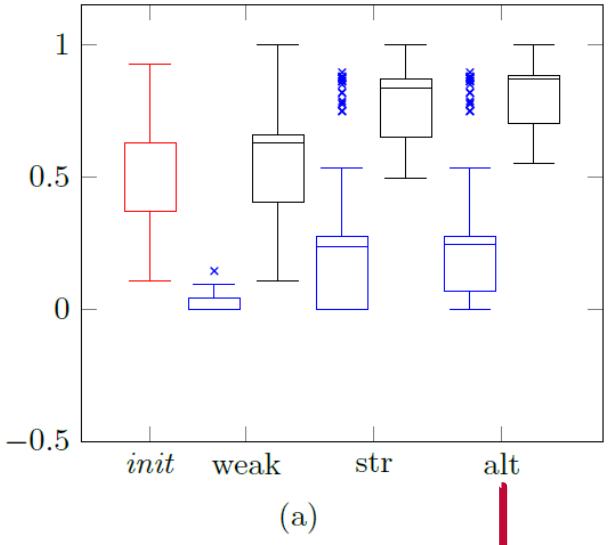
Objectives:
CO2 and travel time

SUMO traffic simulation

The revised norms are significantly better aligned with the objectives

In the figure:

- accuracy of the initial 100 norms
- accuracy of the 100 revised norms
- accuracy change



(a)

		Δ	*Final*
weakening	M	0.0201	0.5485
	SD	0.03165	0.23227
	Min	0	0.10
	Q1	0	0.3911
	Q2	0	0.6262
	Q3	0.0413	0.6608
	Max	0.14	1
strengthening	M	0.2633	0.7918
	SD	0.30455	0.14293
	Min	0	0.50
	Q1	0	0.6445
	Q2	0.2344	0.8352
	Q3	0.2756	0.8743
	Max	0.89	1
alteration	M	0.2881	0.8166
	SD	0.28858	0.13299
	Min	0	0.55
	Q1	0.0656	0.6950
	Q2	0.2418	0.8681
	Q3	0.2756	0.8822
	Max	0.89	1

(b)

Significantly higher accuracy
t(198)=-7.526, p=0.000)

Large effect size
Cohen's delta = 1.59

Utrecht University

IJCAI 2023

*Data-Driven Revision of Conditional Norms in Multi-Agent Systems (Extended Abstract)**

Davide Dell'Anna

Natasha Alechina, Fabiano Dalpiaz, Mehdi Dastani, Brian Logan

* *Full paper:*
Journal of Artificial Intelligence Research 75 (2022) 1549–1593
https://doi.org/10.1613/jair.1.13683