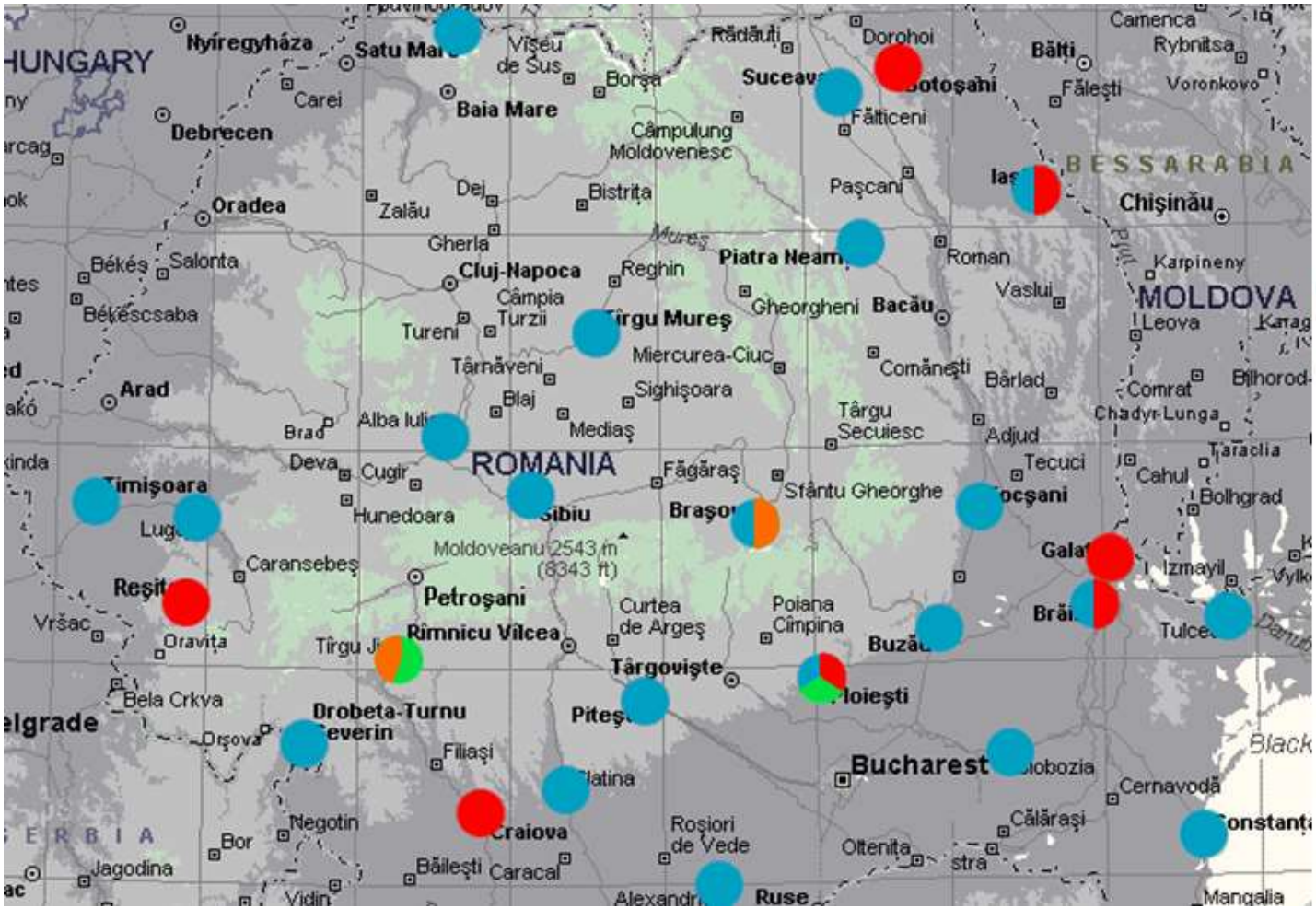
100% electric rolling stock for 26 cities in Romania:

A JASPERS-led 500 MEUR project



Battery electric buses

Trams

Trolleybuses (w/ batteries)

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Context in 2018

- It's mid-programming period (2014-2020) – but thin urban mobility projects pipeline and very limited absorption under Regional OP.
- Urban PT rolling stock (RS) in poor condition in most Romanian cities…
- …very limited experience in rolling stock renewal: was not eligible under Regional OP 2007-2013, plus Reg.1370-compliant PSCs just being rolled out.
- Virtually no experience with battery electric buses – as of 2018 they are operational in just one Romanian city.

JASPERS proposal…

…discussed with the Ministry of Regional Development (MDRAP) in 02/2018 and then agreed with COM during 03/2018 COM-MA ROP-JASPERS tripartite.

- Common procurement project (MDRAP to lead and be procuring entity)
- Open to **all** Romanian cities/towns with **already functional urban PT**

  (but cities could pursue – and many did – parallel independent RS projects)
- Only RS renewal on **existing** PT routes *(up to 30% frequency increase allowed)*
- Predefined RS classes:
  - Electric buses: ~18, 12, 10 m
    (Hybrids excluded – ´transition technology´, leapfrogging recommended)
  - Trams: ~30, 25, 18 m.
  - Trolleybuses: ~18, 12 m
    (including with battery autonomy if needed – i.e. for existing bus routes partly under trolleybus catenary, for cities with operational trolleybus systems)

Cities self assessment

Based on 3 JASPERS-prepared Questionnaires:

- Q1: Expression of interest (03/2018)
- Q2: Needs assessment (04…06/2018) – based on JASPERS-designed Excel tool, generating number of vehicles needed for each route
- Q3: ITS and other particular specifications

		Valori indicate în foaia de lucru "Ruta x" (trebuie să fie non-zero):	Valoare calculată conform datelor introduse în chenarele verzi de mai jos:
	2.6.5. Oferta de transport (în m^2/oră*sens) estimată a fi necesar a fi oferită în condițiile estimării noi pentru cerere	225	280.5
	2.6.7. Durata estimată a cursei (tur+retur, inclusiv timpi morți aferenți capetelor de rută / regularizării) în minute	65	

Introduceți combinații de valori în chenarele verzi (în cadrul unei singure clase: Tv sau Tb sau AbE) astfel încât valoarea din chenarul E4 să fie aproximativ egală cu valoarea din				
Vehicule / plecări pe oră la ora de vârf	Tip de vehicul	Lungime (m)	Lățime (m)	Necesar vehicule în traseu la ora de vârf:
	Tramvai din gama 30 - 32,5 m	30	2.4	(lipsă date)
	Tramvai din gama 23 - 25 m	23	2.4	(lipsă date)
	Tramvai din gama 17 - 19 m	17	2.4	(lipsă date)
	Troleibuz articulat de cca. 18 m	17	2.55	(lipsă date)
	Troleibuz solo de cca. 12 m	11	2.55	(lipsă date)
	Autobuz electric articulat de cca. 18 m	17	2.55	(lipsă date)
10	Autobuz electric solo de cca. 12 m	11	2.55	10.8
	Midibuz electric de cca. 10 m	9.2	2.35	(lipsă date)
	Midibuz electric de cca. 8 m	7.2	2.35	(lipsă date)
		(dimensiuni aferente salonului de călători conform instrucțiunilor de la 2.2.4)		

Timpul între sosiri în stație la ora de vârf (minute):
6.0

Final scope of project

- **26** cities (pop.: 35k…350k), ranging from 1 route to virtually full renewal
- New RS for **122** urban PT routes
- **558** zero emissions vehicles:
  - 397 electric buses + charging stations (slow and fast)
  - 95 trams, of which 13 bidirectional trams for Resita
  - 66 trolleybuses, of which 36 with traction batteries.

City	Route	Tv30	Tv25	Tv18	Tb18	Tb12	AbE18S	AbE12S	AbE12D	AbE10S	AbE10D	CODE
Alba Iulia	103							6				AIL103
Alba Iulia	104							7				AIL104
Alexandria	1A									3		ALX1A
Alexandria	1B									3		ALX1B
Alexandria	2									1		ALX2
Alexandria	3A									1		ALX3A
Alexandria	3B									2		ALX3B
Botoșani	101			5								BOT101
Botoșani	102			4								BOT102
Brăila	2									11		BRL2
Brăila	21			10								BRL21
Brașov	1				6							BRV1
Brașov	2				3							BRV2
Brașov	31				7							BRV31
Brașov	6				10							BRV6
Brașov	4								4			BRV4
Brașov	5						12					BRV5
Brașov	16								4			BRV16
Buzău	10							9				BUZ10
Constanta	100							12				CON100

JASPERS also assisted with:

- Preparation of an electric bus charging strategy (07/2018), e.g. extract:

C. The power of fast charging stations

18. A fast charging station (SR) allows significantly increasing the charging percentage of a battery in a relatively short time. Considering the minimum power of a SR as being 200 kW, for a given number of minutes, considering a charging yield of 95%, we can compute the number of kWh charged as a function of the power of the SR and the time the bus spends coupled to it as being:

Energy (kWh) charged with a yield of 95% [E = 0.95 * Power * t(min)/60]												
kW \ minutes	2	3	4	5	6	7	8	9	10	12	15	20
200	6	10	13	16	19	22	25	29	32	38	48	63
250	8	12	16	20	24	28	32	36	40	48	59	79
300	10	14	19	24	29	33	38	43	48	57	71	95
350	11	17	22	28	33	39	44	50	55	67	83	111
400	13	19	25	32	38	44	51	57	63	76	95	127

19. The following table indicates the energy (in numbers) and the needed charging time (in color), for a SR with a power of 300 kW and a yield of 95%, for routes of various lengths, for each of the five combinations AbE/topography:

Needed autonomy (kWh) for a roundtrip of length L km with AbE/topography (kWh/km)				
km \ type AbE/route (kWh/km)	Flat 10m (1.4)	Flat 12m (1.5)	Hilly 10m and flat 18m (1.7)	Hilly 12 m (1.8)
10	14.0	15.0	17.0	18.0
12.5	17.5	18.8	21.3	22.5
15	21.0	22.5	25.5	27.0
17.5	24.5	26.3	29.8	31.5
20	28.0	30.0	34.0	36.0
22.5	31.5	33.8	38.3	40.5
25	35.0	37.5	42.5	45.0

Charging time for a roundtrip (min)	
≤3	
(3,4]	
(4,5]	
(5,6]	
(6,7]	
(7,8]	
(8,9]	
(9,10]	
>10	

20. As such, through the technical specifications, SRs with a power of at least 300 kW will be requested, to ensure a reasonably reduced time spent by the AbE at the fast charging stations.

Example for Pitesti:

Clasă	Rută	#AbE	λ (min)	L (km)	t (min)	n	#SR	AbE/SR
D12	PIT13	9	6.3	14.2	5.4	3	11	3.6
D12	PIT13B	8	7.1	12.2	4.6			
D12	PIT2B	6	10	18.1	6.9	2.2		
D12	PIT3B	4	11.3	13.0	4.9			
D12	PIT7	7	8	14.9	5.6	2.4		
D12	PIT7B	6	9.2	12.7	4.8			

Locație	#AbE	P încărcare lentă (kW)	#SR	P încărcare rapidă (kW)	P total (kW)
Războieni - capăt rute 13 și 13B	-	-	3	900	900
Arpechim - capăt rute 2B și 3B	-	-	2	600	600
Gh. Doja - capăt rute 7 și 7B	-	-	2	600	600
Garaj	40	1600	4	1200	1600

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22. If at the given terminus there are more (n) SR, then the percentage use is:

$$\pi = \frac{t}{n \times \lambda}$$

Continuing with the example above, if at the route terminus there would they would be in use 30% of the time.

23. If there are multiple routes with termini in that place, then the perce be used is the sum of the percentages corresponding to each route, and stations we can derive:

$$\pi = \frac{1}{n}\sum_i \frac{t_i}{\lambda_i}$$

24. Assuming that for operational flexibility we desire that (at peak time) stations) are not occupied for more than 50% of the time (e.g. reflect th arrivals, or the time needed to access/egress the SR), then we can comp stations to service a package of routes with arrival times λ_i and charging (we substitute π = 0,5; INT = the function "INTEGER", i.e. the number

$$n = INT\left(\frac{1}{0{,}5}\sum_i \frac{t_i}{\lambda_i}\right) + 1$$

(Nevertheless, in some cases we could use rounding down, when the su immediately inferior number – in other words ensuring a π a little over 0

25. In addition, the installation of SRs at depot are foreseen, approximat

- Fast charging (≥300 kW, 1/3…4 buses) + slow (≥40 kW, 1/bus) at depot overnight; power@depot = max(P_{fast}, P_{slow})
- Fast charging operable fully from inside driver cabin
- Battery capacity (/mass) restricted to ~3 roundtrips + independent small backup battery

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Further progress

- JASPERS-contracted experts from Technical University in Cluj-Napoca prepared draft specifications for tenders.
- JASPERS prepared a route-by-route analysis to document **impact** of project (to assist MDRAP with financing applications):
  - total estimated CO_2 eq. emissions reduction: **18,472 tons/year**; the majority (85%) due to the change in propulsion (replacing diesel with electric buses), and the rest due to the modal shift;
  - total estimated increase in PT passengers on the 122 routes was computed to be **24.58 Mpax/year**
    *or 6828 new pax/peak hour, or 56 new pax/(route*peak hour).*
- MDRAP then executed tenders – took a long time, 2019-2022.
  - Winning bidders (~ordered by volume):
    Solaris (PL), Pesa (PL), SOR (CZ), BMC, Karsan, Bozankaya (TR), BYD (CN).

The end result

Lessons & future plans

Lessons learned:

- An easy / low risk way to transition from diesel to electric – renewing buses on existing routes with proven demand.
- Technology has evolved: pretty much any urban / metropolitan PT route feasible (but charging strategy and battery capacity should be optimized).
- (As usual) it's the institutional, rather than the technical dimension where greatest complexity arises. Keep procurement simple & allocate enough hr.
- Common procurement can increase market interest / reduce purchase costs particularly for smaller towns (that might need only e.g. 3 smaller buses).

- A new challenge: electrification of interurban / regional road-based PT. JASPERS and 3 regions in Romania working under action 2020 106 RO TRA HOR Zero emissions regional road public transport in Transylvania
- However institutionally much more complex.

Thank you

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More Information

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