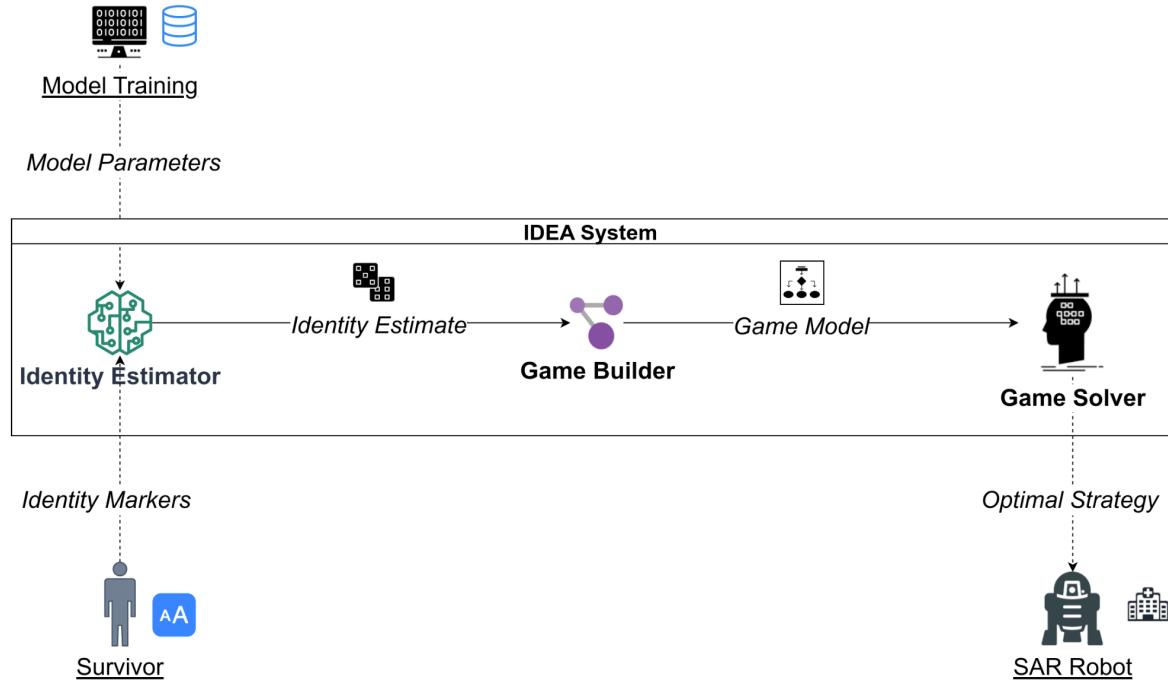




**POLITECNICO**  
MILANO 1863

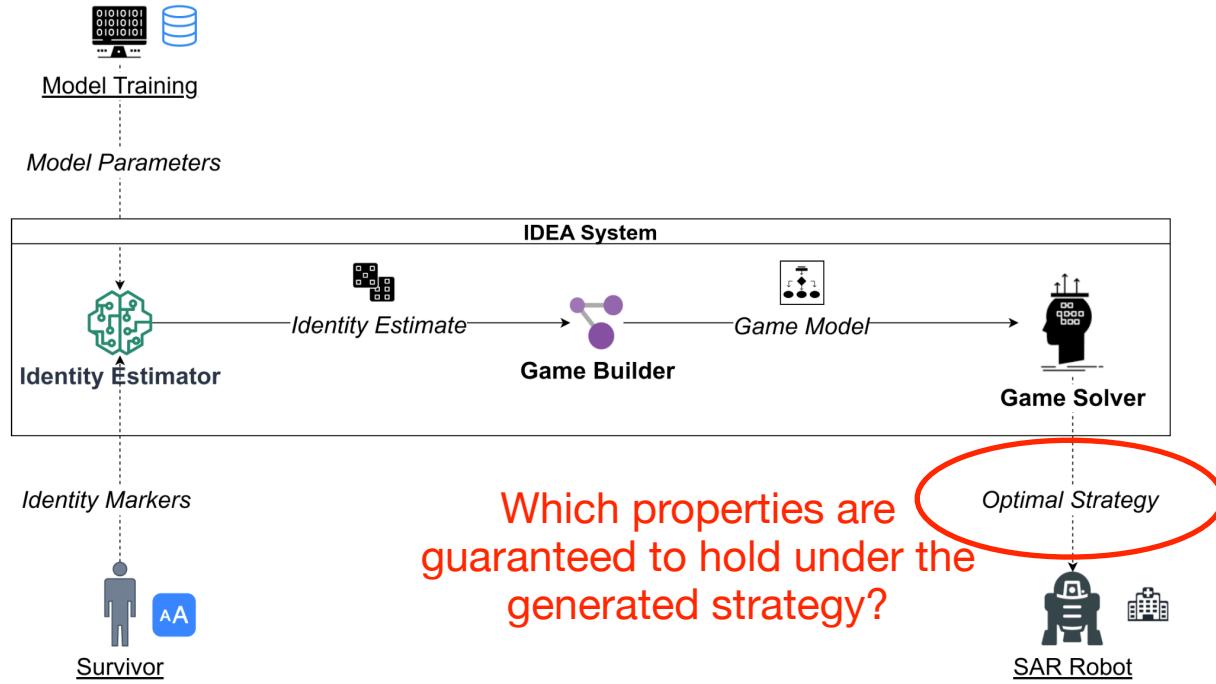
# FormIdeAble: A Formally Verified Identity-Aware Autonomous Systems

# The IDEA Framework [1]



[1] Gavidia-Calderon, C., Kordoni, A., Bennaceur, A., Levine, M., & Nuseibeh, B. The IDEA of Us: An Identity-Aware Architecture for Autonomous Systems. Submitted to TOSEM.

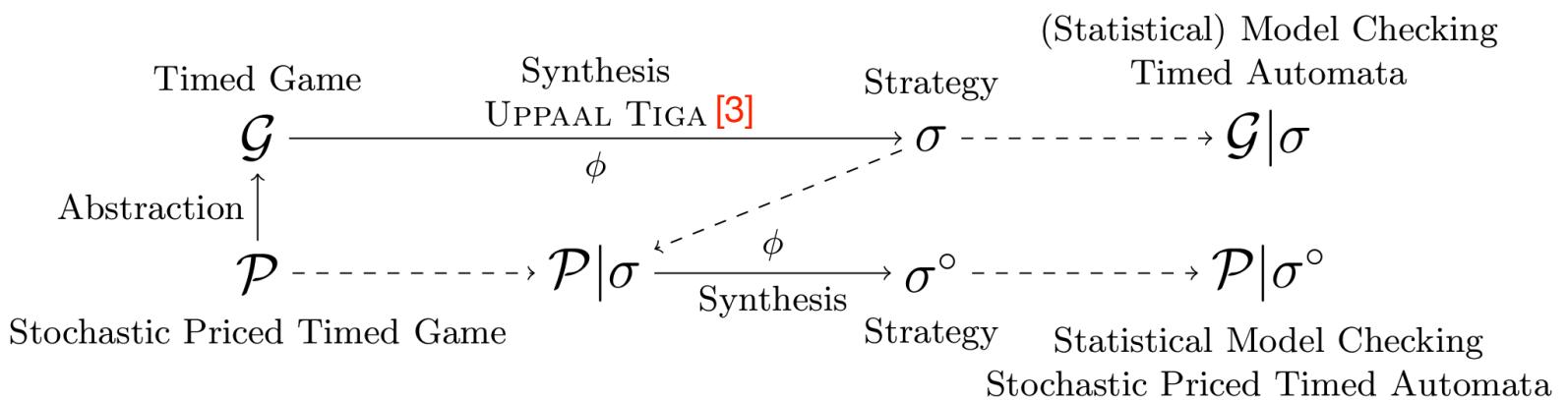
# The IDEA Framework [1]



Which properties are  
guaranteed to hold under the  
generated strategy?

[1] Gavidia-Calderon, C., Kordoni, A., Bennaceur, A., Levine, M., & Nuseibeh, B. The IDEA of Us: An Identity-Aware Architecture for Autonomous Systems. Submitted to TOSEM.

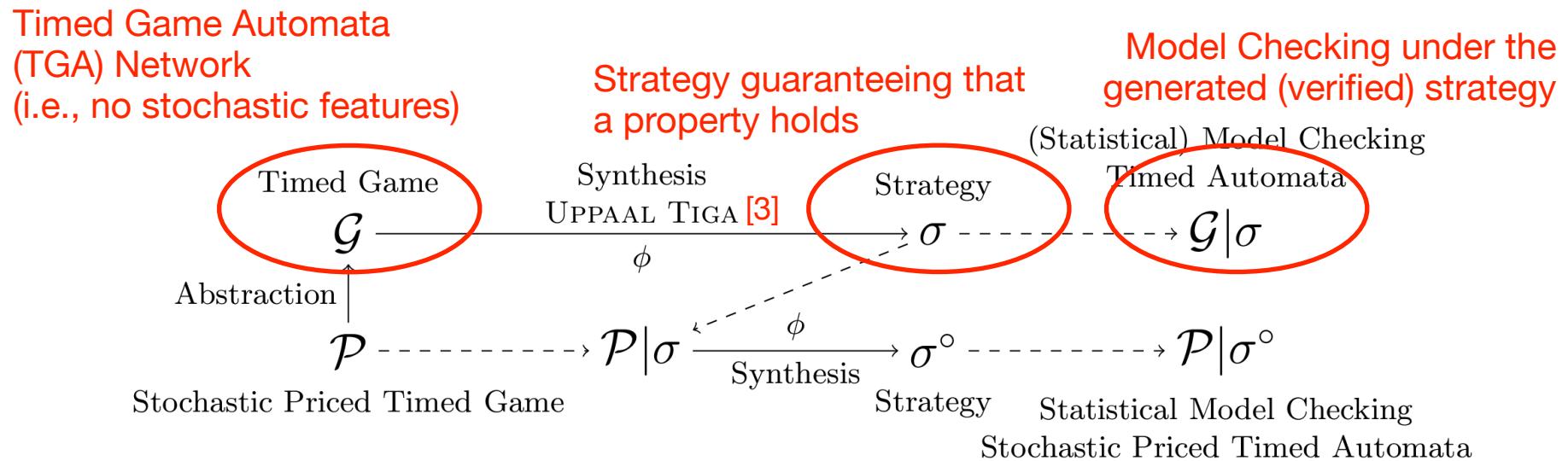
# Uppaal Stratego [2]



[2] David, A., Jensen, P. G., Larsen, K. G., Mikučionis, M., & Taankvist, J. H. (2015). Uppaal stratego. In TACAS 2015, Proceedings 21 (pp. 206-211). Springer Berlin Heidelberg.

[3] Behrmann, G., Cougnard, A., David, A., Fleury, E., Larsen, K. G., & Lime, D. (2007). UPPAAL-Tiga: Time for Playing Games! (Tool Paper). In CAV 2007. Proceedings 19 (pp. 121-125). Springer Berlin Heidelberg.

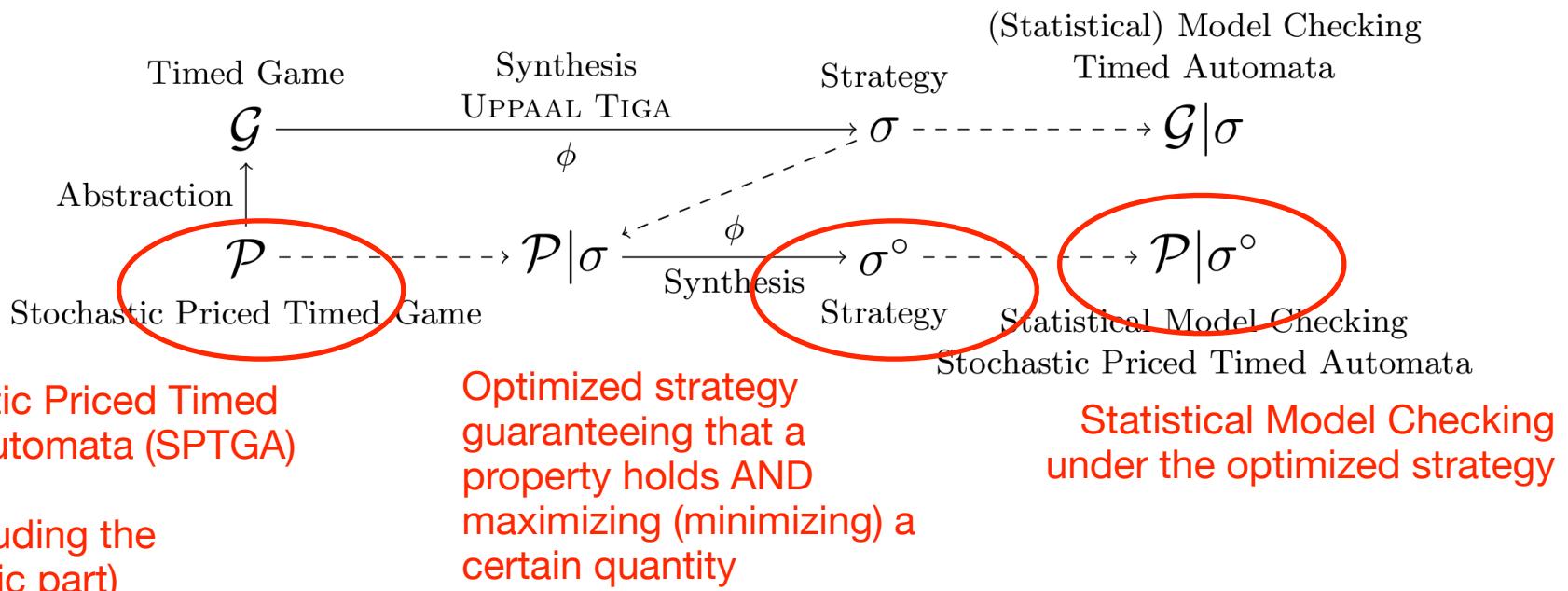
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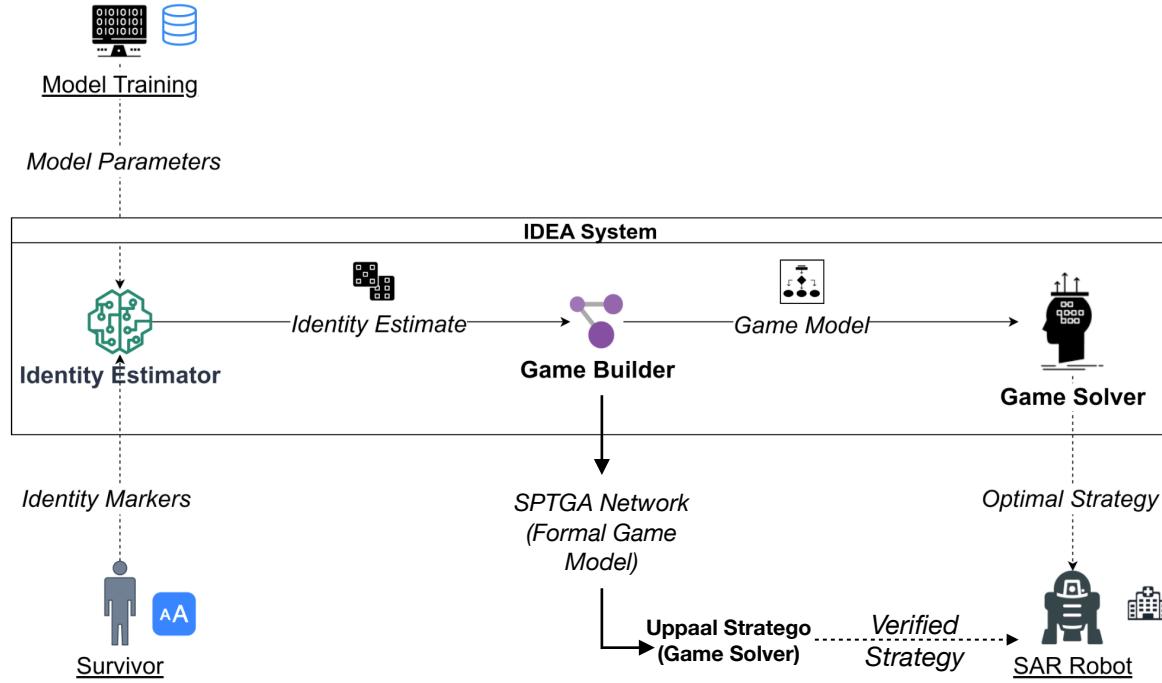
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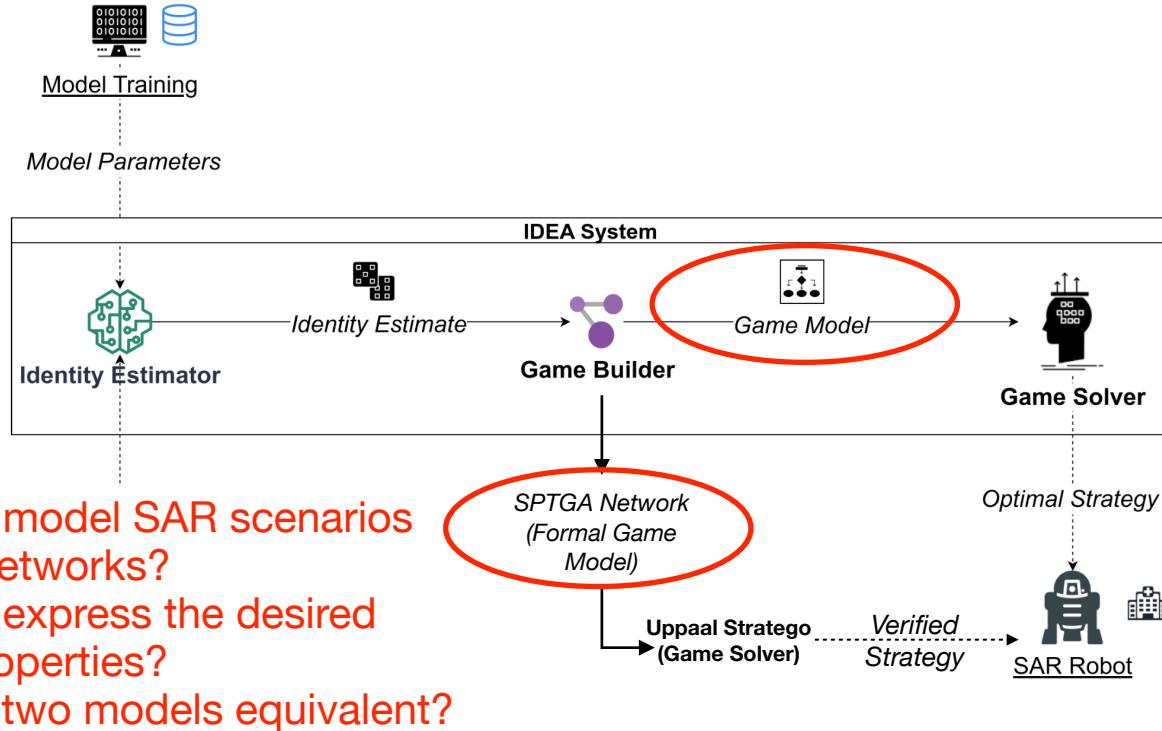
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# The IDEA Framework [1] + Formal Verification



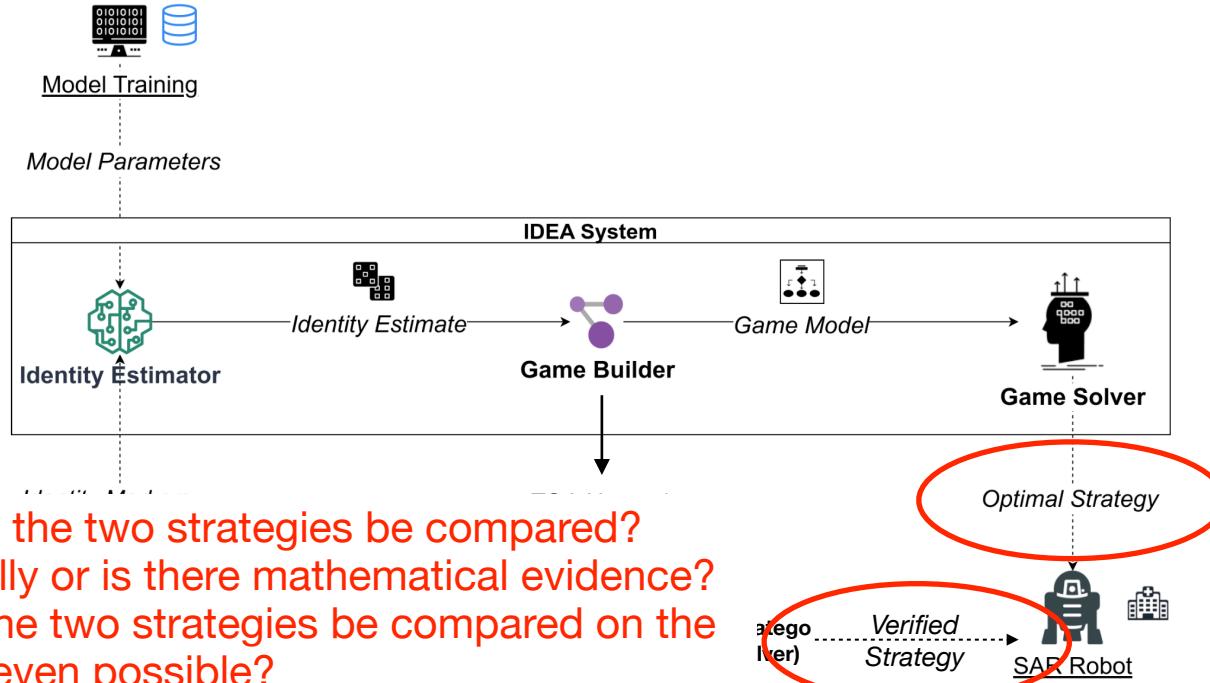
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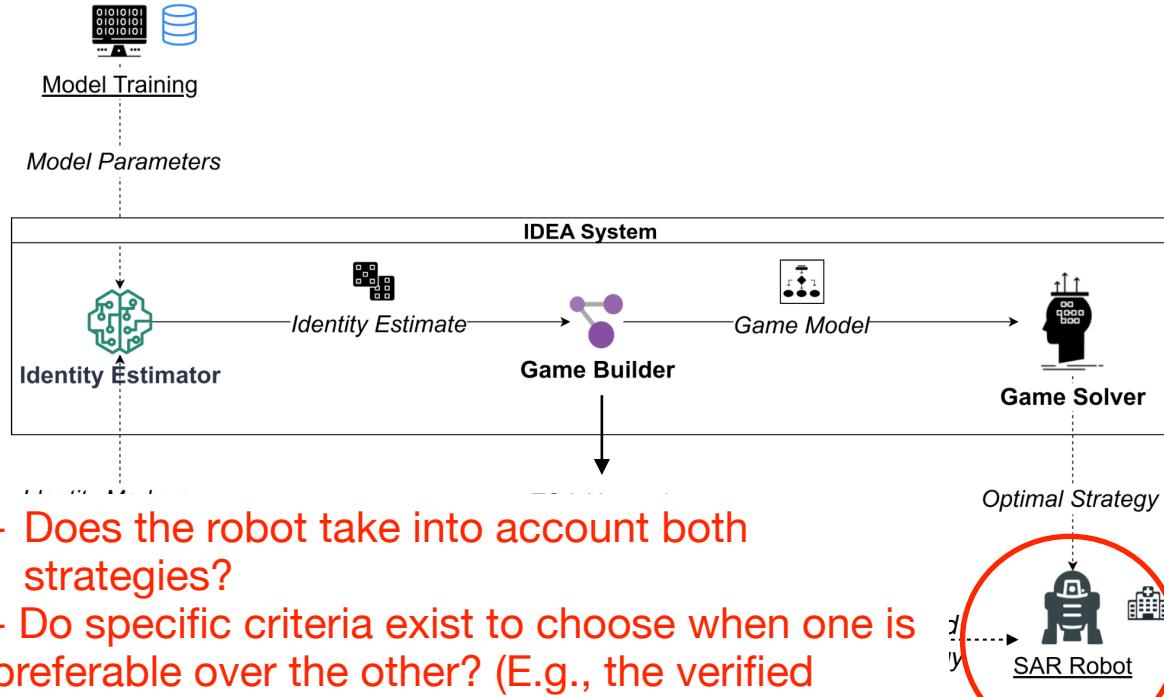
# The IDEA Framework [1] + Formal Verification



- How can the two strategies be compared? Empirically or is there mathematical evidence?
- Should the two strategies be compared on the fly? Is it even possible?
- Can the formally verified strategy realistically be computed at runtime?

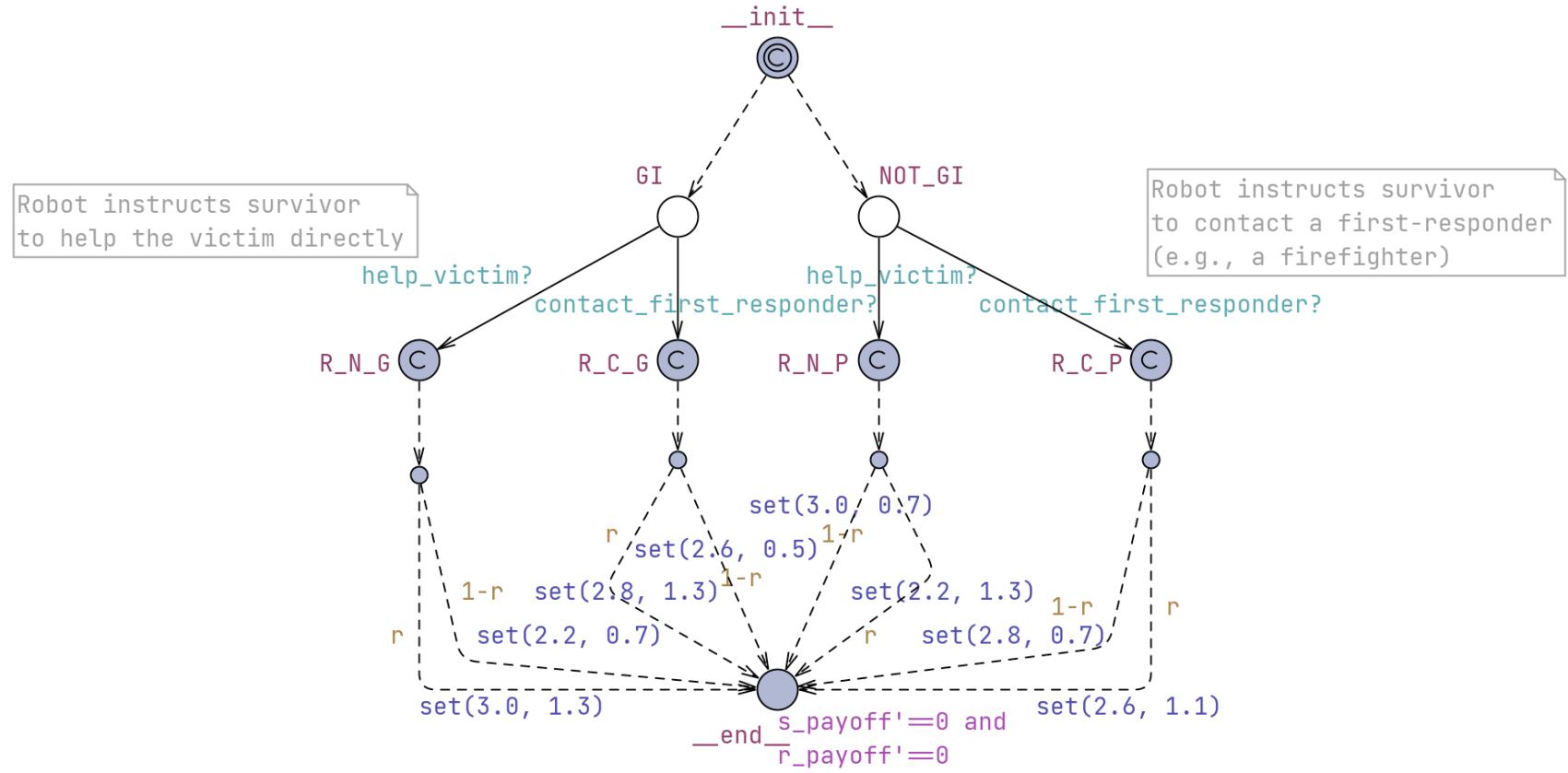
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# The IDEA Framework [1] + Formal Verification

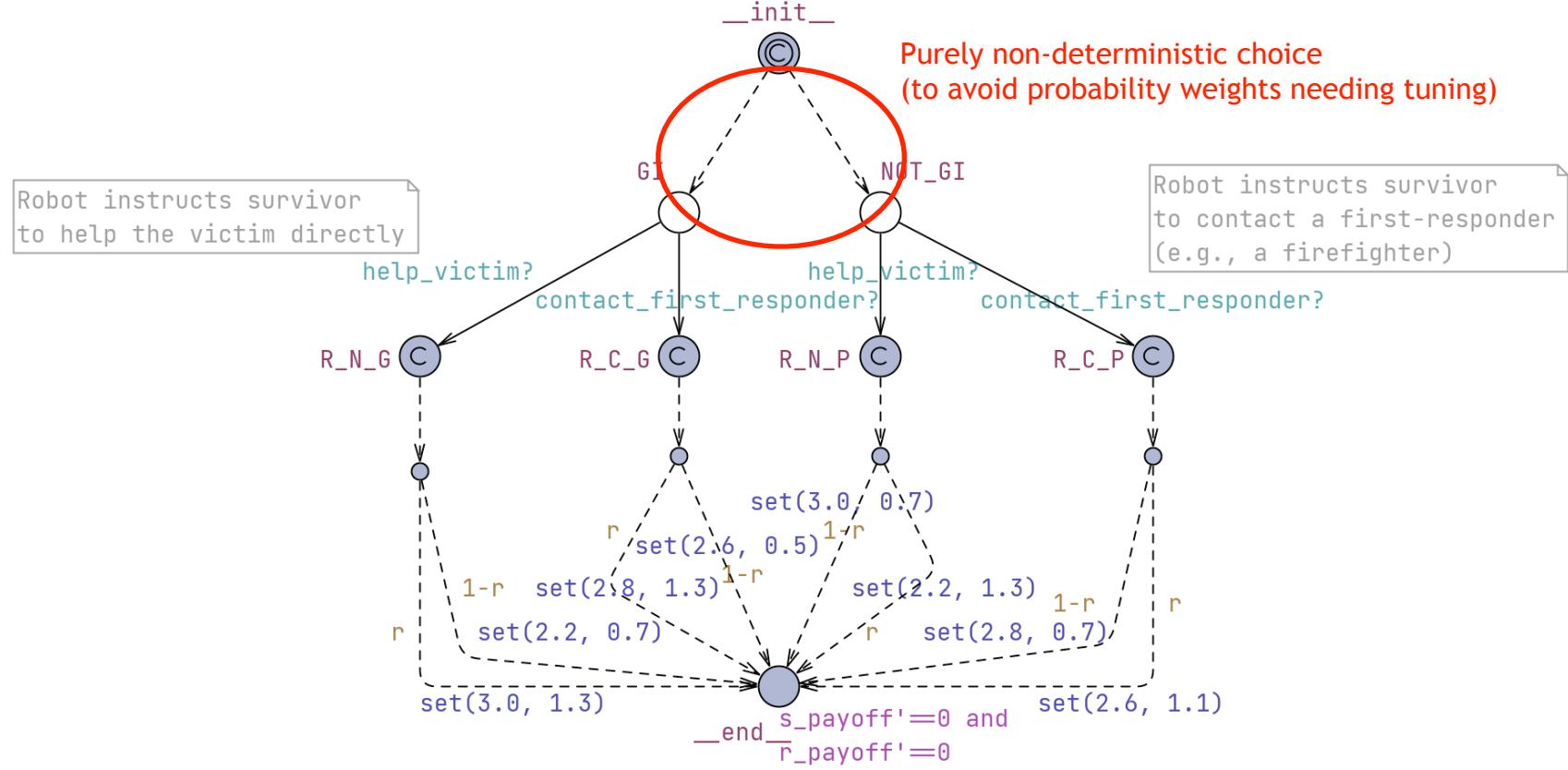


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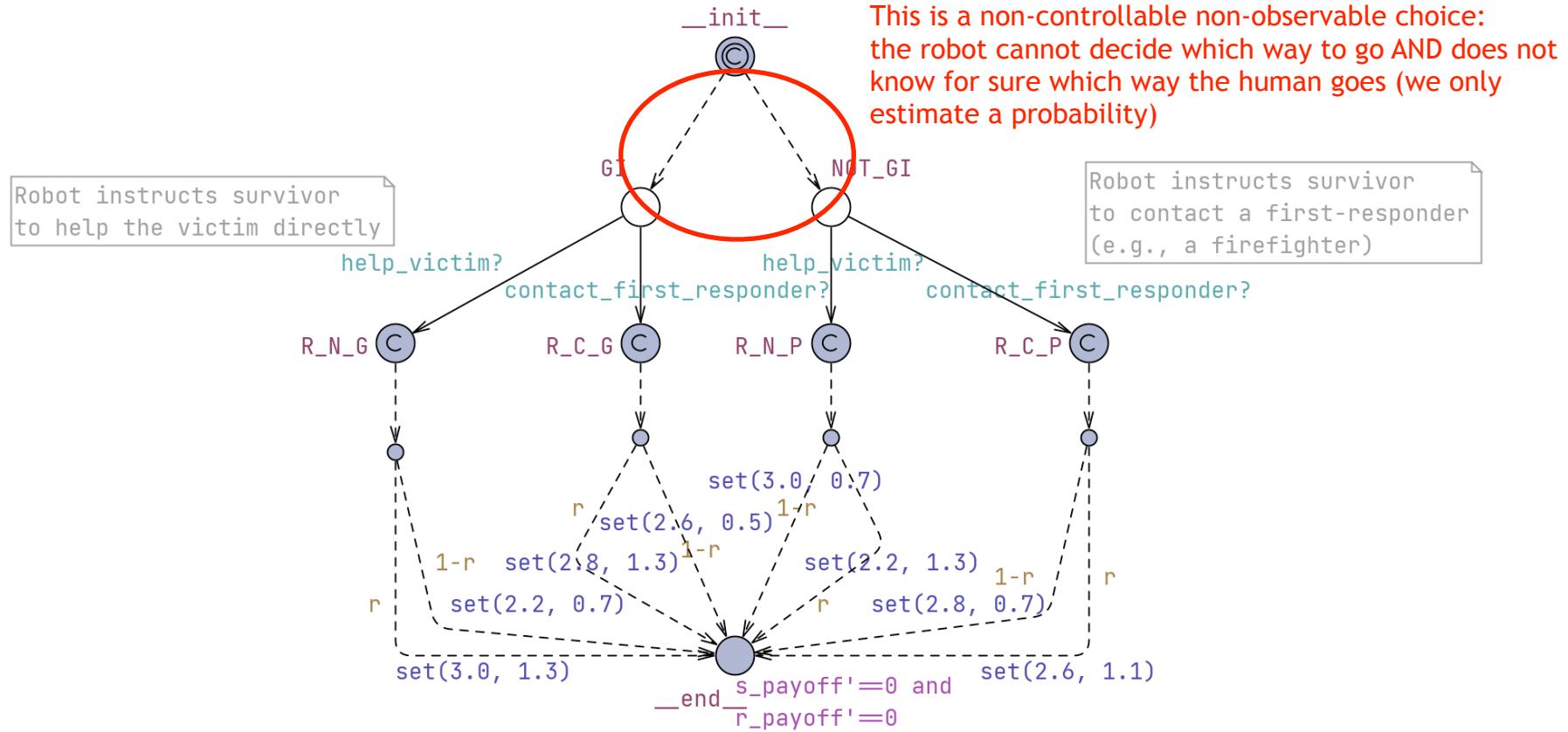
# Formal Model



# Formal Model



# Formal Model



## Synthesized controller: Payoffs?

The robot has two possible choices:  $A_s = \{\text{contact-staff, do-help}\}$

Uppaal Stratego synthesizes a controller for the robot indicating the expected payoff value when choice act  $\in A_s$  is selected in GI or NOT\_GI, indicated as  $U(\text{GI}, \text{act})$  and  $U(\text{NOT\_GI}, \text{act})$ , respectively.

Uppaal optimizes the system's payoff value assuming a certain degree of rationality on the human's side, i.e., parameter r.

For example:

If  $r = 1.0$  (the human is perfectly rational), they developed a shared identity (GI), and the robot instructs them to help, they will help with probability 1 since  $1.3 > 0.7$ .

## Synthesized controller: Payoffs?

!! At runtime (when applying the controller), the robot does not know whether the human is in location GI or NOT\_GI !!

We have an estimate (e.g., through a NN) of  $P(\text{GI})$ ,  $P(\text{NOT\_GI}) = 1 - P(\text{GI})$ .

# Formal Model: How to deal with uncontrollable actions affected by uncertainty?

Re-calibrate the expected payoff value to account for the probability to reach the corresponding state (where act is either call-staff or do-help):

$$u_S(\text{GI}, \text{act}) = U(\text{GI}, \text{act}) \times P(\text{GI})$$

$$u_S(\text{NOT\_GI}, \text{act}) = U(\text{NOT\_GI}, \text{act}) \times (1 - P(\text{GI}))$$

Extracted from Uppaal strategy    Estimated (at runtime)

# Formal Model: How to deal with uncontrollable actions affected by uncertainty?

Re-calibrate the expected payoff value to account for the probability to reach the corresponding state (where act is either call-staff or do-help):

$$u_S(\text{GI}, \text{act}) = U(\text{GI}, \text{act}) \times P(\text{GI})$$

$$u_S(\text{NOT\_GI}, \text{act}) = U(\text{NOT\_GI}, \text{act}) \times (1 - P(\text{GI}))$$

	contact-staff	do-help
GI	2.8	3.0
NOT_GI	2.6	2.2

## Formal Model: How to deal with uncontrollable actions affected by uncertainty?

Re-calibrate the expected payoff value to account for the probability to reach the corresponding state (where act is either call-staff or do-help):

$$u_S(\text{GI}, \text{act}) = U(\text{GI}, \text{act}) \times P(\text{GI})$$

$$u_S(\text{NOT\_GI}, \text{act}) = U(\text{NOT\_GI}, \text{act}) \times (1 - P(\text{GI}))$$

P(GI) = 0.8	contact-staff	do-help
GI	2.8*0.8=2.24	3.0*0.8=2.4
NOT_GI	2.6*0.2=0.52	2.2*0.2=0.44

# Formal Model: How to deal with uncontrollable actions affected by uncertainty?

Re-calibrate the expected payoff value to account for the probability to reach the corresponding state (where act is either call-staff or do-help):

$$u_S(\text{GI}, \text{act}) = U(\text{GI}, \text{act}) \times P(\text{GI})$$

$$u_S(\text{NOT\_GI}, \text{act}) = U(\text{NOT\_GI}, \text{act}) \times (1 - P(\text{GI}))$$

$P(\text{GI}) = 0.8$	contact-staff	do-help	
GI	$2.8 * 0.8 = 2.24$	$3.0 * 0.8 = 2.4$	
NOT_GI	$2.6 * 0.2 = 0.52$	$2.2 * 0.2 = 0.44$	
	2.76	<	2.84
	(do-help is preferable)		

# Formal Model: How to deal with uncontrollable actions affected by uncertainty?

Re-calibrate the expected payoff value to account for the probability to reach the corresponding state (where act is either call-staff or do-help):

$$u_S(\text{GI}, \text{act}) = U(\text{GI}, \text{act}) \times P(\text{GI})$$

$$u_S(\text{NOT\_GI}, \text{act}) = U(\text{NOT\_GI}, \text{act}) \times (1 - P(\text{GI}))$$

$P(\text{GI}) = 0.12$	contact-staff	do-help
GI	$2.8 * 0.12 = 0.33$	$3.0 * 0.12 = 0.36$
NOT_GI	$2.6 * 0.88 = 2.28$	$2.2 * 0.88 = 1.93$

# Formal Model: How to deal with uncontrollable actions affected by uncertainty?

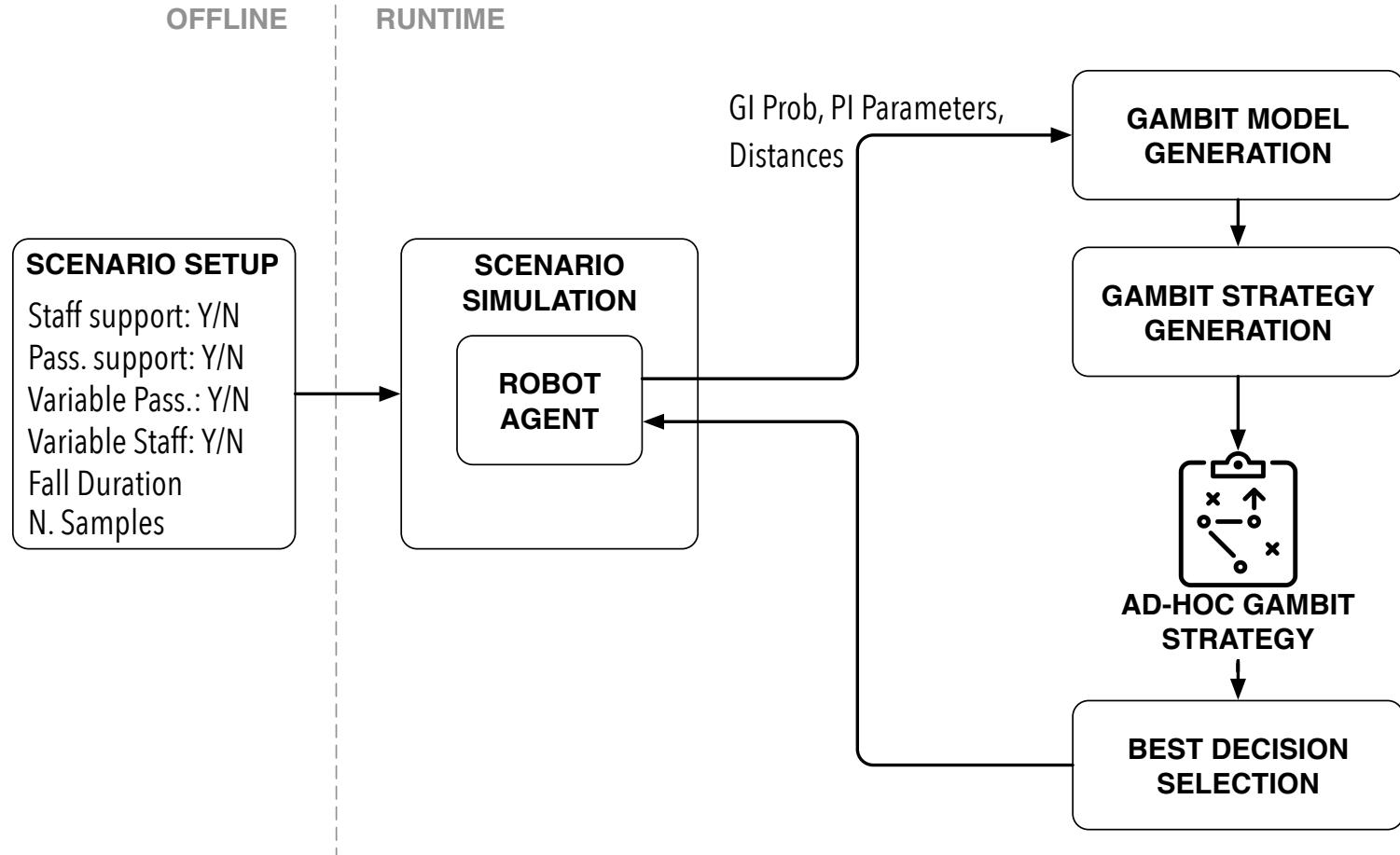
Re-calibrate the expected payoff value to account for the probability to reach the corresponding state (where act is either call-staff or do-help):

$$u_S(\text{GI}, \text{act}) = U(\text{GI}, \text{act}) \times P(\text{GI})$$

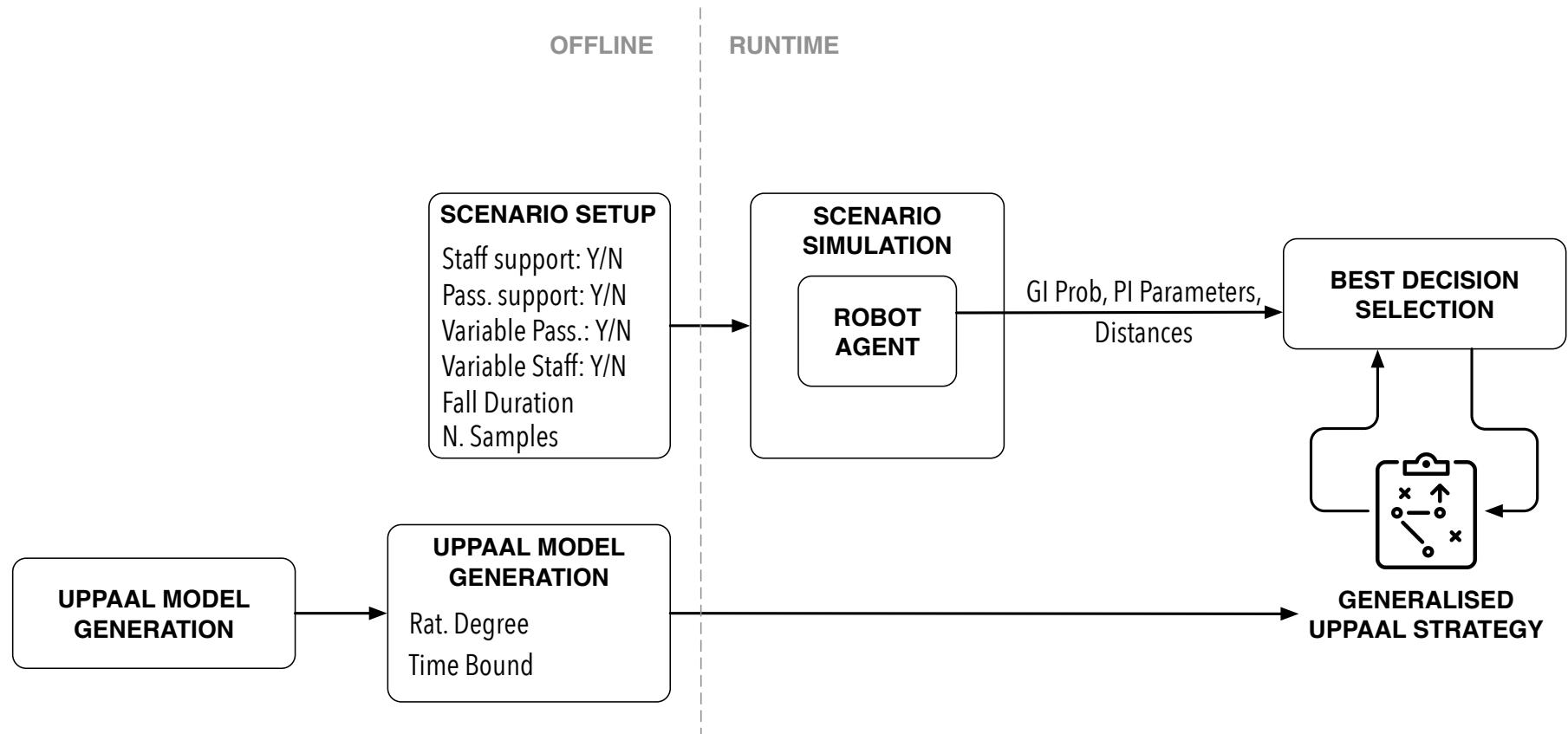
$$u_S(\text{NOT\_GI}, \text{act}) = U(\text{NOT\_GI}, \text{act}) \times (1 - P(\text{GI}))$$

$P(\text{GI}) = 0.12$	contact-staff	do-help	
GI	$2.8 * 0.12 = 0.33$	$3.0 * 0.12 = 0.36$	
NOT_GI	$2.6 * 0.88 = 2.28$	$2.2 * 0.88 = 1.93$	
	2.61	>	2.29
	(contact-staff is preferable)		

# IMPACT+ Framework IDEA agents: Game-theoretic Model

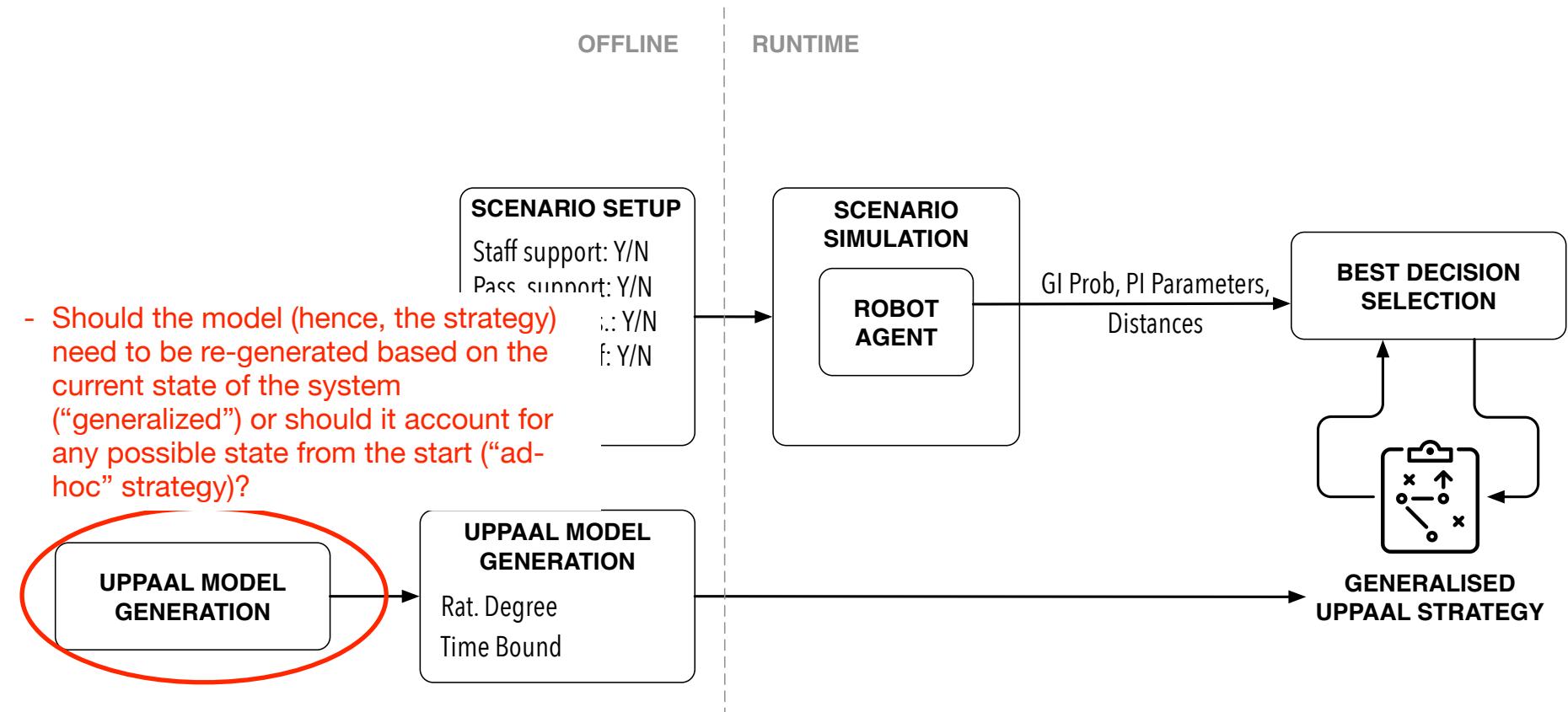


# IMPACT+ Framework for Formalised IDEA agents: Generalised Strategy



# IMPACT+ Framework for Formalised IDEA agents: Generalised Strategy

- Should the model (hence, the strategy) need to be re-generated based on the current state of the system ("generalized") or should it account for any possible state from the start ("ad-hoc" strategy)?



## **Gambit vs. Uppaal Experiments**

## Experimental Settings:

- **Generalized** Strategy
- **Fixed** (800, 1, 8) vs. **variable** (150-700, 1-10%, 1) Passengers/Staff Members
- **Time Bound** 20/50 s
- **Rationality Degree** 1.0/0.5
- **Fall length** 30-600

X

Lowest evac. time

X

Lowest between uppaal and gambit

# 800 Pass/8 Normal Staff/1 Staff (TOSEM setup)

Uppaal Generalized Strategy, TB 50, RAT 0.5

Fall Length	No-support	Staff-support	Passenger-support	Uppaal-support	Gambit-support
30	307.0	268.0	302.0	<b>261.5</b>	293.5
60	317.0	<b>270.0</b>	300.5	273.0	287.0
90	317.5	278.0	294.0	<b>266.0</b>	304.0
120	314.5	<b>268.5</b>	287.5	271.5	282.5
150	314.5	<b>259.0</b>	299.0	272.0	299.0
180	295.0	281.5	286.0	<b>271.0</b>	290.0
210	317.0	<b>262.0</b>	288.5	267.5	307.5
240	297.5	<b>271.5</b>	313.0	304.5	<b>277.5</b>
270	324.0	<b>265.5</b>	301.0	290.5	307.0
300	297.0	305.5	299.5	<b>284.5</b>	308.5
330	304.5	308.0	301.0	<b>278.0</b>	290.5
360	303.5	312.5	<b>287.5</b>	312.5	<b>297.5</b>
390	314.5	<b>312.0</b>	313.5	<b>312.0</b>	314.5
420	299.0	288.5	306.0	<b>273.5</b>	297.5
450	315.5	293.5	280.5	<b>272.5</b>	312.5
480	323.5	312.0	313.0	<b>273.0</b>	309.0
510	324.0	<b>286.5</b>	318.5	279.0	292.5
540	309.0	<b>266.5</b>	316.0	275.0	310.0
570	299.5	<b>272.0</b>	293.0	310.0	<b>293.5</b>
600	314.0	<b>283.5</b>	287.0	318.0	<b>279.0</b>

**var. Pass/1 Normal Staff/var. Staff  
Uppaal Generalized Strategy, TB 50, RAT 0.5**

Fall Length	No-support	Staff-support	Passenger-support	Uppaal-support	Gambit-support
30	317.0	317.5	283.5	285.5	<b>275.0</b>
60	<b>306.0</b>	332.5	321.5	313.5	318.5
90	321.0	317.5	<b>311.0</b>	316.5	320.0
120	329.5	318.0	320.0	<b>304.5</b>	320.5
150	324.5	311.5	318.0	312.5	<b>308.5</b>
180	<b>317.5</b>	325.0	323.0	318.0	321.5
210	317.0	<b>292.0</b>	311.0	293.0	307.0
240	316.0	<b>293.5</b>	326.5	298.5	315.0
270	318.5	<b>314.0</b>	314.5	314.5	318.0
300	319.0	319.0	318.5	321.5	<b>312.5</b>
330	313.5	308.0	294.5	304.0	<b>280.0</b>
360	318.0	327.0	312.5	322.0	<b>304.5</b>
390	316.5	317.0	<b>315.0</b>	<b>315.0</b>	316.5
420	328.5	316.5	324.5	326.5	<b>312.0</b>
450	330.0	318.5	318.5	<b>316.0</b>	319.0
480	314.0	319.5	325.0	<b>311.0</b>	357.0
510	328.0	322.0	321.0	323.5	<b>318.5</b>
540	316.5	319.0	<b>314.0</b>	326.0	<b>314.0</b>
570	312.0	<b>289.0</b>	310.0	<b>317.0</b>	327.0
600	319.0	323.0	324.5	317.0	<b>309.0</b>

## **Uppaal-only Experiments**

## Experimental Settings:

- **Generalized** Strategy
- **Fixed** (462, 6%) vs. **variable** (150-700, 1-10%) Passengers/Staff Members
- **Time Bound** 20/50 s
- **Rationality Degree** 1.0/0.5
- **Fall length** 30-600

X

Configuration with best evacuation time median  
considering **all sim. seeds**

X

Configuration with best evacuation time median  
considering **only sim. seeds where robot makes  
at least 3 decisions**

## Generalized Strategy, fixed Passengers/Staff Members, TB 20, RAT 1.0

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	275.0	274.0	271.5	<b>269.0</b>
60	290.5	<b>268.5</b>	279.0	273.5
90	274.0	<b>271.0</b>	277.0	273.0
120	275.5	<b>269.5</b>	271.0	274.0
150	280.5	<b>271.0</b>	273.5	274.5
180	274.0	276.0	276.0	<b>266.0</b>
210	275.5	<b>271.5</b>	273.0	272.0
240	273.5	272.0	278.5	<b>265.0</b>
270	275.0	273.0	<b>271.0</b>	271.5
300	276.5	<b>265.0</b>	275.0	268.5
330	275.0	277.0	<b>274.5</b>	276.0
360	273.5	271.5	274.0	<b>265.0</b>
390	279.0	<b>269.0</b>	272.0	269.5
420	<b>268.0</b>	268.5	275.0	283.0
450	276.5	273.0	276.5	<b>267.0</b>
480	275.0	282.0	<b>274.0</b>	277.0
510	280.0	<b>272.5</b>	273.5	275.0
540	277.0	278.0	<b>274.0</b>	279.0
570	279.0	<b>265.0</b>	278.0	272.5
600	280.0	267.0	275.0	<b>265.5</b>

## Generalized Strategy, variable Passengers/Staff Members, TB 20, RAT 1.0

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	265.5	260.0	<b>259.5</b>	261.0
60	273.5	290.0	272.5	<b>266.0</b>
90	<b>262.5</b>	270.0	276.0	269.0
120	269.0	262.5	263.0	<b>260.0</b>
150	281.5	270.0	269.5	<b>264.0</b>
180	276.0	273.0	<b>266.5</b>	267.0
210	267.5	303.5	280.0	<b>264.0</b>
240	294.0	<b>261.5</b>	267.5	280.0
270	288.0	267.5	270.5	<b>261.0</b>
300	282.5	<b>263.5</b>	267.5	268.0
330	275.0	<b>260.0</b>	267.5	264.5
360	268.5	266.0	278.0	<b>263.5</b>
390	264.5	265.5	268.5	<b>262.0</b>
420	275.0	296.0	278.0	<b>271.5</b>
450	276.0	<b>266.0</b>	271.5	270.5
480	273.5	<b>260.0</b>	266.0	261.0
510	264.0	267.5	263.5	<b>261.0</b>
540	273.5	272.5	<b>270.5</b>	278.5
570	267.0	<b>259.0</b>	269.0	260.5
600	<b>266.0</b>	<b>266.0</b>	262.5	267.0

## Generalized Strategy, variable Passengers/Staff Members, TB 20, RAT 1.0

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	306.0	<b>266.5</b>	276.5	273.5
60	<b>271.0</b>	297.0	280.0	288.0
90	275.0	<b>271.0</b>	277.0	<b>271.0</b>
120	293.0	<b>270.0</b>	271.0	276.0
150	273.5	275.0	<b>269.5</b>	283.0
180	290.0	281.0	<b>269.0</b>	271.0
210	271.0	311.0	280.0	<b>264.0</b>
240	293.0	<b>265.0</b>	279.0	278.0
270	289.0	289.0	<b>260.5</b>	265.0
300	310.0	276.0	<b>272.0</b>	289.0
330	275.0	<b>259.0</b>	274.0	268.0
360	296.5	271.0	291.5	<b>261.0</b>
390	277.5	274.5	281.5	<b>263.0</b>
420	309.0	323.0	303.0	<b>278.0</b>
450	285.5	<b>268.5</b>	295.0	273.5
480	289.0	273.0	276.0	<b>267.0</b>
510	273.0	275.0	267.0	<b>264.0</b>
540	275.5	313.5	<b>273.5</b>	295.0
570	280.0	267.0	270.0	<b>260.0</b>
600	264.0	263.0	270.0	<b>260.0</b>

## Generalized Strategy, fixed Passengers/Staff Members, TB 20, RAT 0.5

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	282.5	<b>265.0</b>	268.5	268.0
60	298.5	<b>263.5</b>	267.0	<b>263.5</b>
90	275.5	274.5	<b>273.0</b>	273.5
120	274.5	<b>269.0</b>	289.5	282.0
150	286.0	<b>270.0</b>	275.0	297.0
180	272.5	<b>269.0</b>	274.0	272.0
210	272.0	278.5	<b>269.0</b>	295.0
240	286.0	<b>267.5</b>	276.5	274.0
270	267.0	270.0	280.5	<b>265.0</b>
300	277.5	<b>270.5</b>	271.5	<b>270.5</b>
330	287.0	272.5	290.0	<b>263.0</b>
360	290.5	<b>268.5</b>	271.0	270.0
390	<b>268.0</b>	276.0	286.5	285.0
420	276.0	<b>267.0</b>	276.5	<b>267.0</b>
450	<b>268.5</b>	289.5	269.0	<b>268.5</b>
480	278.0	277.5	<b>273.0</b>	273.5
510	270.0	280.0	267.0	<b>264.5</b>
540	279.0	<b>267.5</b>	271.0	276.5
570	289.5	292.5	270.5	<b>265.5</b>
600	266.5	<b>262.0</b>	267.0	296.0

## Generalized Strategy, fixed Passengers/Staff Members, TB 20, RAT 0.5

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	274.0	262.0	294.0	<b>261.0</b>
60	315.5	316.5	<b>267.0</b>	275.5
90	288.0	271.0	274.5	<b>259.0</b>
120	297.0	266.0	297.0	<b>259.0</b>
150	345.0	<b>286.5</b>	314.0	321.5
180	<b>267.5</b>	266.5	268.5	269.5
210	283.0	<b>279.0</b>	288.0	291.0
240	280.0	315.0	<b>278.0</b>	282.0
270	313.0	269.0	269.0	<b>261.0</b>
300	267.0	<b>265.0</b>	270.0	273.0
330	271.0	283.0	305.5	<b>261.0</b>
360	272.0	<b>266.0</b>	270.0	269.0
390	<b>267.0</b>	284.0	280.0	291.0
420	275.0	281.0	276.0	<b>259.0</b>
450	272.0	314.0	316.5	<b>262.0</b>
480	282.0	275.0	300.0	<b>257.0</b>
510	294.0	285.0	271.5	<b>263.5</b>
540	269.0	<b>264.5</b>	267.5	282.5
570	291.0	273.0	<b>261.0</b>	282.0
600	<b>261.5</b>	268.0	276.0	312.5

## Generalized Strategy, variable Passengers/Staff Members, TB 20, RAT 0.5

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	277.0	<b>269.0</b>	273.5	269.5
60	280.0	<b>266.0</b>	277.5	<b>266.0</b>
90	271.0	<b>259.5</b>	269.0	264.5
120	<b>272.5</b>	284.5	281.5	273.5
150	269.0	266.0	268.0	<b>265.0</b>
180	273.5	272.0	269.5	<b>266.5</b>
210	268.0	268.0	271.0	<b>263.0</b>
240	282.5	269.5	<b>268.5</b>	275.5
270	271.0	286.5	264.5	<b>262.5</b>
300	266.5	<b>258.0</b>	270.5	262.0
330	279.0	272.0	<b>268.5</b>	271.5
360	269.0	<b>260.5</b>	267.0	261.5
390	<b>267.5</b>	285.0	279.0	279.0
420	265.5	266.5	<b>263.5</b>	268.0
450	282.5	271.5	278.5	<b>270.0</b>
480	<b>269.0</b>	287.0	269.5	<b>269.0</b>
510	270.0	<b>263.0</b>	272.5	265.5
540	272.5	268.5	276.5	<b>263.5</b>
570	268.5	<b>261.5</b>	267.0	265.0
600	271.5	<b>264.5</b>	269.5	272.5

## Generalized Strategy, variable Passengers/Staff Members, TB 20, RAT 0.5

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	288.0	271.0	281.0	<b>269.0</b>
60	294.0	<b>266.0</b>	306.0	268.5
90	277.5	<b>272.5</b>	277.5	275.0
120	274.0	314.0	268.0	<b>264.0</b>
150	288.0	276.0	<b>273.0</b>	280.0
180	295.0	275.0	<b>272.0</b>	280.0
210	298.0	274.0	280.0	<b>261.0</b>
240	329.0	305.0	285.0	<b>275.0</b>
270	285.0	<b>264.0</b>	296.0	268.0
300	292.0	<b>260.0</b>	284.5	261.5
330	299.5	324.0	<b>276.5</b>	298.5
360	368.0	<b>260.5</b>	282.0	280.5
390	<b>274.0</b>	320.5	300.0	314.5
420	296.0	<b>282.0</b>	285.5	303.0
450	296.0	282.0	283.5	<b>275.5</b>
480	283.0	305.0	274.5	<b>270.0</b>
510	311.0	<b>262.0</b>	286.0	268.0
540	<b>276.0</b>	295.0	315.0	315.0
570	275.0	<b>267.0</b>	289.0	291.0
600	273.5	<b>261.0</b>	296.0	276.5

# Generalized Strategy, fixed Passengers/Staff Members, TB 50, RAT 1.0

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	286.5	272.0	<b>269.0</b>	278.0
60	<b>265.0</b>	269.0	272.5	270.0
90	272.0	271.5	276.5	<b>268.5</b>
120	289.0	<b>266.5</b>	272.0	272.0
150	278.5	266.5	268.0	<b>266.0</b>
180	270.0	<b>262.5</b>	271.5	265.0
210	<b>270.0</b>	273.5	280.0	273.0
240	271.0	272.0	<b>266.0</b>	269.0
270	<b>271.0</b>	272.5	282.0	277.0
300	271.5	272.0	270.5	<b>268.5</b>
330	286.0	275.0	270.0	<b>268.5</b>
360	<b>270.0</b>	279.0	278.5	277.5
390	277.0	<b>265.5</b>	286.0	273.5
420	<b>264.0</b>	267.0	266.5	265.0
450	284.5	<b>277.0</b>	285.5	286.0
480	268.5	<b>268.0</b>	274.0	273.0
510	280.0	<b>275.5</b>	279.5	279.0
540	271.0	<b>265.5</b>	271.0	268.0
570	<b>273.0</b>	273.5	275.5	275.5
600	306.5	<b>264.5</b>	283.5	267.5

# Generalized Strategy, variable Passengers/Staff Members, TB 50, RAT 1.0

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	272.5	275.0	<b>264.0</b>	266.5
60	278.5	270.0	268.5	<b>266.0</b>
90	268.5	267.5	270.0	<b>265.5</b>
120	279.0	279.5	282.0	<b>270.5</b>
150	273.5	266.0	267.5	<b>263.5</b>
180	279.5	<b>257.0</b>	265.0	263.5
210	280.5	268.0	273.5	<b>264.0</b>
240	280.0	265.0	286.5	<b>264.5</b>
270	275.0	269.5	262.5	<b>262.0</b>
300	296.0	287.5	270.5	<b>266.5</b>
330	281.0	272.0	273.0	<b>264.5</b>
360	285.0	<b>265.5</b>	271.0	271.5
390	274.5	<b>274.0</b>	275.0	274.5
420	274.0	<b>262.0</b>	276.0	274.5
450	271.5	<b>260.0</b>	269.0	261.5
480	269.0	270.5	273.5	<b>267.5</b>
510	273.0	<b>261.0</b>	264.5	271.5
540	266.5	262.5	263.5	<b>262.0</b>
570	280.5	272.0	273.0	<b>270.0</b>
600	275.5	266.5	<b>266.0</b>	271.5

# Generalized Strategy, variable Passengers/Staff Members, TB 50, RAT 1.0

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	288.5	317.0	271.5	<b>269.0</b>
60	278.5	276.0	<b>271.5</b>	279.5
90	306.5	274.5	313.5	<b>270.0</b>
120	291.0	313.0	277.0	<b>269.0</b>
150	294.0	<b>262.0</b>	269.0	265.0
180	288.5	<b>265.0</b>	271.0	266.0
210	287.0	272.0	276.0	<b>265.0</b>
240	275.0	<b>266.0</b>	285.0	267.0
270	317.0	294.0	275.0	<b>266.0</b>
300	316.0	286.0	<b>276.0</b>	<b>276.0</b>
330	315.0	<b>265.0</b>	273.0	283.0
360	320.0	<b>260.0</b>	270.0	275.0
390	<b>269.0</b>	301.5	285.0	286.5
420	317.0	<b>259.0</b>	280.0	283.0
450	279.5	271.0	293.0	<b>261.5</b>
480	296.0	284.0	285.0	<b>267.0</b>
510	278.0	<b>267.0</b>	274.0	276.0
540	306.0	<b>279.0</b>	318.0	280.0
570	317.0	283.0	278.0	<b>271.0</b>
600	290.0	<b>269.0</b>	272.0	276.0

## Generalized Strategy, fixed Passengers/Staff Members, TB 50, RAT 0.5

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	<b>270.5</b>	271.5	283.0	276.5
60	281.5	266.5	269.0	<b>265.5</b>
90	277.0	270.0	266.5	<b>266.0</b>
120	274.0	<b>262.5</b>	271.5	263.0
150	267.0	270.0	281.0	<b>264.0</b>
180	280.0	<b>268.0</b>	276.5	271.0
210	273.5	<b>264.0</b>	279.5	<b>264.0</b>
240	275.5	<b>268.5</b>	289.0	277.5
270	274.0	276.5	<b>264.0</b>	273.5
300	268.5	<b>263.5</b>	273.0	271.0
330	271.5	269.0	283.5	<b>265.0</b>
360	285.0	288.5	285.0	<b>276.0</b>
390	287.0	273.0	<b>265.0</b>	272.5
420	284.5	305.5	<b>273.5</b>	274.0
450	278.0	<b>263.0</b>	276.0	267.5
480	281.0	<b>276.5</b>	286.5	283.5
510	277.5	<b>265.0</b>	275.5	281.5
540	271.0	277.5	287.0	<b>268.0</b>
570	268.0	<b>264.5</b>	278.5	277.0
600	277.5	<b>274.5</b>	279.0	276.0

## Generalized Strategy, fixed Passengers/Staff Members, TB 50, RAT 0.5

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	<b>267.0</b>	272.0	271.0	286.0
60	279.0	<b>261.0</b>	289.0	<b>261.0</b>
90	273.0	267.0	<b>263.0</b>	266.0
120	266.0	<b>260.0</b>	270.0	262.5
150	270.0	278.0	285.0	<b>269.0</b>
180	277.0	<b>263.0</b>	280.0	270.5
210	271.0	265.5	272.0	<b>264.0</b>
240	<b>268.0</b>	280.5	292.0	271.5
270	271.0	299.0	272.0	<b>265.0</b>
300	268.0	272.0	273.0	<b>263.0</b>
330	<b>269.5</b>	270.5	288.5	272.5
360	286.0	286.0	278.0	<b>276.0</b>
390	283.5	<b>258.5</b>	266.0	268.0
420	285.0	286.0	269.0	<b>268.5</b>
450	277.0	<b>262.5</b>	273.0	266.5
480	<b>268.0</b>	276.0	304.0	284.0
510	281.0	<b>265.0</b>	277.0	288.5
540	<b>270.0</b>	280.0	279.0	290.0
570	267.5	<b>260.5</b>	282.0	299.5
600	274.0	<b>268.0</b>	273.0	286.0

## Generalized Strategy, variable Passengers/Staff Members, TB 50, RAT 0.5

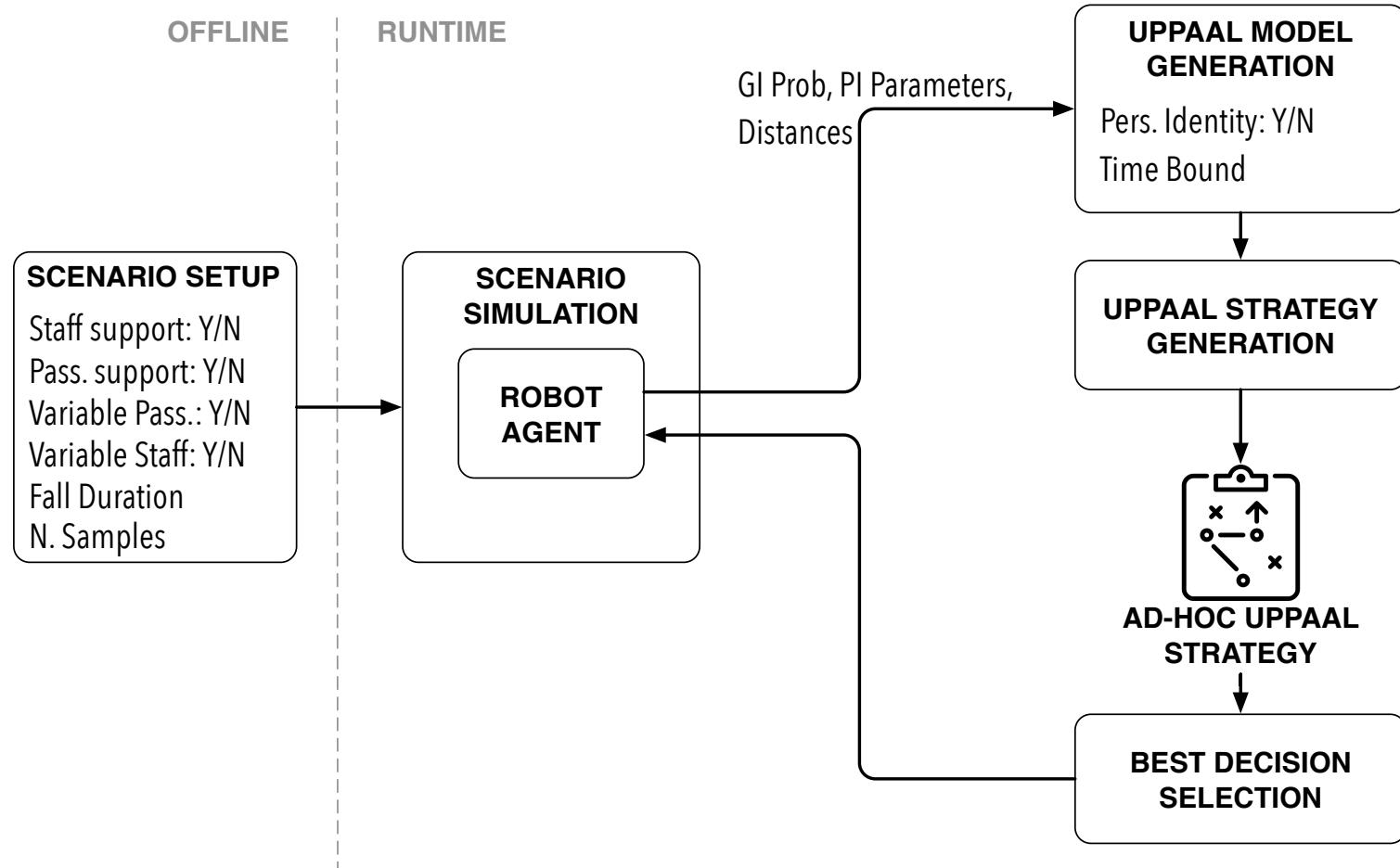
Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	269.0	274.0	<b>260.5</b>	263.0
60	272.5	262.5	264.0	<b>261.5</b>
90	278.0	260.5	<b>259.0</b>	260.5
120	287.5	266.0	276.5	<b>261.0</b>
150	270.0	271.5	273.5	<b>267.5</b>
180	269.0	<b>260.5</b>	265.0	263.5
210	281.0	<b>265.0</b>	265.5	<b>265.0</b>
240	271.5	272.5	<b>269.0</b>	276.0
270	270.0	<b>260.5</b>	274.0	262.5
300	267.0	265.0	267.5	<b>259.5</b>
330	273.0	<b>260.5</b>	272.0	278.5
360	265.0	<b>263.0</b>	274.5	<b>263.0</b>
390	270.0	274.0	271.0	<b>264.0</b>
420	290.0	283.0	277.0	<b>261.0</b>
450	282.5	278.5	279.0	<b>276.0</b>
480	267.0	<b>260.5</b>	269.5	262.5
510	267.5	269.0	277.5	<b>263.0</b>
540	271.0	271.5	262.5	<b>262.0</b>
570	284.0	<b>258.5</b>	279.5	265.5
600	280.5	<b>260.0</b>	<b>260.0</b>	264.5

## Generalized Strategy, variable Passengers/Staff Members, TB 50, RAT 0.5

Best Performance.  
(outperforms  
14/20 times)

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	270.0	313.0	273.5	<b>267.5</b>
60	292.0	264.0	292.0	<b>262.0</b>
90	318.0	271.0	311.0	<b>263.0</b>
120	313.0	279.0	276.0	<b>264.0</b>
150	323.5	269.0	268.0	<b>263.5</b>
180	305.0	261.0	264.5	<b>260.5</b>
210	278.0	303.5	302.0	<b>272.5</b>
240	<b>284.0</b>	293.0	304.5	284.5
270	276.5	313.0	272.5	<b>267.5</b>
300	281.0	266.0	275.0	<b>255.0</b>
330	278.0	<b>265.5</b>	285.0	291.5
360	273.0	267.0	323.0	<b>260.0</b>
390	273.0	286.5	292.5	<b>258.5</b>
420	301.5	328.5	283.5	<b>262.0</b>
450	288.0	306.0	299.5	<b>274.0</b>
480	295.0	<b>259.0</b>	267.0	270.0
510	271.0	273.5	290.0	<b>270.5</b>
540	307.5	295.0	<b>274.5</b>	282.0
570	290.0	<b>261.0</b>	295.0	266.0
600	298.0	<b>262.5</b>	271.0	282.5

# IMPACT+ Framework for Formalised IDEA agents: Ad-hoc strategy



## **Experiment Settings:**

- **Ad-hoc** Strategy
- **Fixed** (462, 6%) vs. **variable** (150-700, 1-10%) Passengers/Staff Members
- **Time Bound** 20/50/200 s
- **Rationality Degree** 1.0/PI ( $0.33 \times \text{same gender} + 0.33 \times \text{same age} + 0.33 \times \text{same culture}$ )
- **Fall length** 30-600

# Ad-hoc Strategy, no PI, fixed Passengers/Staff Members, TB 20, RAT 1.0

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	279.0	267.0	266.0	<b>264.5</b>
60	278.0	269.0	270.5	<b>268.5</b>
90	269.0	<b>262.0</b>	272.0	292.0
120	279.0	<b>264.5</b>	270.0	266.0
150	285.0	267.5	<b>267.0</b>	270.5
180	289.0	274.0	269.0	<b>263.0</b>
210	273.0	280.5	270.0	<b>266.5</b>
240	295.5	<b>268.5</b>	275.5	275.5
270	275.0	<b>265.5</b>	271.0	266.5
300	270.0	277.0	269.5	<b>263.5</b>
330	<b>275.0</b>	315.5	282.0	279.0
360	275.0	287.5	289.5	<b>269.5</b>
390	280.0	<b>268.0</b>	277.5	271.5
420	272.0	<b>262.0</b>	274.0	263.0
450	268.5	<b>265.5</b>	270.0	269.5
480	283.5	283.0	<b>271.5</b>	272.0
510	272.0	281.5	270.0	<b>269.5</b>
540	274.0	<b>265.5</b>	273.0	285.5
570	273.5	269.0	<b>268.0</b>	<b>268.0</b>
600	282.0	273.5	272.0	<b>266.0</b>

# Ad-hoc Strategy, no PI, fixed Passengers/Staff Members, TB 20, RAT 1.0

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30				
60	267.5	276.0	274.5	<b>265.0</b>
90	<b>264.0</b>	267.0	272.0	292.0
120	307.0	<b>262.5</b>	277.5	268.0
150	270.0	273.0	276.0	<b>263.0</b>
180	312.0	276.0	<b>262.0</b>	<b>262.0</b>
210				
240	291.0	<b>266.0</b>	270.0	269.0
270	298.5	<b>261.0</b>	268.0	265.0
300				
330	278.5	323.0	292.5	<b>274.0</b>
360	303.0	289.0	295.0	<b>262.0</b>
390	<b>267.0</b>	270.0	315.0	279.0
420	274.0	311.0	274.0	<b>260.0</b>
450	266.5	<b>262.5</b>	289.5	263.0
480	<b>268.5</b>	273.5	309.0	297.5
510				
540	<b>267.5</b>	271.5	290.0	277.5
570	267.5	269.0	277.0	<b>267.0</b>
600	283.0	277.0	<b>268.0</b>	285.0

## Ad-hoc Strategy, no PI, variable Passengers/Staff Members, TB 20, RAT 1.0

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	287.0	<b>262.5</b>	268.5	271.0
60	272.5	<b>267.0</b>	281.5	268.0
90	280.5	279.5	274.0	<b>273.0</b>
120	276.5	265.0	<b>264.0</b>	267.5
150	282.5	276.5	<b>267.5</b>	278.5
180	<b>270.5</b>	277.5	277.5	281.5
210	295.5	285.5	<b>266.0</b>	<b>266.0</b>
240	272.5	268.0	272.0	<b>262.0</b>
270	276.5	263.0	264.5	<b>260.5</b>
300	285.5	<b>269.0</b>	287.0	271.5
330	278.5	271.5	273.5	<b>268.5</b>
360	271.5	<b>270.5</b>	276.0	290.0
390	287.0	283.0	<b>263.5</b>	266.0
420	275.5	266.0	268.5	<b>265.5</b>
450	272.5	270.0	<b>265.5</b>	266.0
480	<b>270.0</b>	272.5	274.0	297.5
510	276.0	<b>258.5</b>	269.5	268.0
540	278.0	276.5	<b>268.0</b>	269.0
570	282.0	273.0	<b>268.0</b>	275.5
600	<b>271.0</b>	285.0	294.5	271.5

## Ad-hoc Strategy, no PI, variable Passengers/Staff Members, TB 20, RAT 1.0

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	297.0	<b>261.5</b>	302.5	286.0
60	281.0	276.0	297.0	<b>273.0</b>
90	308.5	281.0	277.5	<b>262.5</b>
120	305.5	302.0	<b>280.5</b>	288.5
150	313.0	289.0	<b>267.0</b>	283.0
180	292.0	283.0	<b>273.0</b>	285.0
210	327.0	310.0	306.0	<b>287.0</b>
240	365.0	292.0	315.0	<b>267.0</b>
270	278.0	265.5	265.5	<b>259.5</b>
300	311.0	307.5	289.0	<b>284.0</b>
330	277.0	278.0	271.0	<b>268.0</b>
360	<b>275.5</b>	303.5	279.0	301.5
390	<b>287.0</b>	306.5	299.0	295.5
420	334.0	267.0	271.0	<b>264.0</b>
450	269.0	271.0	275.0	<b>268.0</b>
480	280.0	275.0	<b>265.0</b>	290.0
510	279.0	<b>259.5</b>	273.5	282.0
540	288.0	309.0	318.0	<b>284.0</b>
570	293.0	279.0	<b>272.5</b>	281.0
600	280.5	274.0	308.5	<b>271.5</b>

# Ad-hoc Strategy, no PI, fixed Passengers/Staff Members, TB 200, RAT 1.0

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	273.0	279.5	273.0	<b>265.0</b>
60	285.0	272.5	<b>266.5</b>	271.5
90	299.0	<b>261.0</b>	274.5	266.5
120	274.5	<b>270.0</b>	274.0	273.0
150	313.5	270.0	276.5	<b>267.5</b>
180	<b>271.0</b>	288.0	284.5	273.5
210	280.0	275.5	272.0	<b>270.0</b>
240	<b>271.0</b>	276.5	274.5	281.5
270	279.5	274.0	276.5	<b>267.0</b>
300	267.0	<b>266.0</b>	284.5	<b>266.0</b>
330	276.5	270.0	<b>266.5</b>	299.0
360	289.5	269.5	277.0	<b>266.5</b>
390	274.5	276.0	<b>272.0</b>	273.5
420	277.0	268.0	269.5	<b>265.0</b>
450	279.0	<b>263.0</b>	267.0	264.0
480	<b>274.0</b>	288.0	295.0	295.5
510	271.5	274.0	273.5	<b>266.0</b>
540	270.5	<b>264.5</b>	270.5	268.0
570	274.5	279.0	268.0	<b>265.5</b>
600	283.5	266.0	279.5	<b>265.0</b>

# Ad-hoc Strategy, no PI, fixed Passengers/Staff Members, TB 200, RAT 1.0

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	273.0	274.5	275.5	<b>258.5</b>
60	281.5	<b>259.0</b>	286.0	275.0
90	305.5	<b>256.5</b>	269.5	260.5
120				
150	323.5	<b>266.5</b>	283.0	267.5
180	<b>271.0</b>	315.0	313.0	273.0
210				
240	292.5	<b>267.5</b>	277.0	269.0
270	<b>265.0</b>	277.0	<b>265.0</b>	267.0
300	270.5	271.0	294.0	<b>259.0</b>
330	288.0	272.5	<b>263.0</b>	308.5
360	279.0	277.0	276.0	<b>264.0</b>
390	293.0	288.0	<b>263.0</b>	306.0
420				
450	267.0	<b>255.0</b>	267.0	268.0
480	275.5	284.5	288.5	<b>267.0</b>
510	272.0	273.0	269.0	<b>261.0</b>
540	270.5	260.0	269.5	<b>259.5</b>
570	277.5	292.5	267.5	<b>261.0</b>
600	270.0	<b>259.0</b>	289.0	262.0

## Ad-hoc Strategy, no PI, variable Passengers/Staff Members, TB 200, RAT 1.0

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	273.0	<b>261.0</b>	<b>261.0</b>	276.5
60	268.5	<b>261.0</b>	263.5	266.5
90	278.0	267.0	267.0	<b>265.5</b>
120	273.5	261.5	264.5	<b>260.0</b>
150	269.5	274.5	<b>268.5</b>	275.0
180	282.5	267.5	264.5	<b>263.5</b>
210	272.5	281.0	276.0	<b>263.5</b>
240	264.0	265.5	263.0	<b>261.5</b>
270	290.0	262.5	<b>262.0</b>	262.5
300	278.5	267.5	268.0	<b>259.5</b>
330	265.5	<b>260.0</b>	266.0	266.0
360	276.5	265.0	267.0	<b>264.0</b>
390	269.5	<b>264.0</b>	271.0	277.5
420	290.5	<b>259.0</b>	269.0	260.5
450	276.5	<b>260.0</b>	265.0	262.0
480	276.5	<b>258.0</b>	263.0	259.0
510	315.0	<b>271.0</b>	279.0	274.5
540	<b>263.0</b>	269.5	272.5	266.5
570	<b>267.0</b>	268.5	272.0	270.5
600	285.5	275.0	<b>261.0</b>	270.0

## Ad-hoc Strategy, no PI, variable Passengers/Staff Members, TB 200, RAT 1.0

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	288.0	275.0	<b>260.0</b>	312.0
60	325.5	<b>263.0</b>	282.0	272.0
90	300.0	278.0	<b>267.0</b>	277.0
120	285.0	<b>273.0</b>	317.0	280.0
150	300.0	270.0	274.0	<b>267.0</b>
180	278.5	<b>269.0</b>	272.5	316.0
210	290.5	306.0	<b>285.0</b>	274.0
240	271.0	311.0	274.0	<b>264.0</b>
270	329.0	303.0	288.0	<b>259.0</b>
300	401.0	273.0	279.5	<b>260.5</b>
330	<b>271.0</b>	274.0	272.0	285.0
360	<b>287.0</b>	293.0	289.0	313.0
390	286.5	<b>267.5</b>	301.0	301.0
420	301.5	259.5	295.5	<b>257.5</b>
450	278.0	271.0	290.0	<b>268.0</b>
480	309.5	273.5	293.5	<b>262.0</b>
510	316.0	275.0	274.0	<b>266.5</b>
540	310.5	<b>262.5</b>	297.5	267.0
570	287.0	<b>283.5</b>	309.0	288.5
600	294.0	<b>262.5</b>	265.5	281.5

# Ad-hoc Strategy, with PI, fixed Passengers/Staff Members, TB 20

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	<b>268.5</b>	292.5	276.0	271.0
60	280.0	280.5	<b>268.5</b>	275.0
90	281.5	273.0	273.5	<b>272.0</b>
120	273.5	<b>271.0</b>	272.5	277.0
150	299.5	<b>265.0</b>	267.5	268.5
180	283.5	<b>261.5</b>	275.5	268.5
210	265.5	<b>263.5</b>	268.5	273.0
240	<b>269.5</b>	275.0	280.0	275.5
270	275.5	<b>262.0</b>	272.5	295.5
300	272.5	<b>261.5</b>	275.0	<b>261.5</b>
330	277.5	262.5	267.5	<b>261.5</b>
360	282.5	<b>267.0</b>	274.0	<b>267.0</b>
390	<b>272.0</b>	279.0	275.0	274.0
420	277.5	<b>263.0</b>	264.5	265.0
450	269.0	266.5	277.5	<b>265.5</b>
480	<b>269.0</b>	273.0	272.0	286.5
510	275.5	<b>266.5</b>	268.5	268.0
540	274.5	<b>269.5</b>	286.0	281.5
570	270.5	<b>269.0</b>	309.5	275.5
600	288.5	273.5	<b>272.0</b>	273.0

# Ad-hoc Strategy, with PI, fixed Passengers/Staff Members, TB 20

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	288.0	285.5	<b>276.0</b>	278.0
60	277.0	282.5	<b>272.0</b>	280.0
90	287.0	<b>263.5</b>	272.0	270.0
120	271.5	<b>266.5</b>	273.5	268.5
150	277.0	<b>276.0</b>	286.5	278.5
180	307.0	<b>261.0</b>	274.0	281.0
210	<b>263.0</b>	273.0	271.0	273.0
240	<b>269.5</b>	278.5	288.5	275.5
270	269.0	<b>260.0</b>	265.5	295.5
300	274.0	<b>261.5</b>	275.0	267.0
330	275.0	<b>260.0</b>	264.0	264.0
360	277.0	283.0	274.0	<b>267.0</b>
390	<b>269.0</b>	284.0	288.0	282.0
420	288.0	267.0	275.0	<b>265.0</b>
450	266.0	270.0	283.0	<b>264.0</b>
480	268.0	<b>265.0</b>	272.0	302.0
510	277.5	<b>258.5</b>	267.5	270.0
540	272.5	<b>260.5</b>	273.0	303.0
570	<b>269.0</b>	<b>269.0</b>	312.0	275.0
600	283.0	269.0	<b>265.0</b>	272.0

# Ad-hoc Strategy, with PI, variable Passengers/Staff Members, TB 20

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	282.5	271.5	272.5	<b>269.0</b>
60	277.5	268.5	268.0	<b>262.0</b>
90	<b>266.5</b>	267.5	<b>266.5</b>	272.5
120	277.5	<b>257.0</b>	263.5	260.0
150	<b>268.5</b>	275.0	281.0	271.5
180	276.5	<b>262.0</b>	271.0	271.0
210	295.5	271.5	270.5	<b>263.5</b>
240	275.0	<b>261.5</b>	270.5	268.0
270	270.5	<b>260.0</b>	278.0	264.0
300	280.5	266.0	<b>264.0</b>	267.0
330	276.5	<b>264.5</b>	271.5	274.0
360	269.0	265.5	<b>265.0</b>	267.0
390	274.5	<b>262.5</b>	267.0	263.0
420	302.0	266.5	266.5	<b>265.0</b>
450	265.0	<b>264.0</b>	266.0	271.5
480	283.5	273.0	268.0	<b>263.0</b>
510	273.5	265.5	269.0	<b>260.0</b>
540	279.5	264.5	266.0	<b>259.5</b>
570	263.0	263.0	265.5	<b>260.0</b>
600	274.0	270.0	265.0	<b>264.0</b>

# Ad-hoc Strategy, with PI, variable Passengers/Staff Members, TB 20

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	303.0	<b>273.0</b>	281.0	280.0
60	280.0	287.0	279.0	<b>264.0</b>
90	310.0	<b>263.0</b>	272.0	273.0
120	311.0	<b>255.5</b>	263.5	267.0
150	285.5	290.0	282.5	<b>269.5</b>
180	306.5	275.5	<b>273.0</b>	275.0
210	276.0	296.0	311.0	<b>267.0</b>
240	318.0	<b>261.0</b>	278.0	277.0
270	279.0	<b>264.0</b>	275.0	271.0
300	283.0	273.0	<b>264.0</b>	269.0
330	280.0	279.0	<b>275.0</b>	289.0
360	281.0	273.0	<b>260.0</b>	273.0
390	281.0	<b>267.0</b>	269.0	269.5
420	311.0	<b>266.5</b>	273.0	271.0
450	280.0	<b>275.0</b>	<b>275.0</b>	<b>275.0</b>
480	283.5	294.0	293.0	<b>269.0</b>
510	273.5	312.5	274.5	<b>272.5</b>
540	286.5	266.5	277.5	<b>262.5</b>
570	271.0	268.0	266.0	<b>261.0</b>
600	291.0	314.5	<b>261.5</b>	271.0

# Ad-hoc Strategy, with PI, fixed Passengers/Staff Members, TB 50

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	272.0	267.0	267.5	<b>264.0</b>
60	269.5	276.5	281.0	<b>263.5</b>
90	268.5	267.5	267.0	<b>263.0</b>
120	275.5	<b>268.0</b>	285.5	272.5
150	280.0	<b>264.5</b>	272.0	271.5
180	276.5	272.0	281.0	<b>269.0</b>
210	283.5	263.0	267.0	<b>261.0</b>
240	280.0	270.5	271.0	<b>264.5</b>
270	271.5	276.5	<b>270.5</b>	290.0
300	266.0	269.0	266.0	<b>261.0</b>
330	283.0	281.0	<b>262.5</b>	277.5
360	280.0	272.0	277.0	<b>271.5</b>
390	280.5	<b>267.0</b>	286.0	273.0
420	<b>264.0</b>	269.5	276.5	267.5
450	277.0	<b>260.0</b>	262.5	263.5
480	282.5	273.0	268.5	<b>267.0</b>
510	275.0	268.0	279.0	<b>263.5</b>
540	280.5	280.0	270.0	<b>265.0</b>
570	307.0	267.5	275.0	<b>263.5</b>
600	291.0	<b>267.5</b>	274.0	270.0

# Ad-hoc Strategy, with PI, fixed Passengers/Staff Members, TB 50

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	270.0	<b>259.0</b>	262.0	260.0
60	267.0	277.0	304.0	<b>263.0</b>
90	289.0	292.0	278.0	<b>267.0</b>
120	277.0	<b>270.0</b>	303.5	285.0
150	274.5	276.5	272.0	<b>266.5</b>
180	297.0	<b>272.0</b>	280.0	286.0
210	287.0	<b>271.5</b>	279.5	277.5
240	277.0	265.0	<b>261.0</b>	<b>261.0</b>
270	263.0	285.0	<b>262.0</b>	276.0
300	272.0	<b>261.0</b>	266.0	262.0
330	270.0	269.0	<b>260.0</b>	277.5
360	<b>261.5</b>	292.5	315.5	266.5
390	282.5	<b>266.5</b>	319.5	312.0
420	279.0	290.0	284.5	<b>278.5</b>
450	278.5	261.5	266.0	<b>259.0</b>
480	306.0	<b>274.0</b>	278.0	303.0
510	292.0	274.0	295.0	<b>261.0</b>
540	274.0	282.0	<b>269.0</b>	301.0
570	306.0	308.0	274.0	<b>265.0</b>
600	318.0	269.0	<b>268.5</b>	277.0

## Ad-hoc Strategy, with PI, variable Passengers/Staff Members, TB 50

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	<b>266.0</b>	269.5	287.0	276.0
60	278.0	<b>257.0</b>	261.0	262.0
90	269.0	<b>258.0</b>	265.5	265.0
120	267.0	269.5	268.5	<b>261.5</b>
150	281.5	267.5	<b>265.5</b>	266.5
180	<b>268.0</b>	269.5	273.0	270.5
210	302.0	279.0	270.5	<b>267.0</b>
240	265.5	<b>262.5</b>	273.5	263.0
270	276.5	267.5	266.5	<b>262.0</b>
300	278.0	<b>262.0</b>	264.0	267.0
330	283.5	<b>266.0</b>	291.0	269.0
360	264.0	263.5	267.5	<b>259.5</b>
390	274.0	<b>265.5</b>	267.5	271.5
420	273.0	<b>260.5</b>	270.5	268.5
450	306.5	<b>262.5</b>	268.0	266.0
480	<b>264.0</b>	264.5	276.5	284.5
510	272.5	263.5	265.5	<b>261.0</b>
540	<b>269.5</b>	271.0	274.5	271.0
570	287.0	269.0	282.5	<b>266.0</b>
600	274.0	269.0	267.0	<b>263.0</b>

# Ad-hoc Strategy, with PI, variable Passengers/Staff Members, TB 50

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	314.0	<b>264.0</b>	288.0	299.0
60	335.0	<b>259.0</b>	270.0	314.0
90	283.5	285.0	281.5	<b>278.0</b>
120	281.0	288.0	269.0	<b>260.0</b>
150	297.0	273.0	<b>268.0</b>	285.0
180	279.0	<b>265.0</b>	273.0	277.0
210	283.0	<b>266.5</b>	295.0	267.0
240	280.5	<b>258.5</b>	296.5	268.0
270	292.0	270.0	271.0	<b>259.0</b>
300	281.0	<b>265.0</b>	274.0	282.0
330	295.0	<b>264.0</b>	315.0	285.0
360	277.0	<b>274.0</b>	275.0	<b>274.0</b>
390	294.5	<b>257.5</b>	277.5	271.5
420	276.0	<b>262.0</b>	282.0	292.0
450	327.0	<b>266.0</b>	280.0	271.0
480	283.0	281.0	<b>275.0</b>	300.0
510	276.0	271.0	279.0	<b>260.0</b>
540	300.5	289.0	<b>281.5</b>	308.0
570	288.0	307.0	327.0	<b>264.0</b>
600	280.0	278.0	<b>274.0</b>	300.5

# Ad-hoc Strategy, with PI, fixed Passengers/Staff Members, TB 200

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	272.0	<b>263.0</b>	275.5	266.0
60	<b>269.5</b>	284.5	278.5	313.5
90	282.0	268.0	267.0	<b>259.0</b>
120	278.0	276.0	<b>271.0</b>	278.0
150	269.0	283.0	<b>264.5</b>	269.5
180	276.0	<b>268.0</b>	293.5	271.5
210	271.5	265.0	<b>264.5</b>	269.5
240	272.5	269.5	<b>263.0</b>	264.0
270	271.5	273.0	<b>261.5</b>	272.5
300	287.0	<b>263.5</b>	272.5	265.0
330	279.0	272.5	282.0	<b>269.5</b>
360	287.5	<b>271.5</b>	276.0	275.0
390	273.5	<b>263.0</b>	275.0	298.0
420	273.5	268.0	279.0	<b>262.5</b>
450	<b>267.0</b>	276.0	282.5	272.5
480	270.5	273.5	<b>269.0</b>	280.5
510	272.0	274.5	270.0	<b>268.0</b>
540	288.0	280.0	270.0	<b>258.0</b>
570	312.0	<b>272.0</b>	278.0	276.0
600	276.0	<b>262.5</b>	266.0	264.5

# Ad-hoc Strategy, with PI, fixed Passengers/Staff Members, TB 200

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	264.0	<b>260.0</b>	268.0	290.0
60	<b>271.0</b>	294.0	275.0	318.0
90	287.0	268.0	262.0	<b>257.0</b>
120	270.0	295.0	<b>266.0</b>	277.0
150	272.0	272.0	<b>268.0</b>	313.0
180	285.0	262.5	280.0	<b>261.0</b>
210	270.0	<b>264.0</b>	<b>264.0</b>	277.0
240	286.0	<b>260.0</b>	<b>260.0</b>	274.0
270	297.0	279.5	<b>267.0</b>	274.5
300	309.0	263.0	282.0	<b>256.0</b>
330	275.0	<b>264.5</b>	277.0	276.0
360	<b>262.0</b>	267.0	268.0	263.0
390	270.0	<b>263.0</b>	276.0	275.0
420	<b>264.5</b>	290.0	284.0	266.5
450	268.5	289.0	298.5	<b>259.5</b>
480	270.5	<b>261.0</b>	265.5	275.5
510	272.0	268.0	277.0	<b>266.0</b>
540	297.0	269.0	270.0	257.0
570	313.0	<b>273.0</b>	<b>273.0</b>	287.0
600	279.0	<b>258.0</b>	271.0	264.0

## Ad-hoc Strategy, with PI, variable Passengers/Staff Members, TB 200

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	284.0	<b>260.0</b>	269.0	264.5
60	277.5	271.0	<b>265.0</b>	268.0
90	264.5	264.5	270.5	<b>261.5</b>
120	277.5	<b>261.0</b>	276.0	268.0
150	275.0	<b>262.5</b>	284.0	271.0
180	<b>267.5</b>	275.0	272.0	275.5
210	277.0	273.5	<b>272.5</b>	280.5
240	270.5	<b>263.0</b>	267.5	269.0
270	<b>266.5</b>	267.0	271.0	269.0
300	283.0	<b>263.0</b>	269.0	264.5
330	275.5	265.0	<b>262.0</b>	266.0
360	273.5	290.5	276.0	<b>268.0</b>
390	277.0	263.0	265.5	<b>262.5</b>
420	<b>267.5</b>	272.5	271.5	278.5
450	267.0	<b>261.5</b>	274.0	266.0
480	269.5	<b>264.5</b>	267.5	273.5
510	270.0	<b>259.5</b>	272.5	264.5
540	286.5	274.5	272.5	<b>269.5</b>
570	267.5	277.0	272.0	<b>267.0</b>
600	281.5	266.5	278.0	<b>265.0</b>

# Ad-hoc Strategy, with PI, variable Passengers/Staff Members, TB 200

Fall Length	No-support	Staff-support	Passenger-support	Adaptive-support
30	307.0	<b>260.0</b>	278.0	263.0
60	295.0	313.0	<b>265.5</b>	267.5
90	273.0	284.0	321.0	<b>263.0</b>
120	297.0	<b>259.0</b>	270.5	285.5
150	292.0	<b>269.5</b>	279.0	271.5
180	263.0	274.0	272.0	<b>262.0</b>
210	284.5	295.5	<b>282.0</b>	314.5
240	275.0	280.0	273.0	<b>266.0</b>
270	298.5	<b>278.5</b>	281.5	302.0
300	300.0	<b>265.0</b>	281.0	290.0
330	282.0	283.0	282.0	<b>269.0</b>
360	<b>291.0</b>	320.0	302.0	297.0
390	266.0	<b>262.0</b>	265.5	276.5
420	283.0	<b>275.0</b>	286.0	276.0
450	364.0	283.0	<b>278.0</b>	287.0
480	275.5	277.0	326.5	<b>276.5</b>
510	272.5	<b>258.5</b>	301.0	302.0
540	291.0	272.5	272.5	<b>267.5</b>
570	278.0	283.5	279.5	<b>265.5</b>
600	283.5	<b>263.5</b>	294.5	294.5