



SCALING TRANSPORT SOLUTIONS: A PHASED **TRAM-TRAIN STRATEGY** FOR LOWER-DENSITY AREAS

Enrico Fedeli

TPS Pro Srl, Bologna, Italy | Politecnico di Torino, Italy

Content

01 Introduction

- Tram-train & lower-density challenge

02 Case study: Ascoli Piceno

03 Methodology

- From targets to Scenarios

04 Results

- Why Tram-train?

05 Towards Implementation

- The ladder Strategy

06 Limits, Recommendations, & Further Research

07 Final Remarks

01 Introduction

Tram-Train: What is it?

The tram-train infrastructure seamlessly integrates urban tram networks with regional heavy rail, resolving differences in electrification, signalling, gauge profile, platform height and crashworthiness



Source: Prior, G. (2025)

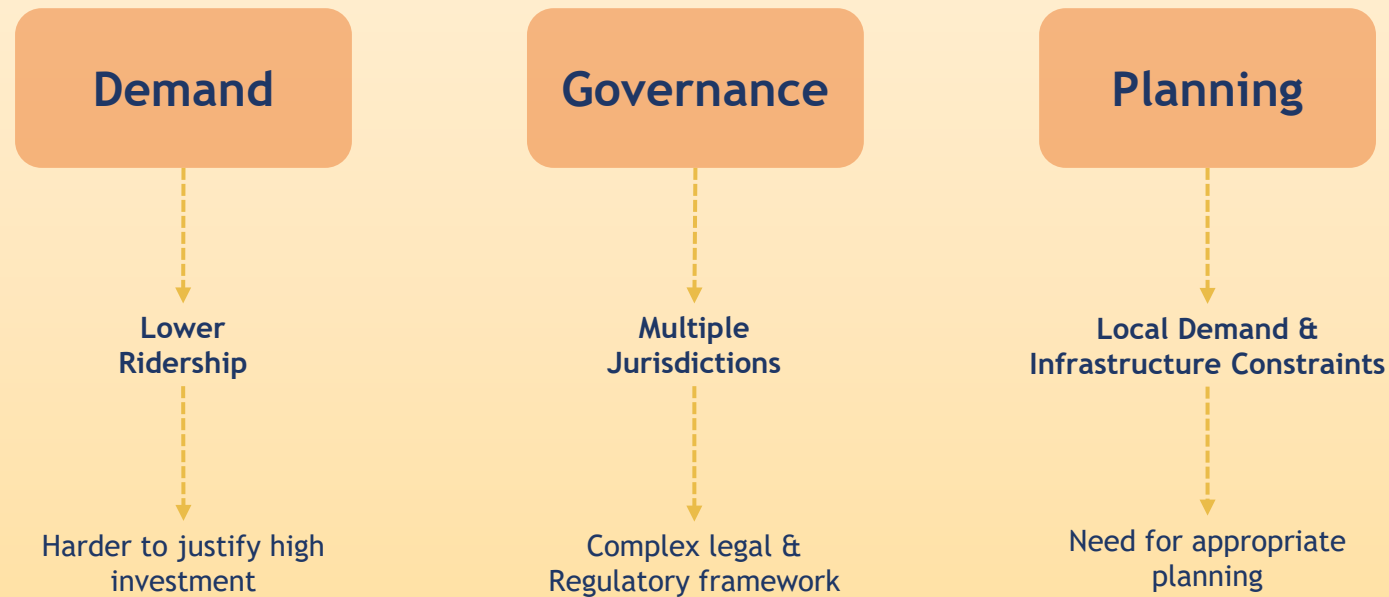


Source: Egloff-Schoenen (2020)

It was initially developed and implemented in the city of Karlsruhe, Germany. Thus the name “Karlsruhe Model”

01 Introduction

Why is Tram-Train difficult to Scale?



Can the benefits be justified in a lower-density context?

01 Introduction

Italian Context

September 2025

The ANSFISA decree defines the tram-train vehicle and establishes two operating regimes applicable to the same vehicle according to the infrastructure it occupies:

1. Tramway: Driving on sight
2. Railway: Signaling protection

2025

2026

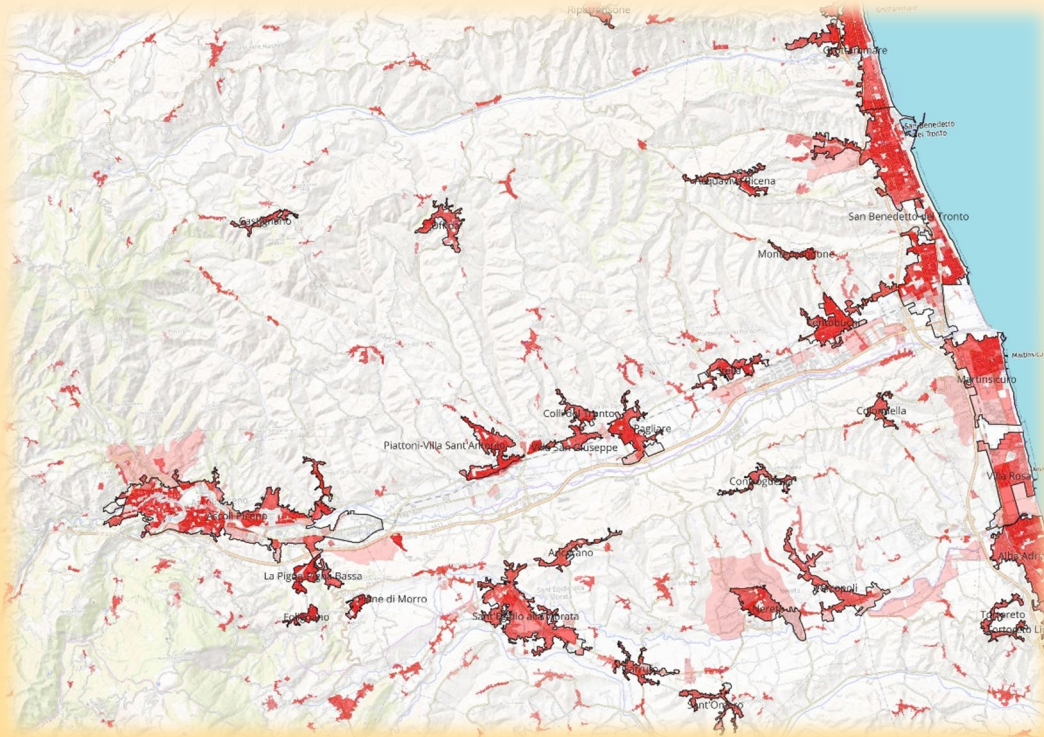
2006-2025

Light rail vehicles on the national railway network fell between the tramway and railway frameworks. Experiments in Cagliari and Sassari practically failed to get to a proper tram-train

02 Case Study: Ascoli Piceno

Case Study: Ascoli

A small inland city connected to a coastal urban system



45k
Residents

158 km²
Of inland
territory

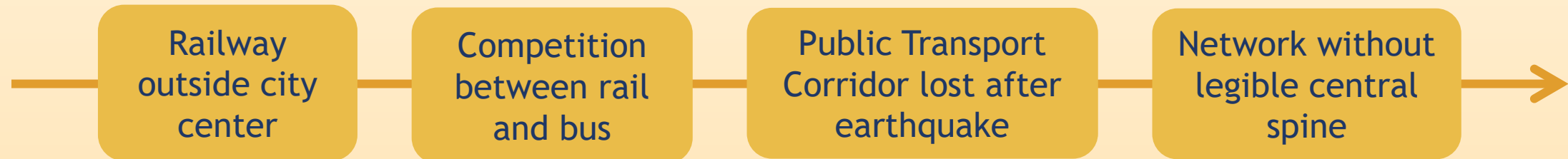
28km
Electrified
railway



Source: Sironi (2025)

02 Case Study: Ascoli Piceno

Why Ascoli?: Four Connectivity Problems



The terminal station is >1km separated from the historic core, imposing exactly the interchange penalty the tram-train concept exists to remove

Source: Google Earth(2026)

02 Case Study: Ascoli Piceno

Why Ascoli?

Italian SUMPs are prepared under a ministerial framework specifying macro-objectives and indicators. Four features of common practice are relevant, and each is what the **Ascoli plan** departed from

Aspect	Common Italian SUMP practice	Ascoli SUMP what is different?
Mobility targets	Targets are generally not used as a strong constraint on scenario construction	Ascoli fixed two quantified targets through backcasting before developing the scenarios, which could later determine which scenarios were admissible
Scenario construction	Scenarios can combine different measures and interventions, making it harder to isolate the effect of a specific transport choice	Ascoli created four nested scenarios containing the same plan actions , while changing the public transport configuration . This made the PT alternatives directly comparable
Road capacity	Road-capacity interventions can remain part of the planning framework	Ascoli proposed no new road capacity anywhere in the plan
Scenario evaluation	Scenario assessment is not necessarily based on a formal combination of target testing, transport modelling and multicriteria analysis	Ascoli combined three methods : transport modelling, backcasting/target compliance, and a BOCR-structured AHP to evaluate the alternatives

03 Methodology

Methodology

01

Participatory Planning
and “Quadro
conoscitivo”

02

Backcasting

03

Scenario
Building

04

No new road
capacity
approach

05

Transport
Model

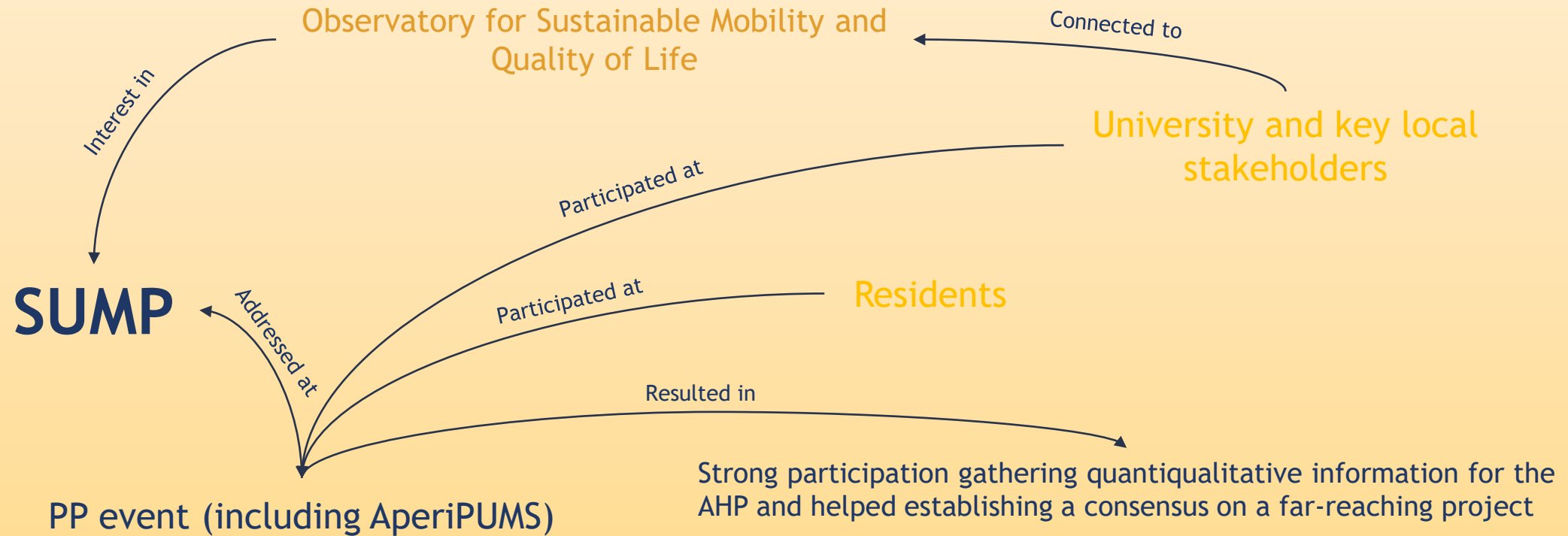
06

Multi-criteria
Analysis

03 Methodology

Participatory Planning

The participatory approach and the analysis of context and existing projects/plans (in Italian 'Quadro conoscitivo'), being a mandatory part of SUMP guidelines, are no novelty for a plan. What has been treated differently are the construction and use of their results



Quadro conoscitivo



03 Methodology

Backcasting

Process Flow

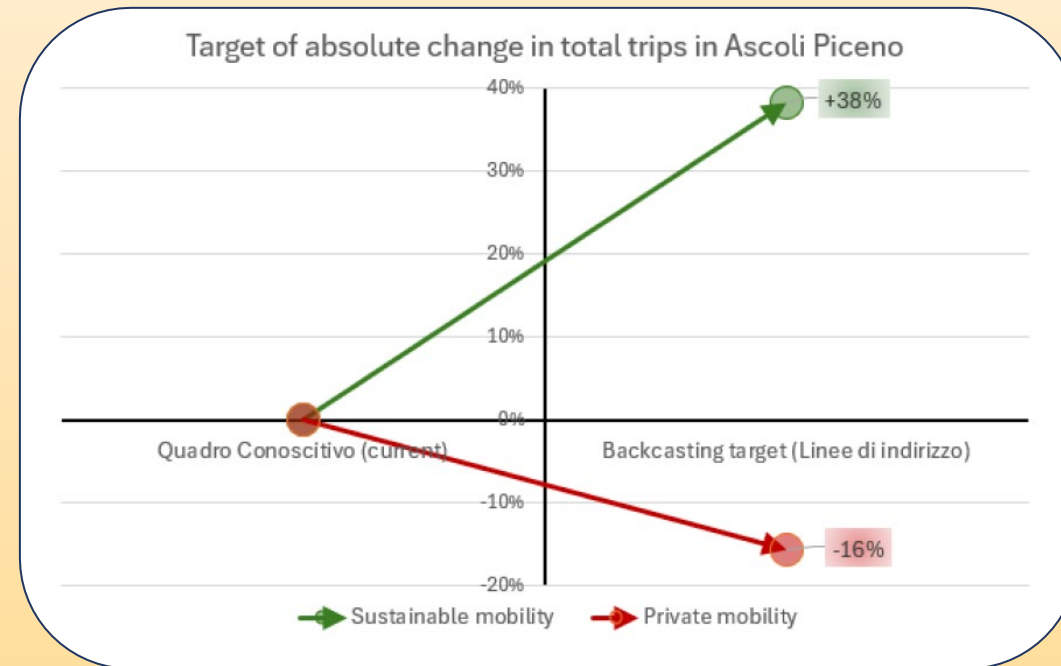
01 Setting Desire outcomes

02 Fixing Targets

03 Exploring Scenarios

04 Admissible?

In this case:



03 Methodology

Scenarios Building

Four Scenarios, **one** controlled comparison

Scenario	A0 → Demand-responsive
Scenario	A1 → Bus-centred
Scenario	B1 → Rail-centred
Scenario	C1 → Tram-train

Where:

A: No intervention in railway development; B: Suburban style railway service development; C: Tram-train development

0: No major intervention in urban public transport; 1: Reestablishment of a trunk corridor for the urban center

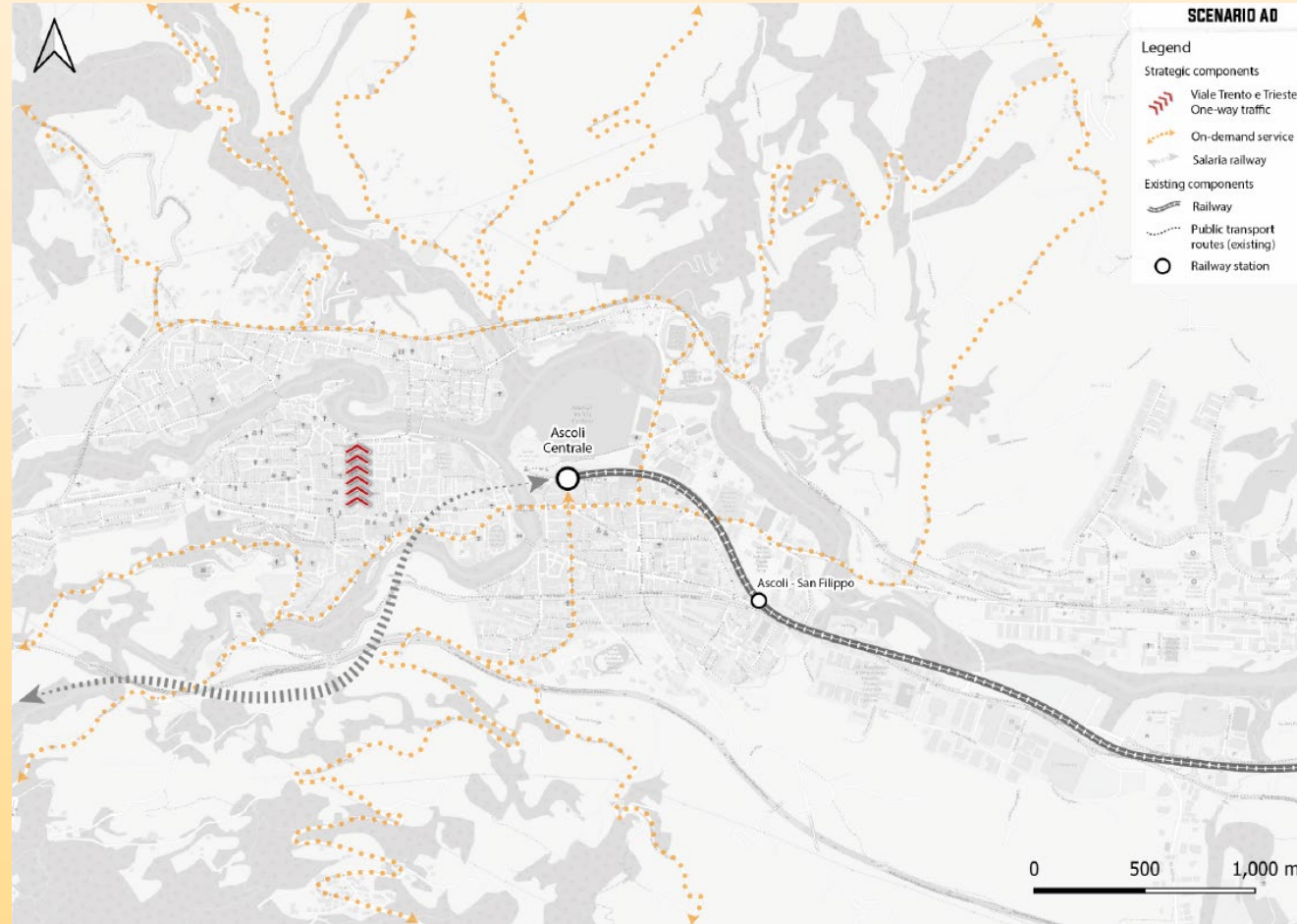
03 Methodology

Scenarios Building

Scenario	Non-PT plan actions	Public transport configuration	New rail infrastructure
Current	none	Current network	none
Reference	Committed only (Biciplan, Salaria railway, Tronto bridge)	Current network	Salaria railway (national connection to Rome)
A0	All	demand-responsive transport in low-density areas; existing rail and bus roles retained; no central pass-through	Salaria railway
A1	All	A0 + restored bidirectional central urban corridor; urban bus network fully redesigned onto a few strong axes	Salaria railway
B1	All	A1 + increased rail frequencies, additional suburban stops, buses progressively converted to feeders	New train stops and loops
C1	All	B1 + tram-train conversion of the suburban service, urban penetration Stazione FS – Porta Romana, bus restructured as local distribution	New train stops, tramway RoW in the city core

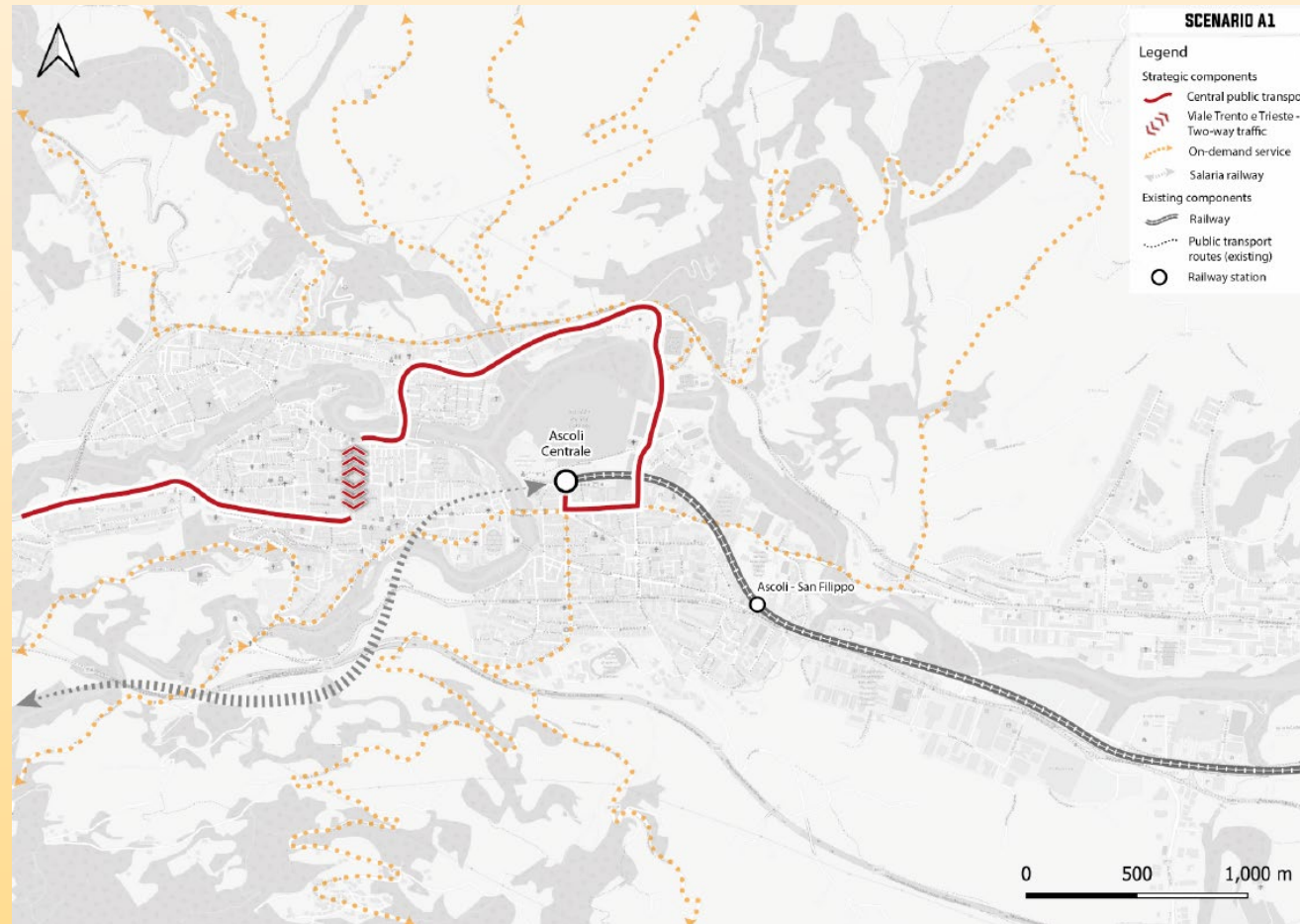
03 Methodology

Scenarios Building: A0

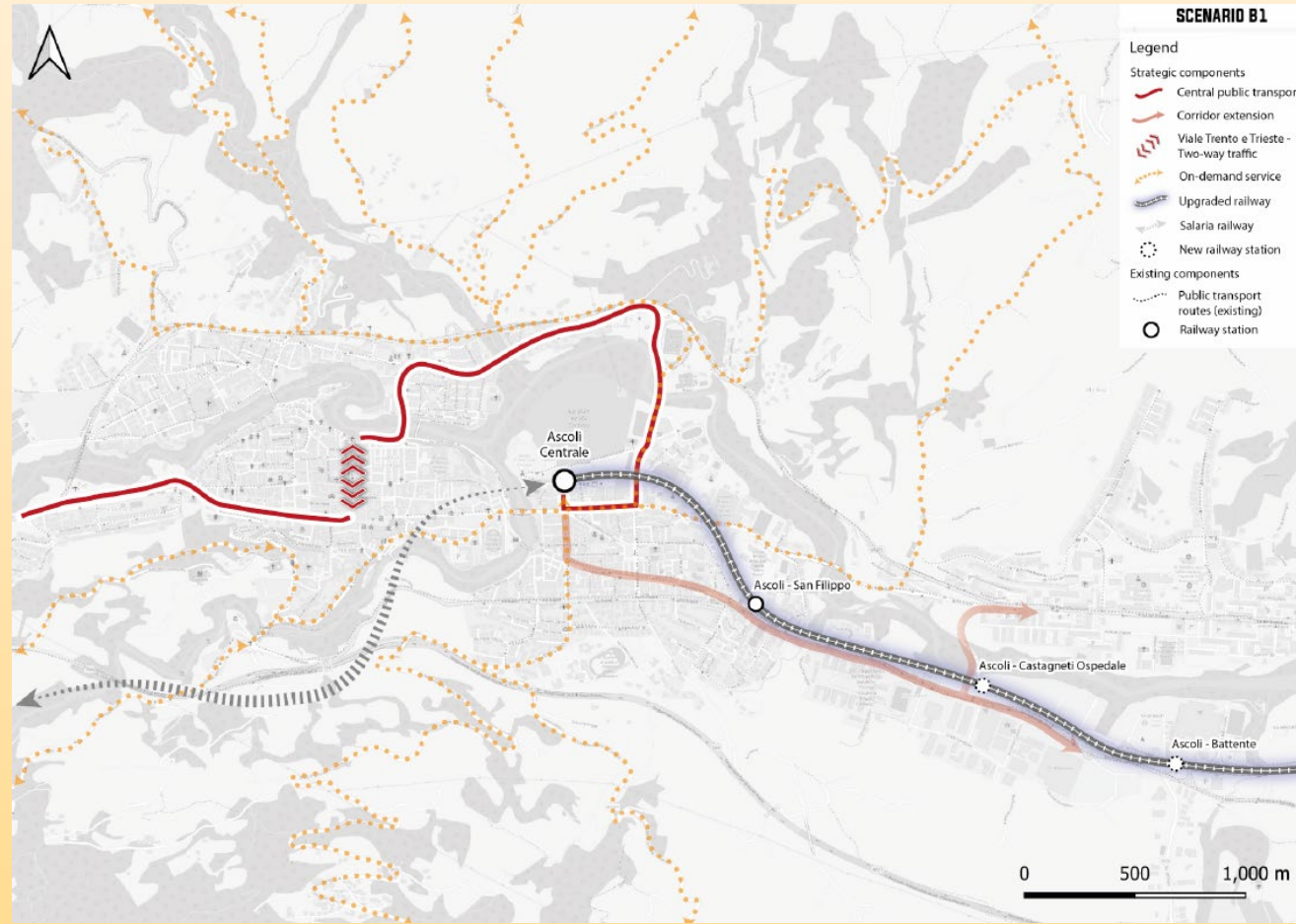


03 Methodology

Scenarios Building: A1

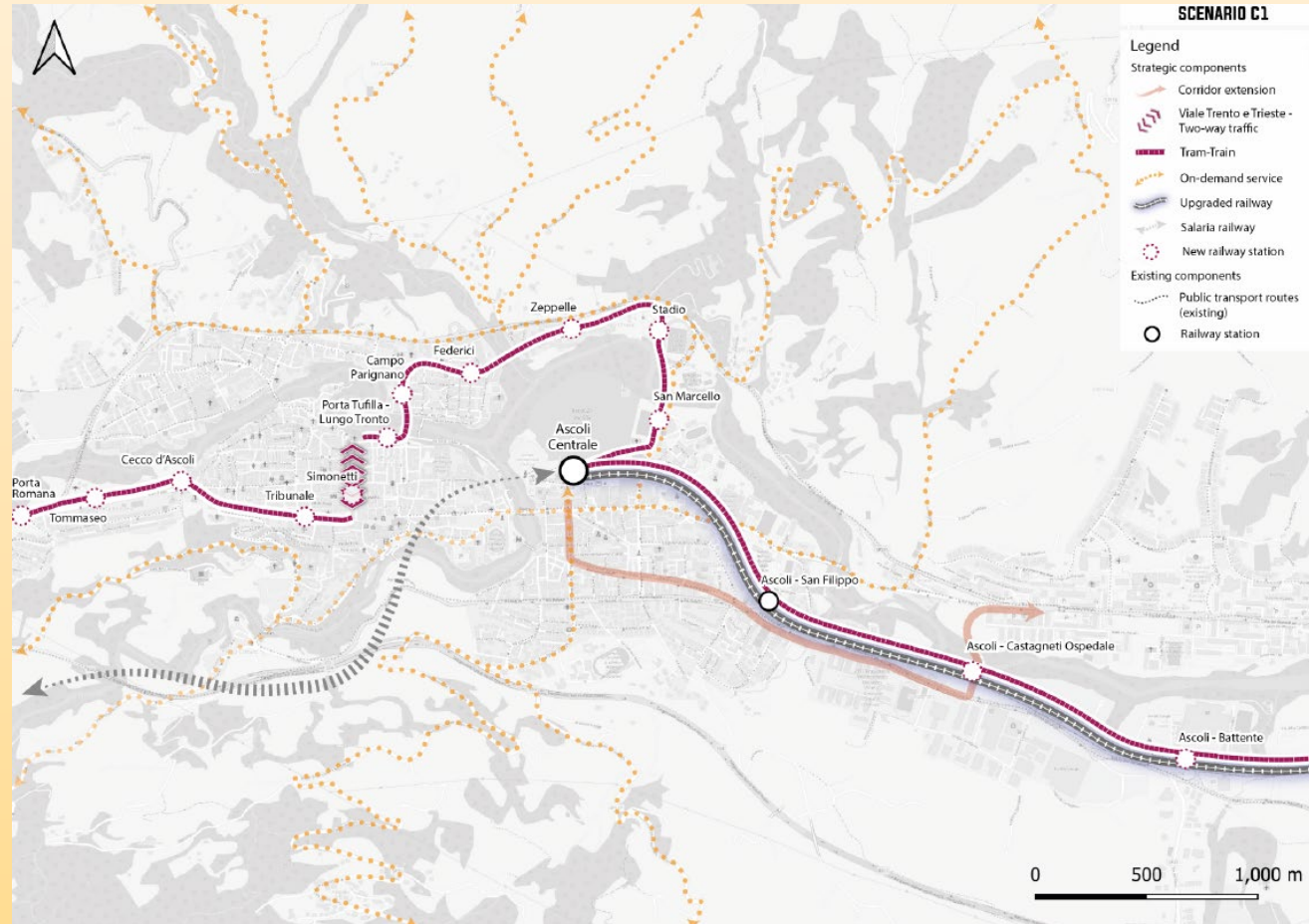


Scenarios Building: B1



03 Methodology

Scenarios Building: C1



03 Methodology

No new road capacity

→ Although unusual, the plan's entire supply-side intervention is: **public transport, cycling and street space reallocation**

→ The car mode share falls in **every scenario** without any offsetting capacity effect to disentangle

The transport model

28,370 links

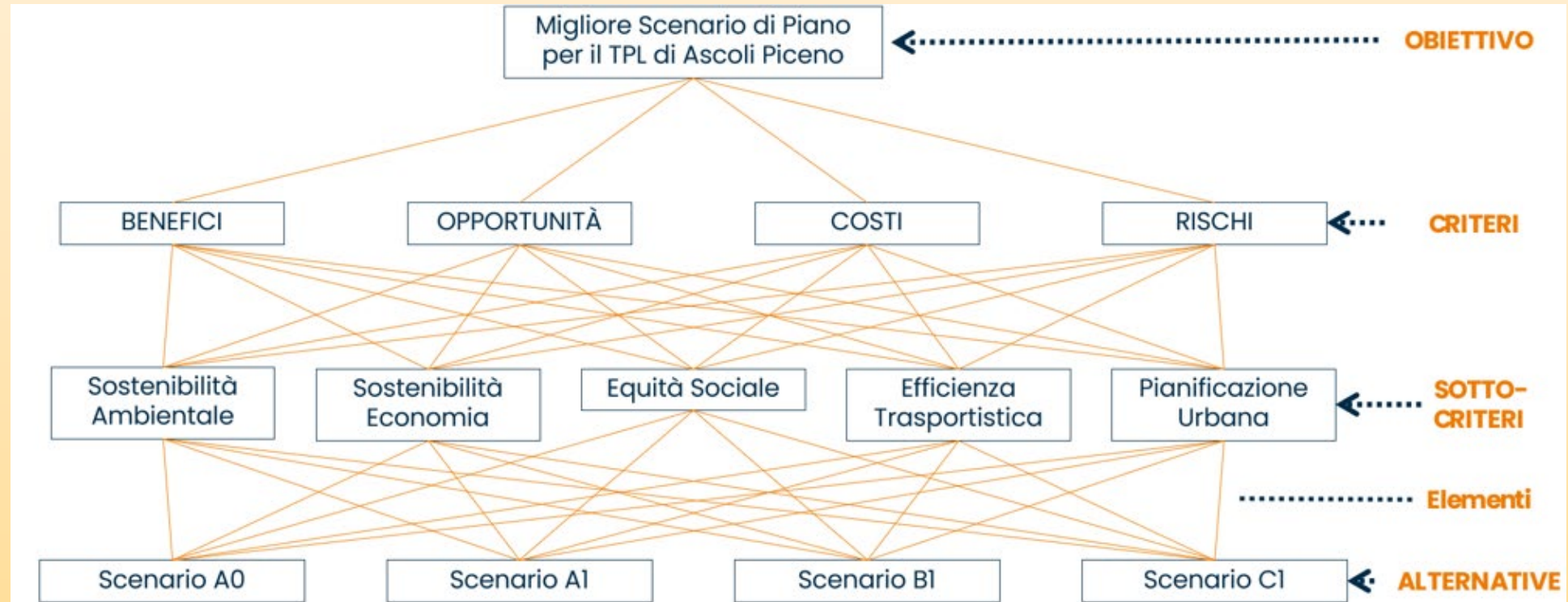
Weekday morning peak

Private demand: FCD

PT demand: ISTAT 2011 commuting matrix

$R^2 = 98\%$ turning movements and 96% screenlines

Multicriteria Analysis



03 Methodology

Multicriteria Analysis

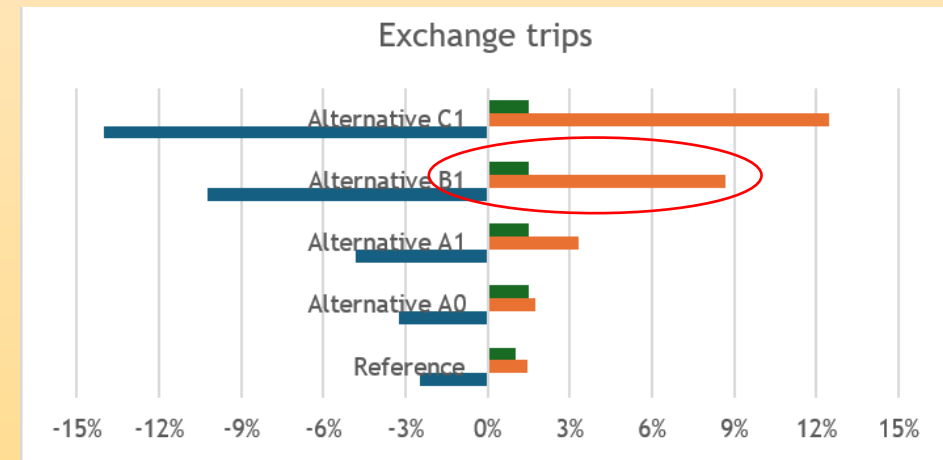
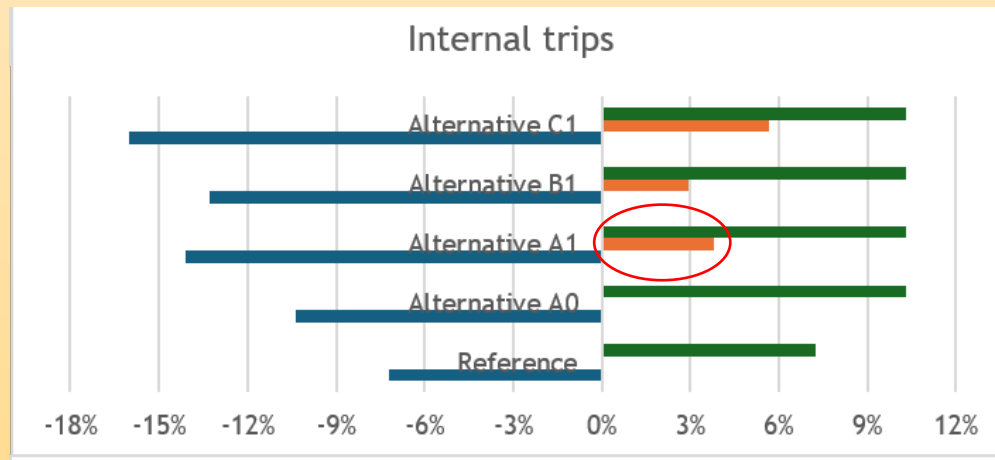
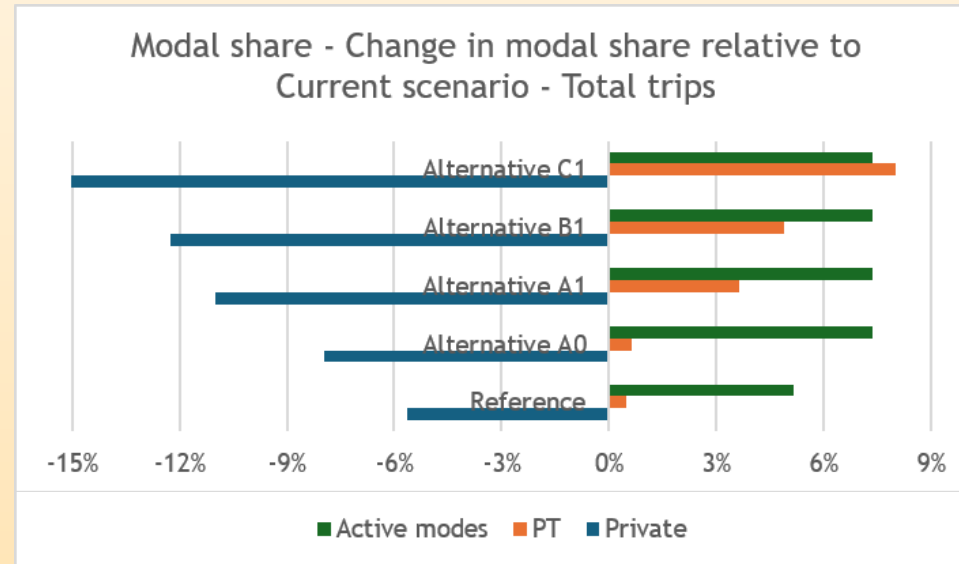
BOCR	Criteria	Elements
Benefits	Environmental	Reduction of greenhouse gas emissions
		Reduction of air pollution
	Economic	Increase in fare / tariff revenue
	Social	Consistency with local expectations
		Territorial equity
	Mobility	Modal split
		Spatial accessibility
		Reliability and regularity
		Travel times
	Urban Planning	Synergy with other urban projects
		Increase in urban resilience
Opportunities	Environmental	Acoustic impact
	Economic	Commercial enhancement of economic activities
		Reduction in road maintenance costs
		Increase in property value
	Social	Territorial equity
		Inclusivity
	Mobility	Road safety
	Urban Planning	Connection between different cities in the province
		Creation of a new urban image
		Improvement of urban quality

Multicriteria Analysis

Costs	Economic	Investment costs
		Financial sustainability
		Operational costs
	Social	Construction times
		Reduction of revenue for local commerce during construction
	Mobility	Redesign of vehicular space
Risks	Economic	Shortage of national and/or regional funding sources
	Social	Opposition to the project
	Mobility	Substantial changes to traffic circulation schemes
	Urban Planning	Presence of territorial / regulatory constraints

04 Results

Results



04 Results

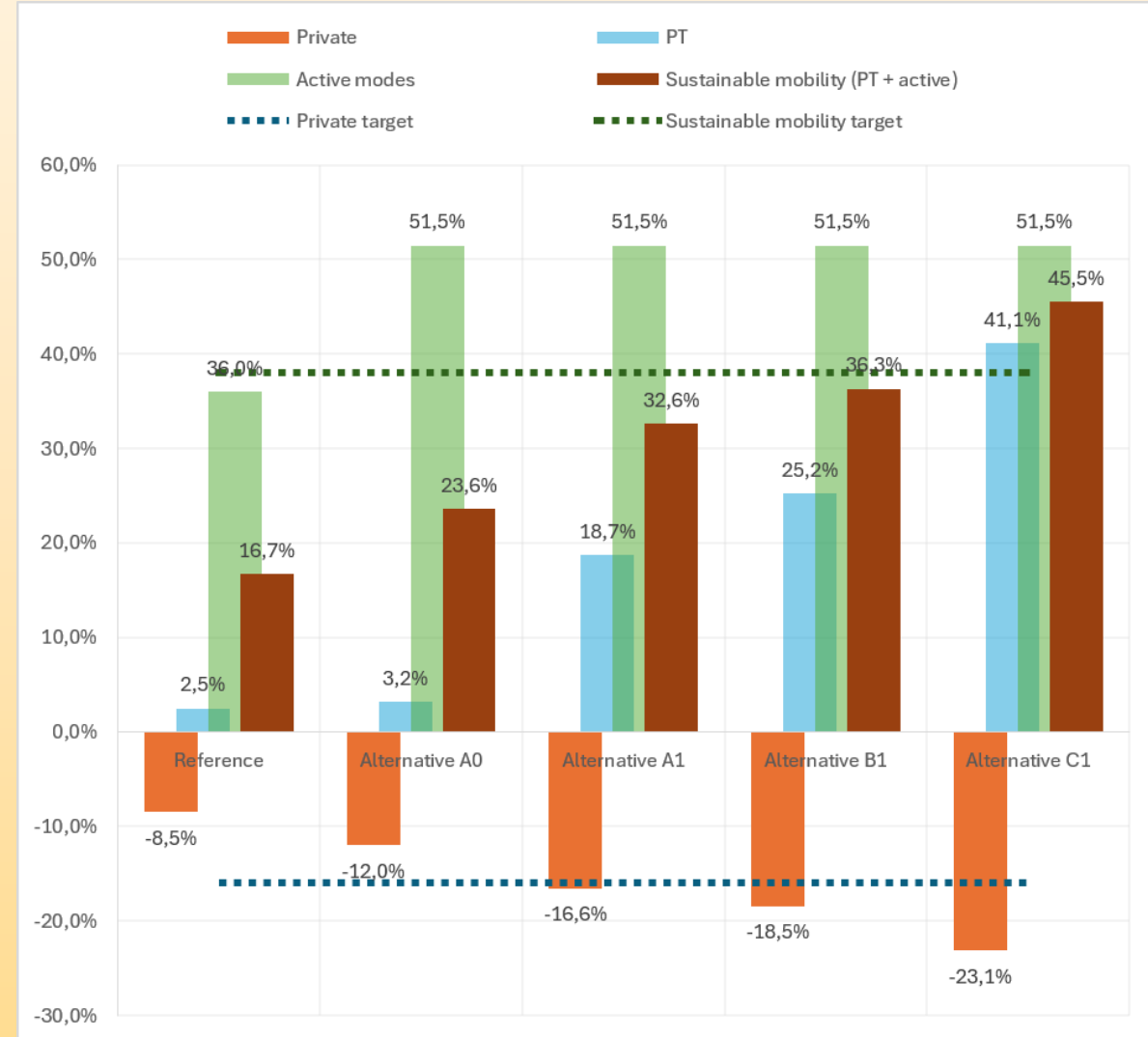
Results: Final results of AHP

					FINAL WEIGHT	RANKING	FINAL WEIGHT	RANKING	FINAL WEIGHT	RANKING	
RESULTS	B	O	C	R	$B \cdot O \cdot 1 / C \cdot 1 / R$		$B + O - C - R$		$B^{1/2} \cdot C^{-1/2} \cdot O^{1/2} \cdot R^{-1/2}$		MEDIAN RANKING
A0	0,18	0,09	0,15	0,10	1,13	4	0,02	4	1,06	4	4
A1	0,27	0,09	0,13	0,09	2,09	2	0,14	3	1,45	2	2,33
B1	0,46	0,14	0,27	0,12	1,89	3	0,20	2	1,37	3	2,66
C1	0,81	0,19	0,31	0,23	2,21	1	0,47	1	1,49	1	1,00

04 Results

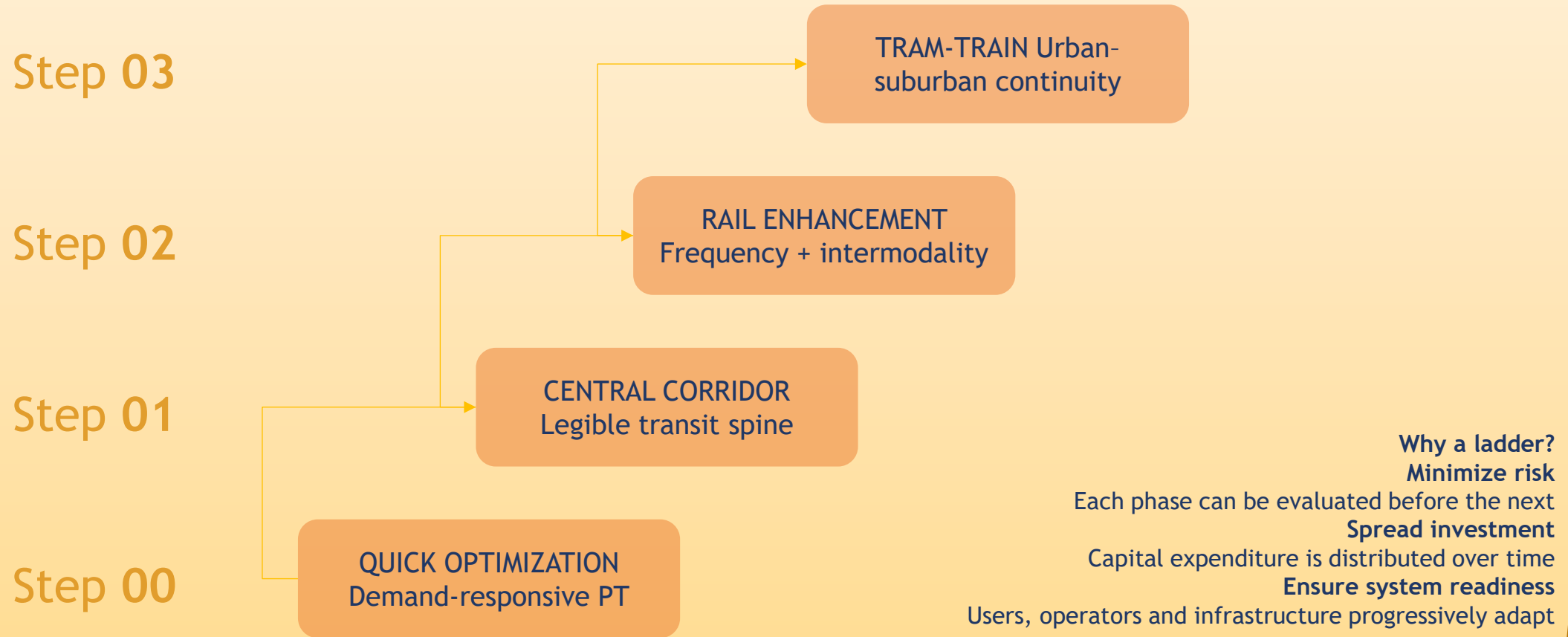
Results

Scenario C1: Not only best score, but also the only scenario able to hit the targets



05 Towards Implementation

Towards Implementation: The ladder strategy



06 Limits, Recommendations, & Further Research

Limitations

ONE CASE

Single case → only one observation

No induced or suppressed demand

FIXED DEMAND

NO COSTING YET

No complete capital or operating cost figures exist for the scenarios

Transferability

WHAT CAN BE TRANSFERRED?

SET TARGETS FIRST

Targets should be fixed before scenarios

ISOLATE THE DECISION

Hold non-relevant interventions constant

TEST EVERY SCENARIO

A target should be checked against every alternative

MATCH THE CORDON TO THE FUNCTION

Municipal boundaries should not obscure supra-municipal effects

Further Research

- Use ISTAT municipal commuting matrices to estimate corridor-relevant trips excluded by the municipal cordon and re-scale the C1 incremental effect
- Check against stress test for AHP and transport model
- Quantify costs (investment and O&M)
- Check the methodology in other low-density contexts

Final Remarks

1

The tram-train was not an advocacy choice

2

It was the only scenario satisfying both quantified targets

3

Its implementation is conceived as a progressive ladder, not a single leap

Thank you!

Find out more on our website



CONTACTS

TPS Pro Srl: Bologna • Perugia • Florence

: www.tpspro.it

: info@tpspro.it

: +39 051 0419112

