Simulation-Based Capacity Analysis for Strategic Medical Evacuation to Civilian Healthcare Systems

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21st NATO CA²X² Forum Rome, Italy 2026

IABG

der Bundeswehr Universität München

der Bundeswehr Universität München

ComPat Partner

Kommando Gesundheitsversorgung der Bundeswehr (KdoGesVersBw)
Bundeswehr Medical Support Command

Sanitätsakademie der Bundeswehr (SanAkBw)
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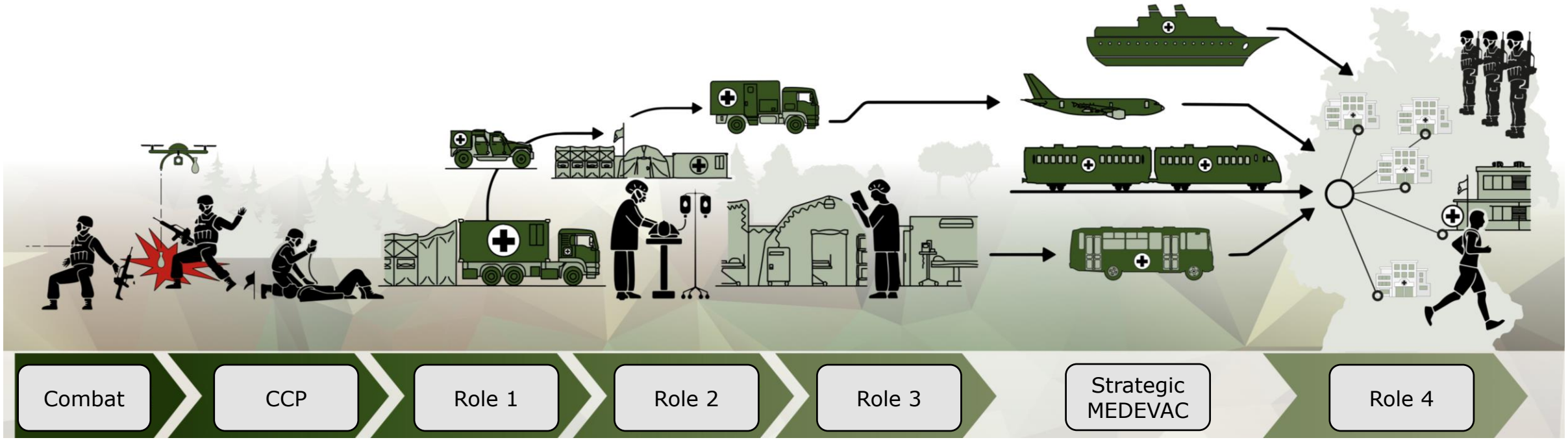
Bundeswehr Joint Support Command

Bundeswehrzentralkrankenhaus (BwZKrhs)
Bundeswehr Central Hospital

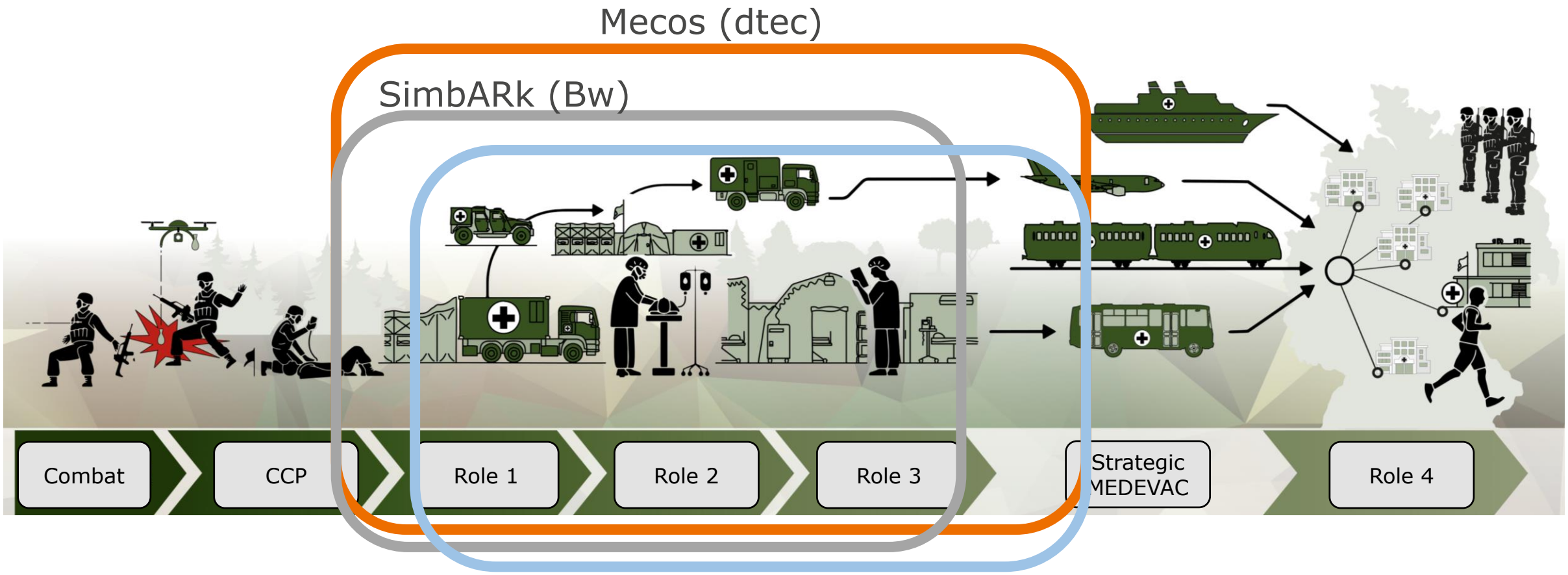
Bundesamt für Bevölkerungsschutz und Katastrophenhilfe

The Federal Office of Civil Protection and Disaster Assistance

Overview

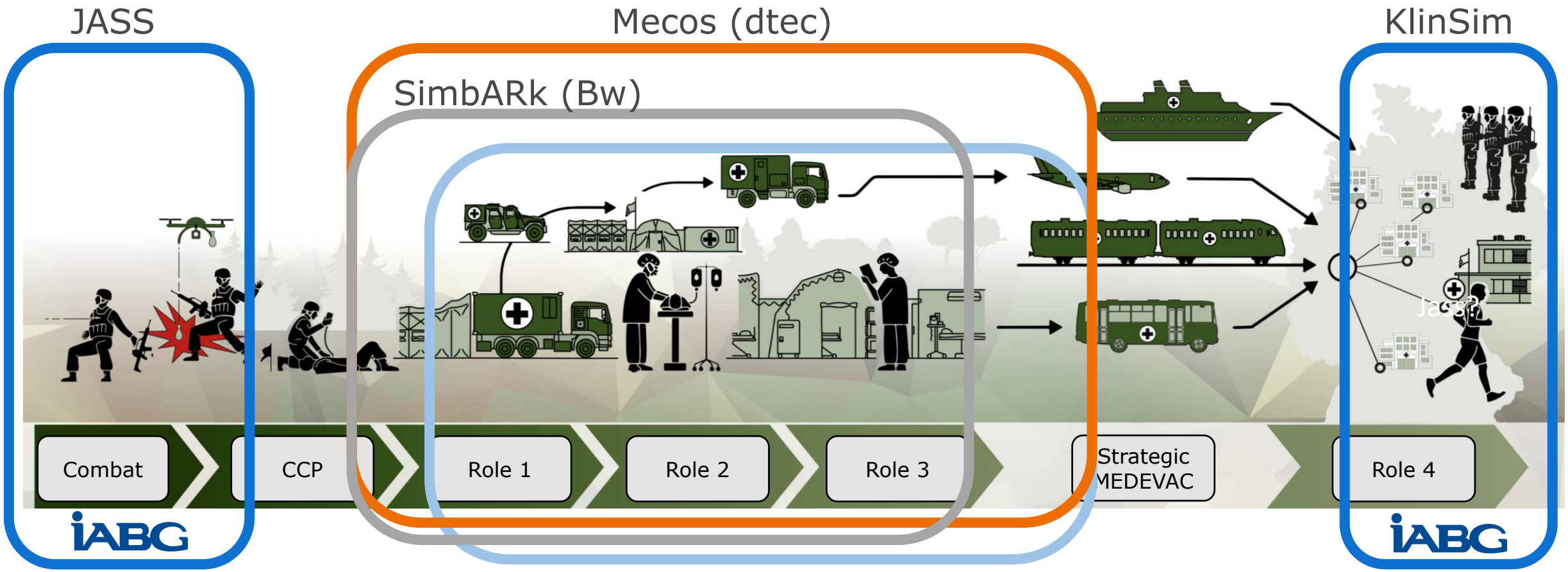


Overview



MSG-HFM-239 / Military Medical Support Simulation for Large Scale Combat Operations (LSCO) Planning

Overview



NATO MSG-HFM-239 / Military Medical Support Simulation for Large Scale Combat Operations (LSCO) Planning

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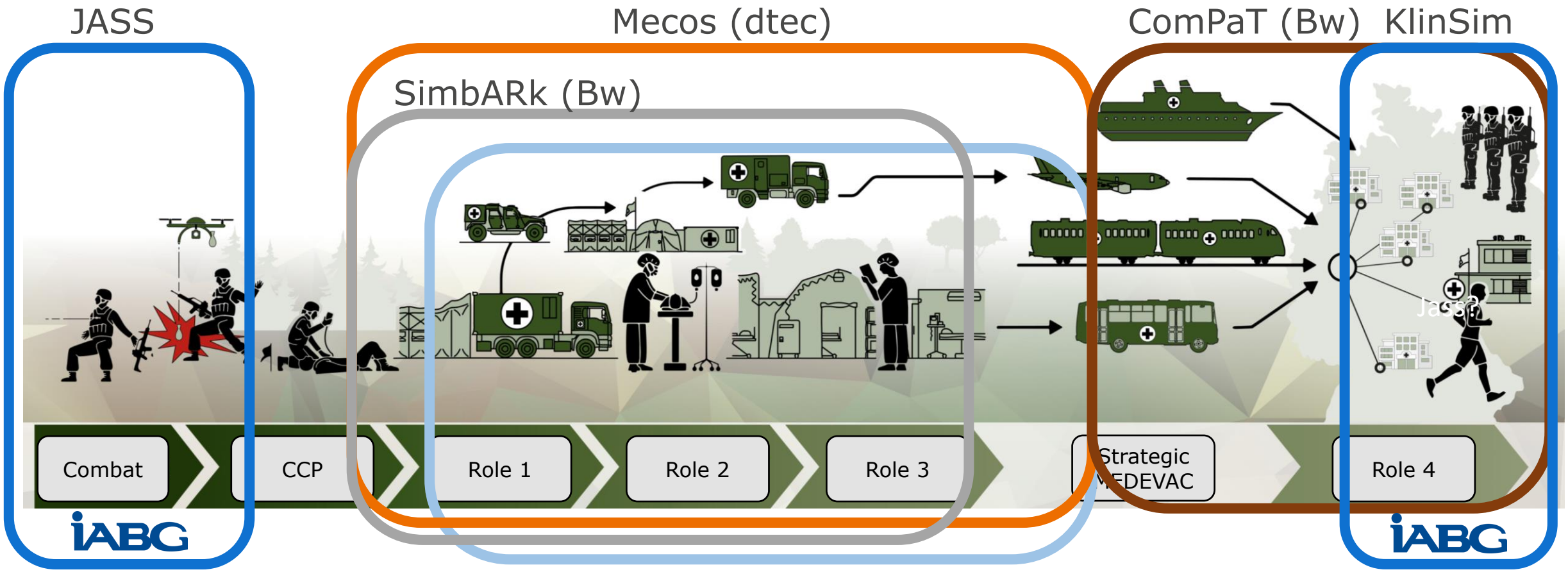
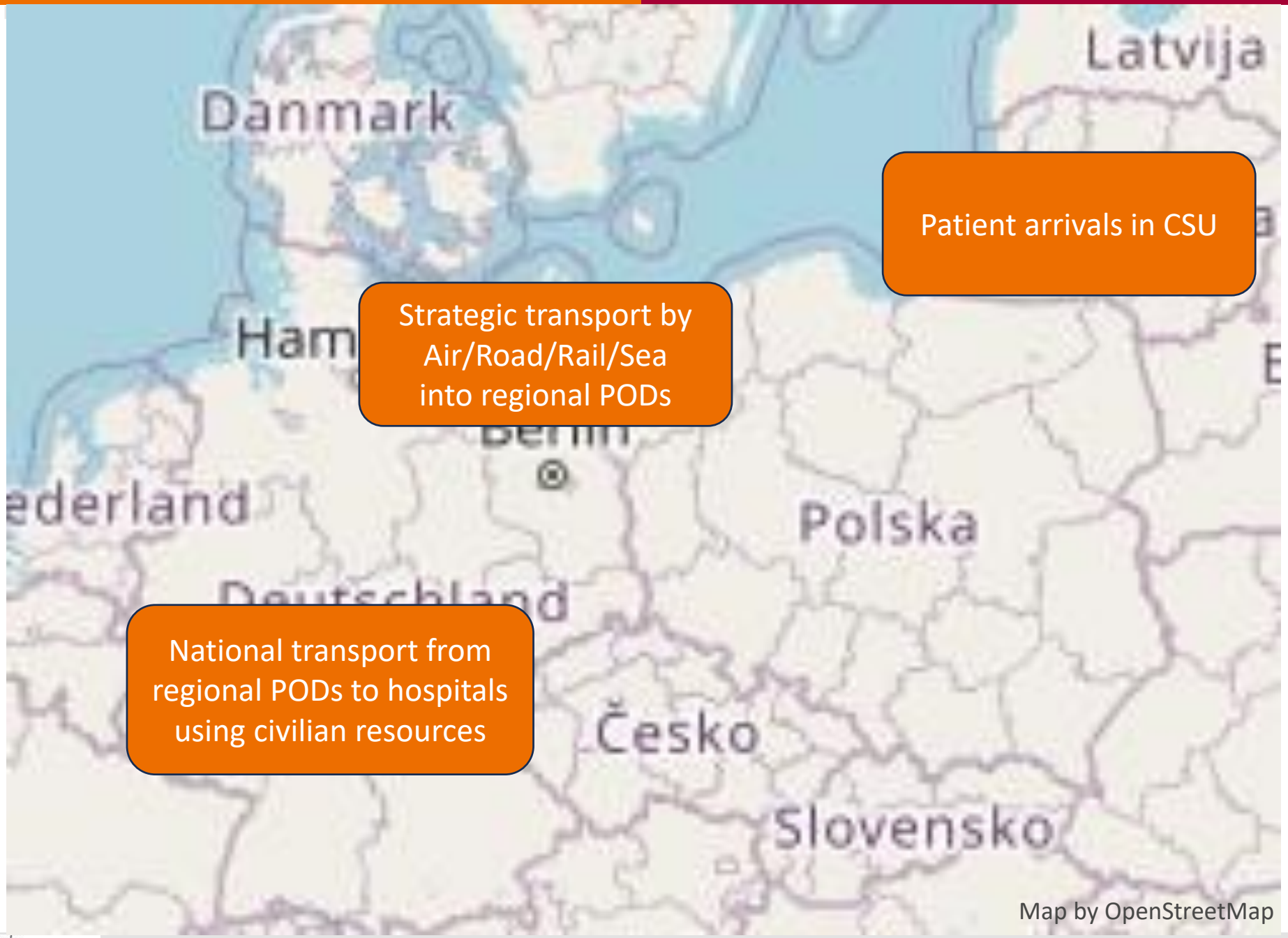
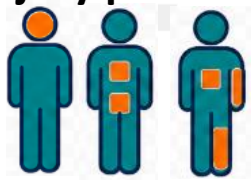


NATO MSG-HFM-239 / Military Medical Support Simulation for Large Scale Combat Operations (LSCO) Planning


Latvija
Danmark
Patient arrivals in CSU
Strategic transport by Air/Road/Rail/Sea into regional PODs
Ham
Berlin
ederland
Polska
Deutschland
National transport from regional PODs to hospitals using civilian resources
Česko
Slovensko
Map by OpenStreetMap

International transport

Injury pattern



Patient arrival

Selection of CSUs and PODs

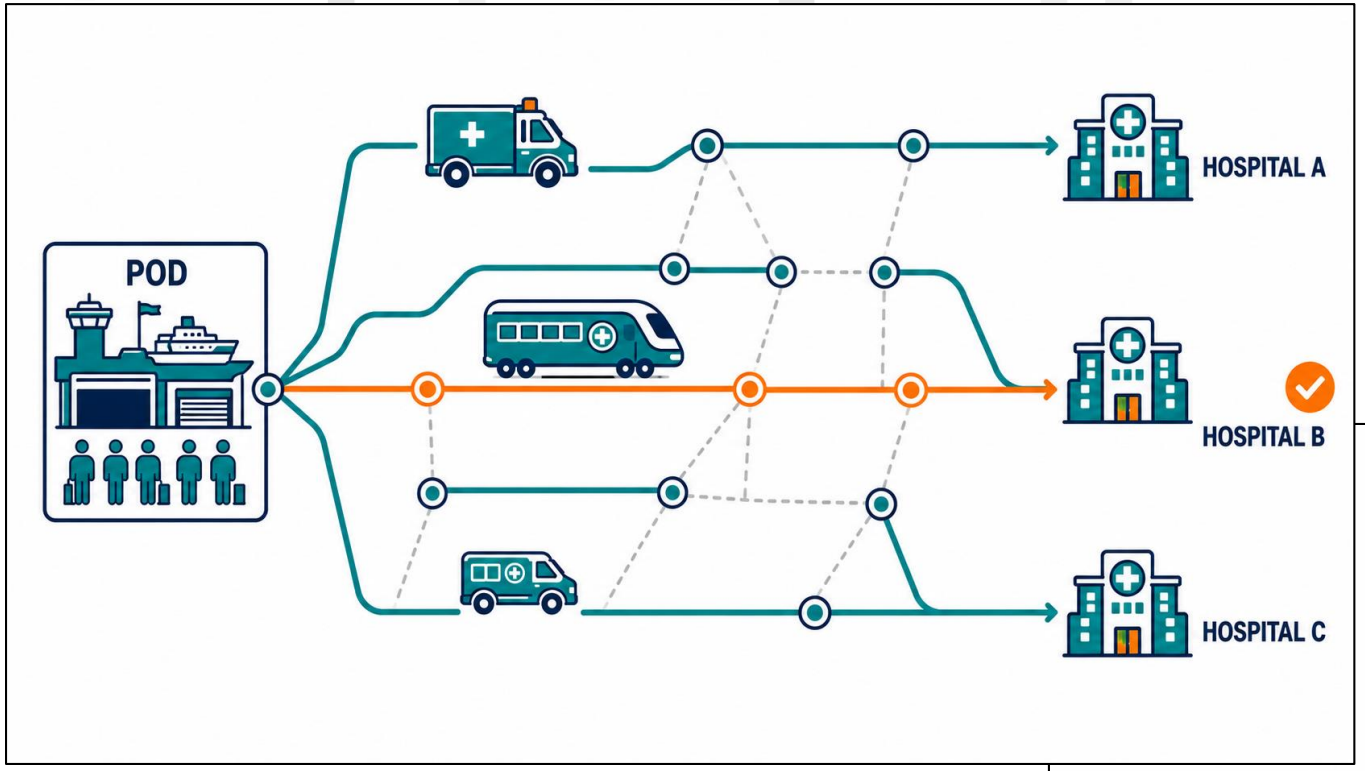
International Transport

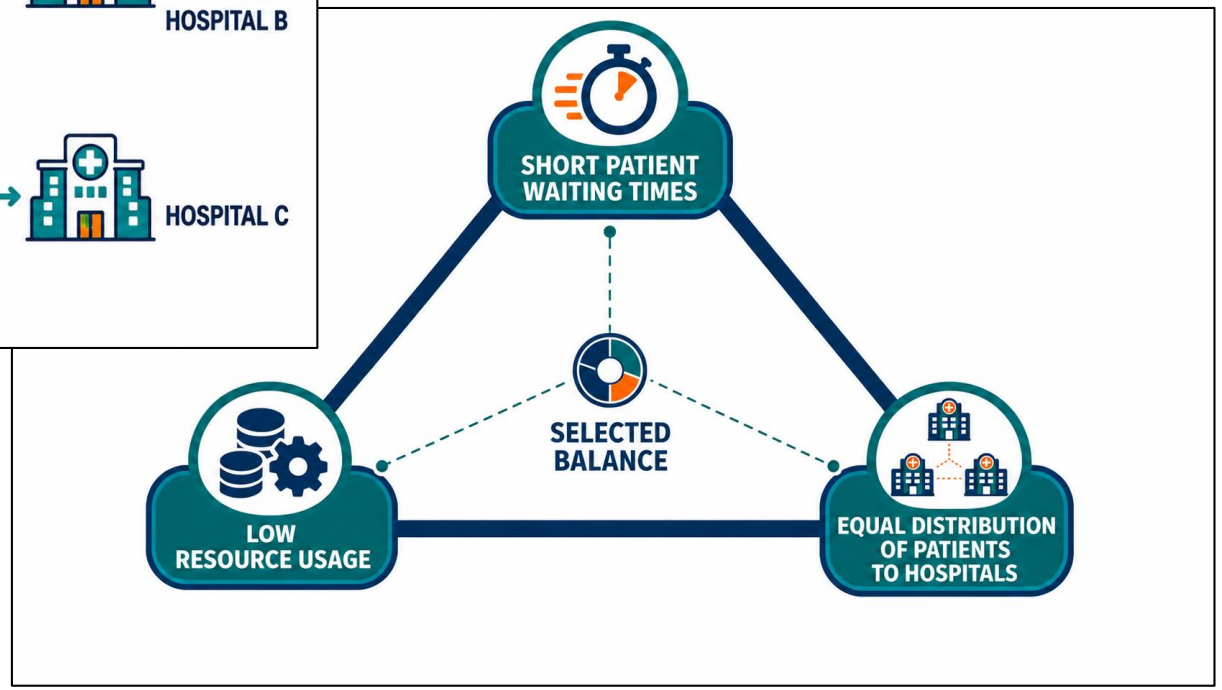
Transport modes

Carrying capacity

Vehicle & vessel availability

National transport





Data-agnostic simulation architecture

Open model, controlled data

- Public data supports transparent model development and validation.
- Authorized restricted data enables context-specific operational decision support.
- The simulation logic remains separate from the data supplied to it.

A patients path to treatment: Generation

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	ID	Name	Type	IsInjury	P	D	C	ICU Stretcher	Litter Kit	Seat	HC Time in Days	NC Time in Days	Requires Assistance	Treatment Requirement
2	1	Injury Pattern 1	T1	yes	1	1	3	yes	no	no	5	22	yes	
3	2	Injury Pattern 2	T1	yes	1	1	3	yes	no	no	4	21	yes	
4	3	Injury Pattern 3	T1	yes	1	1	3	yes	no	no	3	20	yes	
5	4	Injury Pattern 4	T1	yes	3	2	3	yes	yes	no	2	21	yes	
6	5	Injury Pattern 5	T1	yes	1	2	3	yes	no	no	5	20	yes	
7	6	Injury Pattern 6	T1	yes	2	3	3	yes	yes	no	4	18	yes	
8	7	Injury Pattern 7	T1	yes	3	3	3	yes	yes	no	2	17	yes	
9	8	Injury Pattern 8	T1	yes	2	3	3	yes	yes	no	1	16	yes	
10	9	Injury Pattern 9	T1	yes	1	4	3	yes	no	no	21	15	yes	Burn
11	10	Injury Pattern 10	T1	yes	2	4	3	yes	no	no	5	21	yes	
12	11	Injury Pattern 11	T1	yes	2	4	3	yes	no	no	6	21	yes	
13	12	Injury Pattern 12	T1	yes	2	4	3	yes	no	no	7	21	yes	
14	13	Injury Pattern 13	T1	yes	2	4	3	yes	no	no	5	21	yes	
15	14	Injury Pattern 14	T1	yes	2	4	3	yes	no	no	8	21	yes	
16	15	Injury Pattern 15	T2	yes	2	4	3	yes	no	yes	0	21	no	
17	16	Injury Pattern 16	T2	yes	2	4	3	yes	yes	yes	0	14	no	Eye
18	17	Injury Pattern 17	T2	yes	2	4	3	yes	yes	yes	0	2	no	

*Dummy data for presentation

A patients path to treatment: Generation

Transport requirements | Treatment duration in hospital | Handling requirem. | Treatment requirem.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	ID	Name	Type	IsInjury	P	D	C	ICU Stretcher	Litter Kit	Seat	HC Time in Days	NC Time in Days	Requires Assistance	Treatment Requirement
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9	8	Injury Pattern 8	T1	yes	2	3	3	yes	yes	no	1	16	yes	
10	9	Injury Pattern 9	T1	yes	1	4	3	yes	no	no	21	15	yes	Burn
11	10	Injury Pattern 10	T1	yes	2	4	3	yes	no	no	5	21	yes	
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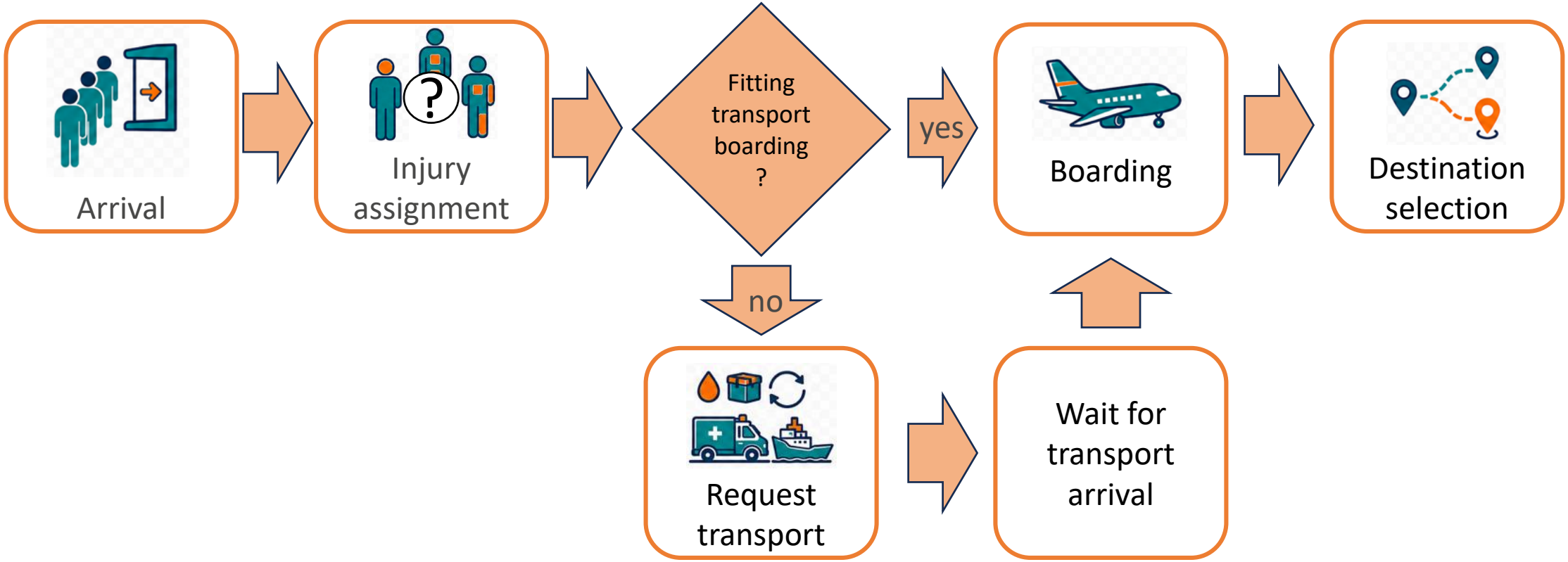
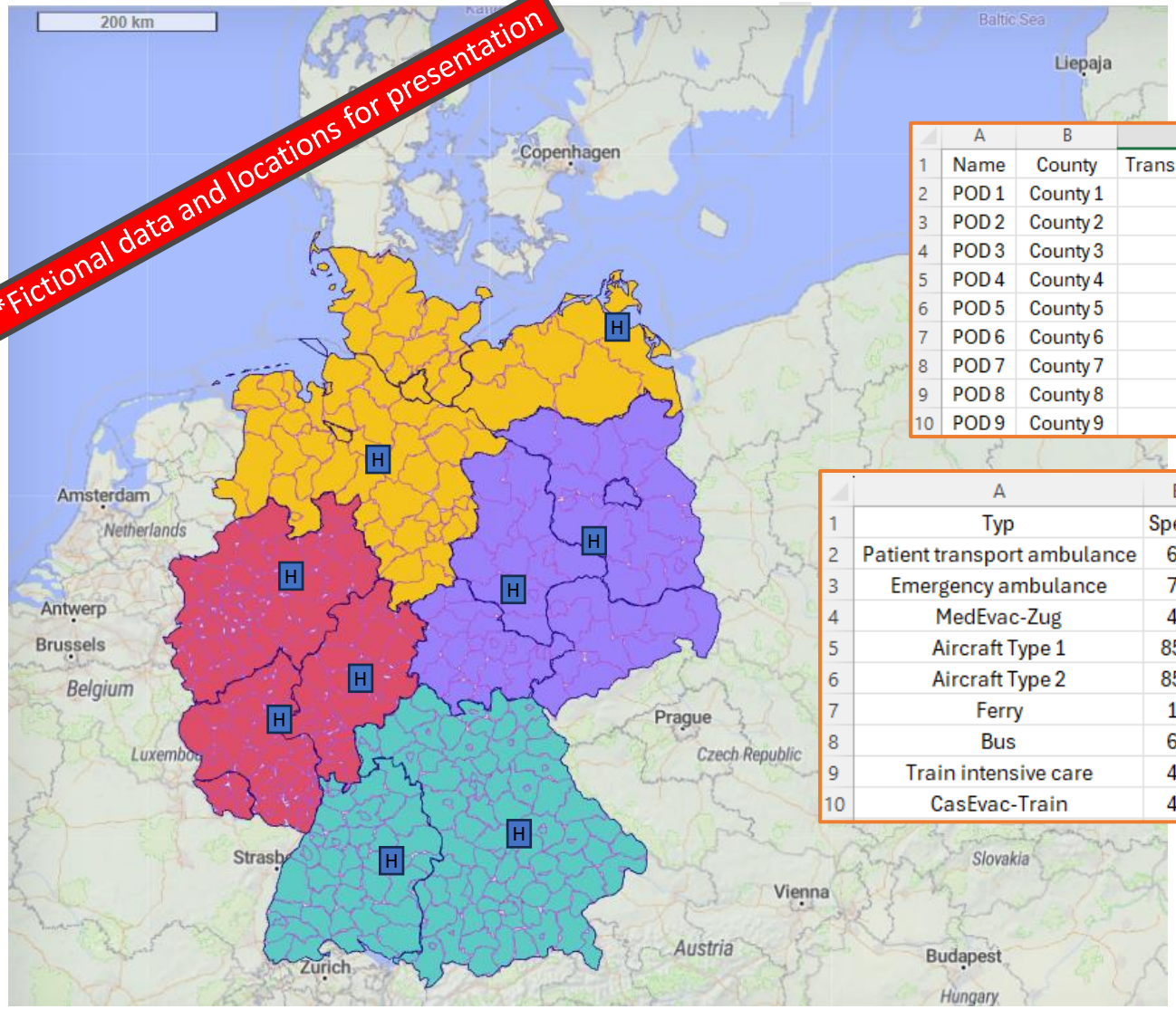
13	12	Injury Pattern 12	T1	yes	2	4	3	yes	no	no	7	21	yes	
14	13	Injury Pattern 13	T1	yes	2	4	3	yes	no	no	5	21	yes	
15	14	Injury Pattern 14	T1	yes	2	4	3	yes	no	no	8	21	yes	
16	15	Injury Pattern 15	T2	yes	2	4	3	yes	no	yes	0	21	no	
17	16	Injury Pattern 16	T2	yes	2	4	3	yes	yes	yes	0	14	no	Eye
18	17	Injury Pattern 17	T2	yes	2	4	3	yes	yes	yes	0	2	no	

*Dummy data for presentation

A patients path to treatment: CSU



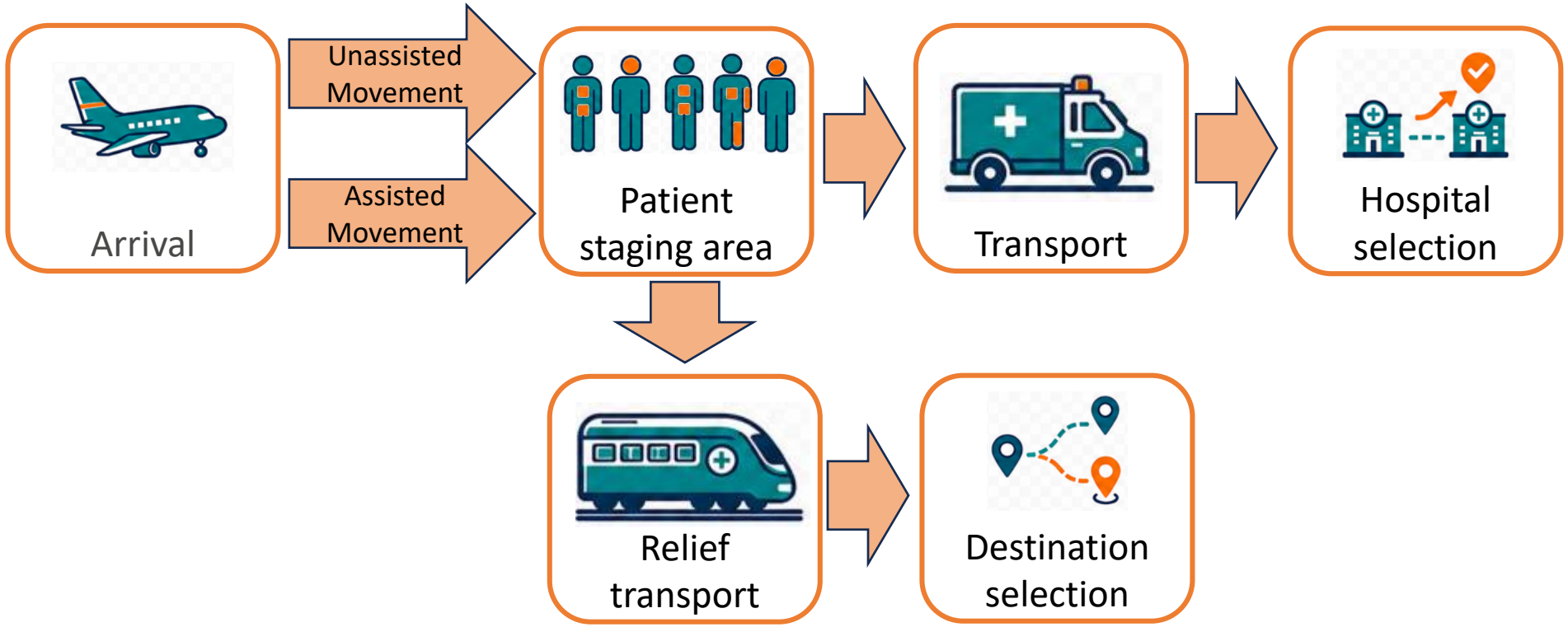
A patients path to treatment: Strategic transport



	A	B	C	D	E	F	G	H
1	Name	County	Transport mode international	Waiting_IC	Waiting_Lying	Carrying teams	Carrying duration	Transport paths
2	POD 1	County 1	Rail	10	50	8	10	8
3	POD 2	County 2	Road	10	50	8	10	8
4	POD 3	County 3	Rail	10	50	8	10	8
5	POD 4	County 4	Air	10	50	8	10	8
6	POD 5	County 5	Air	10	50	8	10	8
7	POD 6	County 6	Rail	10	50	8	10	8
8	POD 7	County 7	Air	10	50	8	10	8
9	POD 8	County 8	Rail	10	50	8	10	8
10	POD 9	County 9	Sea	50	250	8	10	8

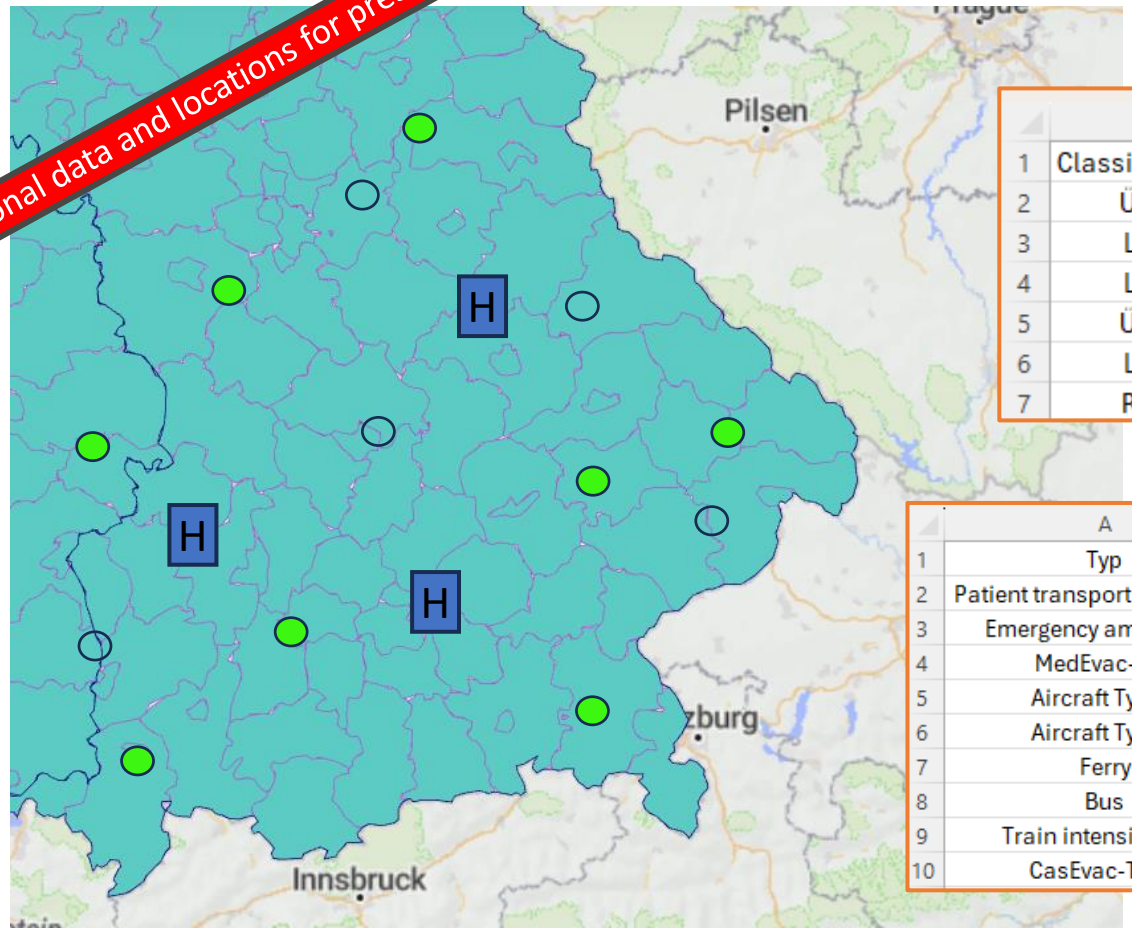
	A	B	C	D	E	F	G	H	I
1	Typ	Speed	Mode	Capa_IC	Cap_Strecher	Capa_Seated	Threshold_total	Threshold_Perfect	Parallel_Loading
2	Patient transport ambulance	60	Road		2				1
3	Emergency ambulance	70	Road	1		1			1
4	MedEvac-Zug	45	Rail	12	90	100	90	90	8
5	Aircraft Type 1	850	Air	8	10	25	18	18	4
6	Aircraft Type 2	850	Air	4	12	25	18	18	4
7	Ferry	15	Sea	40	90	300	240	240	10
8	Bus	60	Road			6	3	3	2
9	Train intensive care	45	Rail	45	0	0	25	25	8
10	CasEvac-Train	45	Rail	0	0	500	225	225	8

A patients path to treatment: POD



A patients path to treatment: National transport

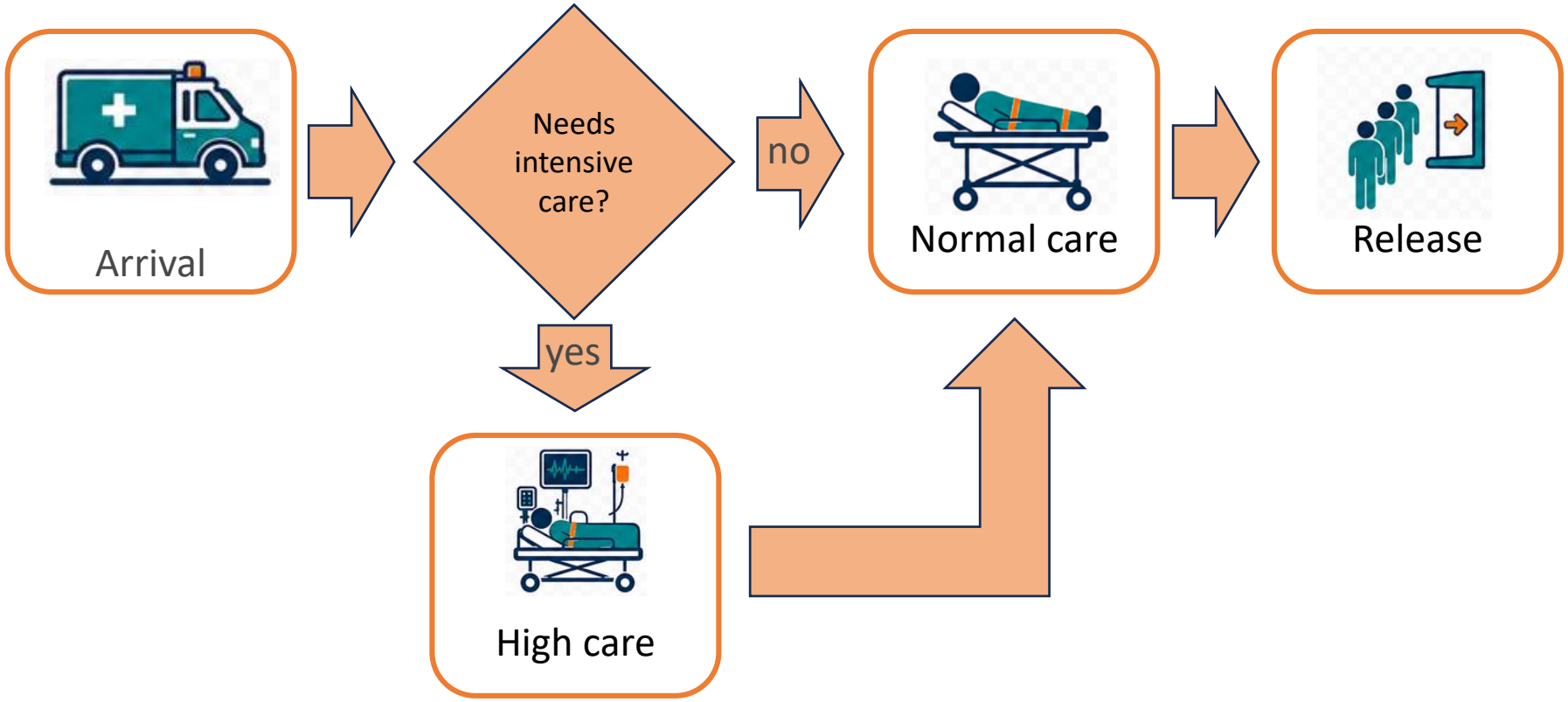
*Fictional data and locations for presentation



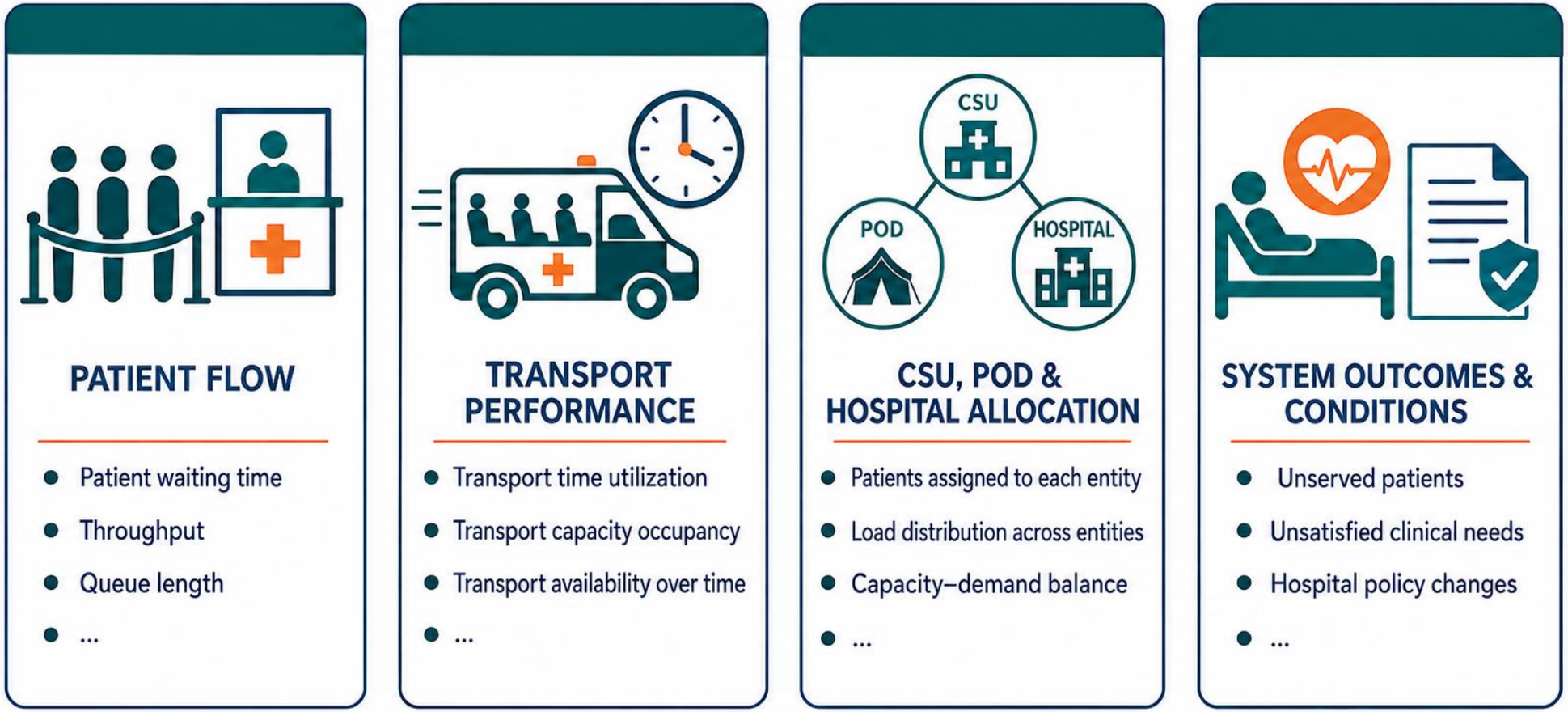
	A	B	C	D	E	F
1	Classification	Name	Beds_total	Relevant_Count_NC	Relevant_Count_HC	Capabilities
2	ÜTZ	Hospital 1	473	345	24	
3	LTZ	Hospital 2	356	153	20	Eye
4	LTZ	Hospital 3	220	167	17	
5	ÜTZ	Hospital 4	1354	592	67	Eye
6	LTZ	Hospital 5	234	167	21	
7	RTZ	Hospital 6	268	188	10	Burn

	A	B	C	D	E	F	G	H	I
1	Typ	Speed	Mode	Capa_IC	Cap_Strecher	Capa_Seated	Threshold_total	Threshold_Perfect	Parallel_Loading
2	Patient transport ambulance	60	Road		2				1
3	Emergency ambulance	70	Road	1		1			1
4	MedEvac-Zug	45	Rail	12	90	100	90	90	8
5	Aircraft Type 1	850	Air	8	10	25	18	18	4
6	Aircraft Type 2	850	Air	4	12	25	18	18	4
7	Ferry	15	Sea	40	90	300	240	240	10
8	Bus	60	Road			6	3	3	2
9	Train intensive care	45	Rail	45	0	0	25	25	8
10	CasEvac-Train	45	Rail	0	0	500	225	225	8

A patients path to treatment: Hospitals



Analysis


PATIENT FLOW
Patient waiting time
Throughput
Queue length
...
TRANSPORT PERFORMANCE
Transport time utilization
Transport capacity occupancy
Transport availability over time
...
CSU
POD
HOSPITAL
CSU, POD & HOSPITAL ALLOCATION
Patients assigned to each entity
Load distribution across entities
Capacity–demand balance
...
SYSTEM OUTCOMES & CONDITIONS
Unserved patients
Unsatisfied clinical needs
Hospital policy changes
...

Simulation turns data into preparedness

Tests fleet adequacy: Is the vehicle and vessel mix sufficient?

Tests patient distributions: Numbers, injury patterns and transport needs

Tests allocation strategies: Allocation of patients across regions and hospitals

Compares algorithms: Assignment, routing and destination selection

Identifies gaps: Capacity shortages, delays and bottlenecks

Adapts to context: Public or authorized operational data

Evidence-based planning before real operations begin.