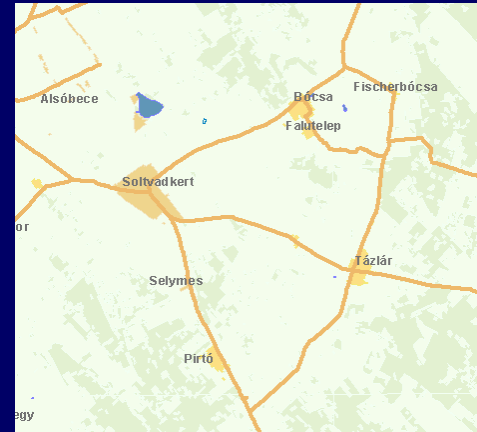
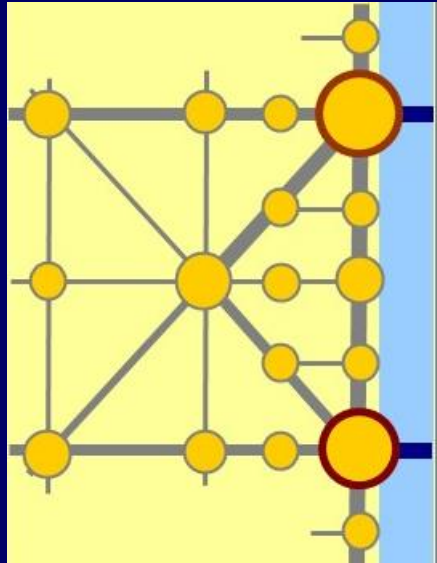


Spatial structure and transport networks



Transport networks 1.
András Gulyás PhD habil
associate professor

Syllabus

1. **Spatial structure and transport networks**
2. **Transport policy, strategies, road network development**
3. **Road network hierarchy, network planning**
4. **Traffic planning of road networks**
5. **Network characteristics, trans-European networks**
6. **Network connections, multimodality**
7. **Public transport networks**
8. **Freight transport, water and air networks**
9. *International railway networks*
10. *High-speed railway networks*
11. *Railway network development*
12. *Urban rail networks*
13. Mid-term test
14. Mid-term test retake

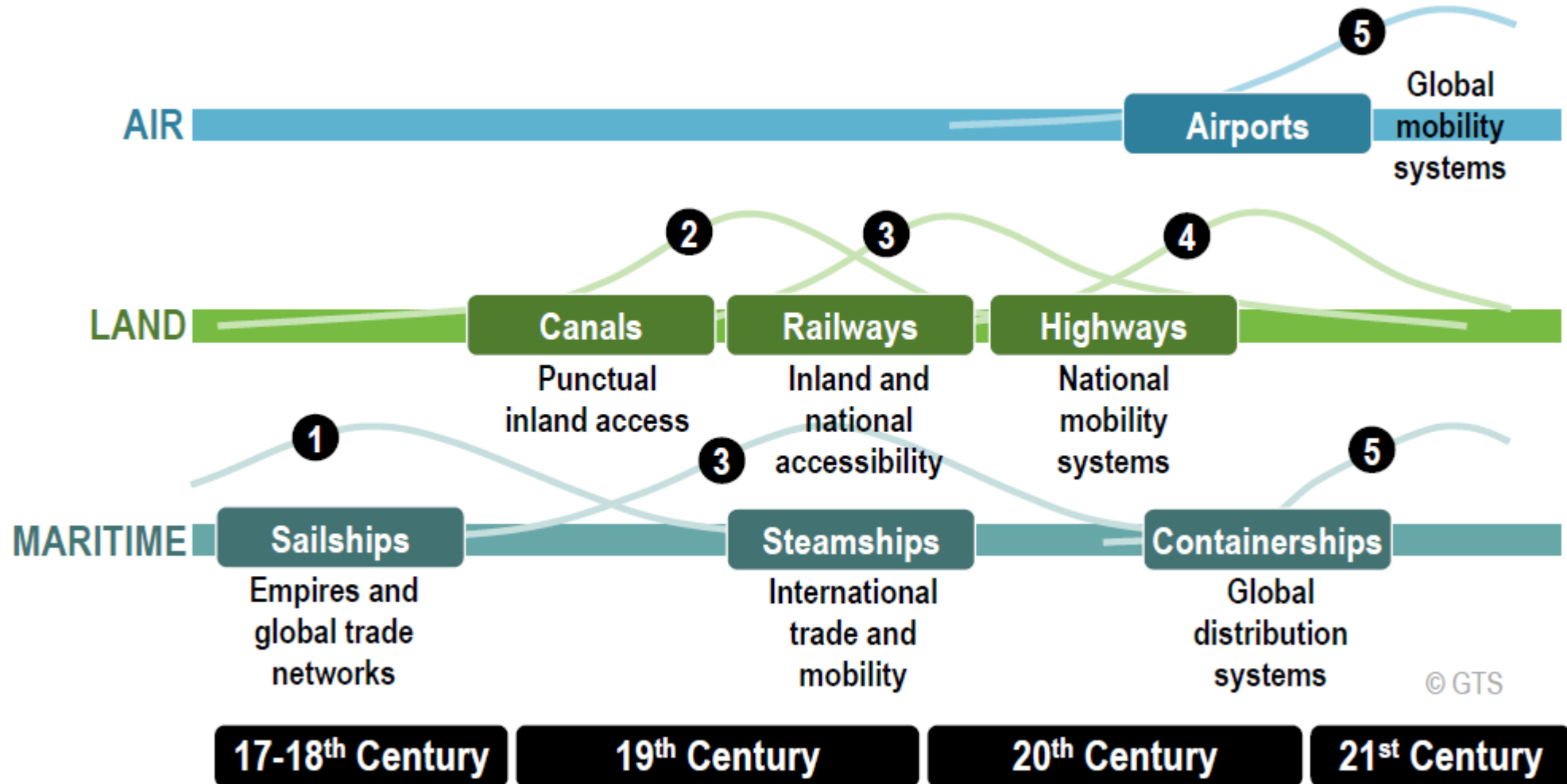
Content

- **Development of transport accessibility**
- **Transport networks and the economy**
- **Spatial structure and infrastructure**
- **Main types of transport networks**
- **Spatial characteristics of transport networks**
- **Settlement structure and transport connections**
- **Internal transport networks of settlements**

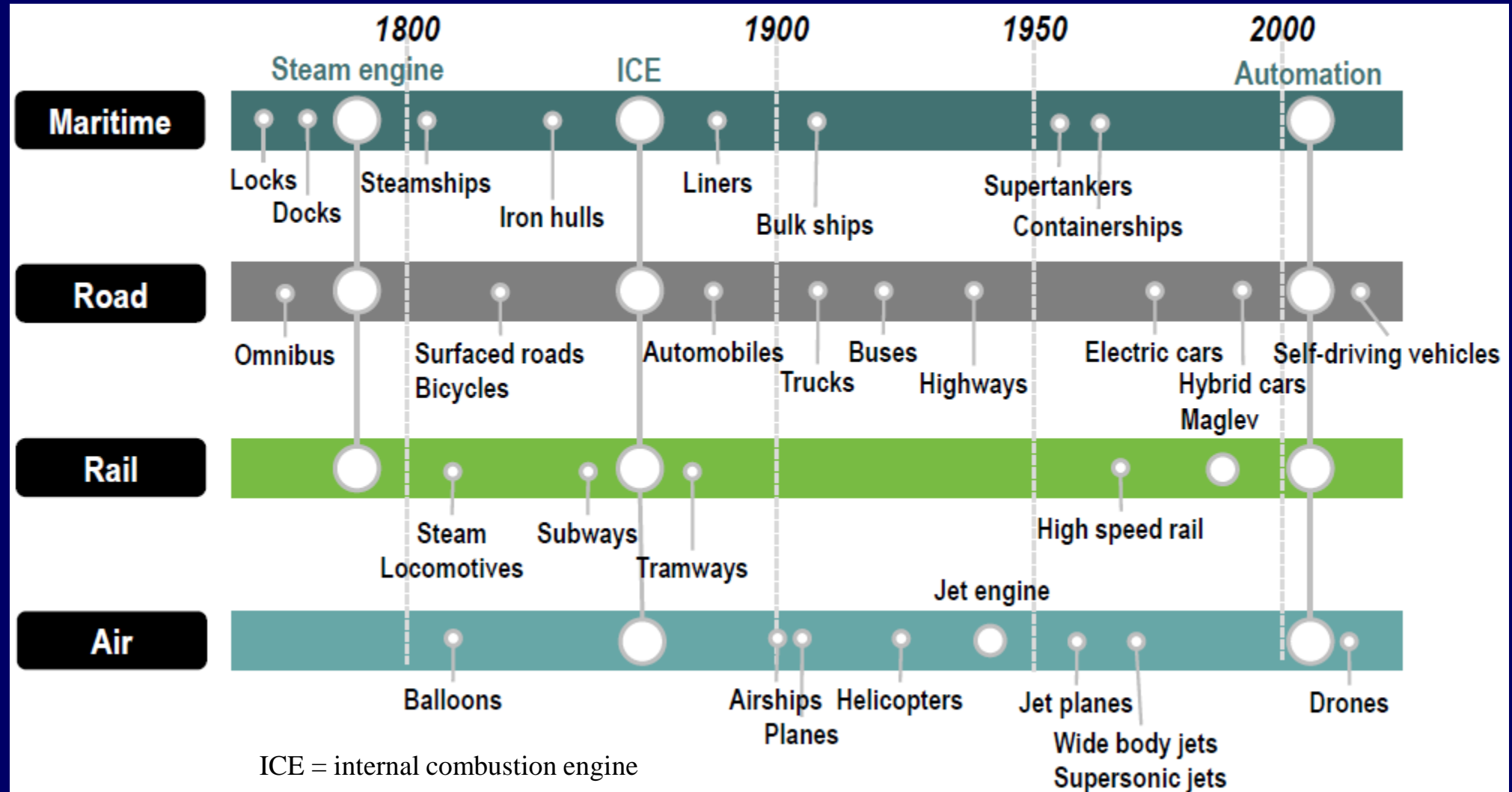
Development of transport accessibility

- **Transport is the movement of goods and persons from place to place and the various means by which such movement is accomplished.**
- **Transport provides accessibility to activities at different places, connecting these places.**
- **In the past transport routes started along rivers and seashores linearly. In the ancient Roman Empire an advanced road network had been developed.**
- **Technological development of infrastructure and vehicles has significantly reduced travel time in the past 200 years.**

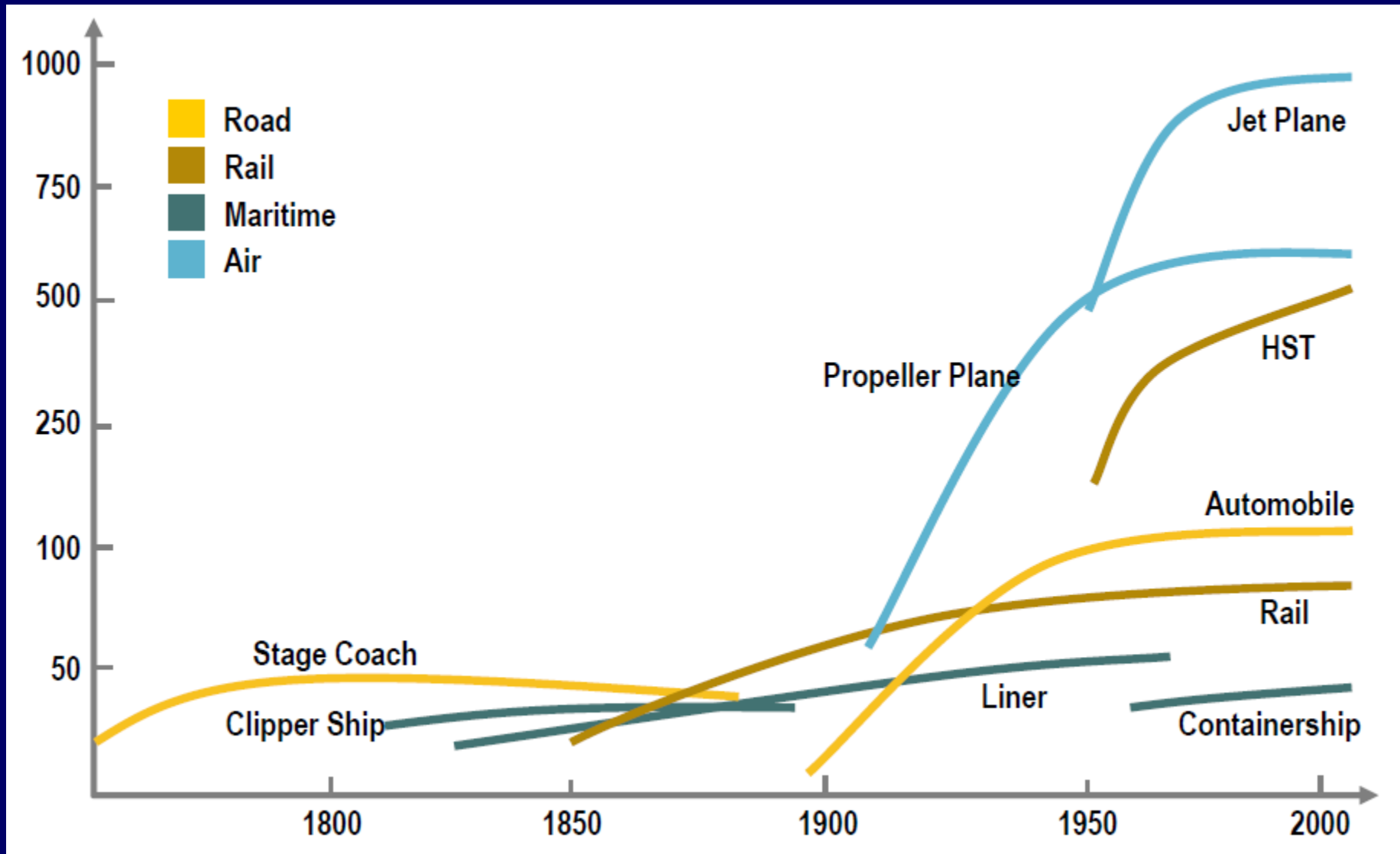
Development of transport accessibility



Development of transport technology



Transport speed development km/h



Transport networks and the economy

- **Density of transport networks and their traffic volume are in strong correlation with economic development. Quality of transport network elements is related to economic development as well, such as high-speed road and railway lines.**
- **Development level of transport network is one of the main prerequisites of any spatial development. Spatial accessibility is nowadays one of the most important conditions of any economic location choice for deployment.**
- **Spatial development requires up-to-date personal and freight transport facilities in all modes of transport.**

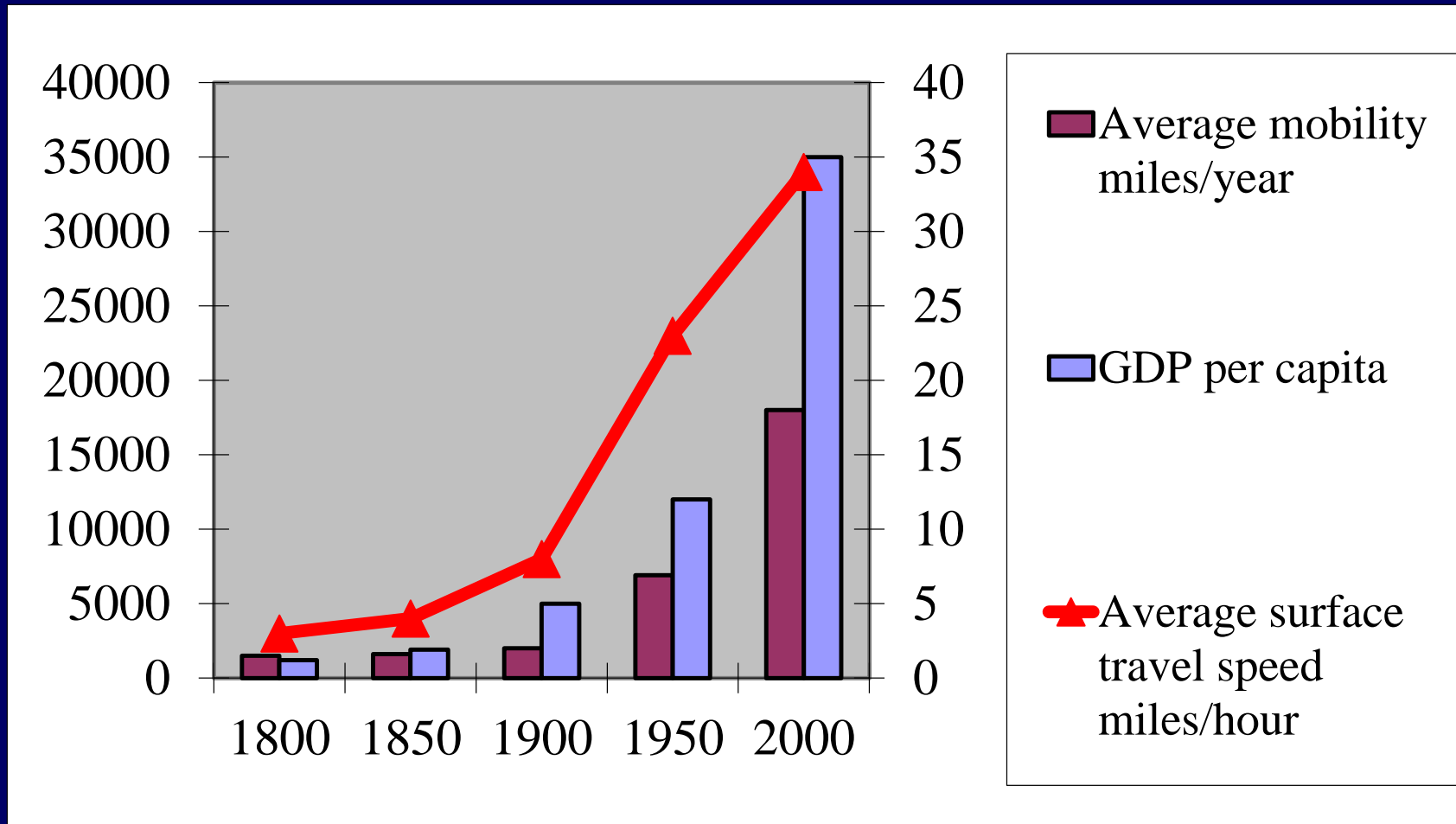
Transport networks and the economy

Development of mobility, USA, 1800-2000

	Average surface travel speed	Average mobility	GDP per capita
1800	3 miles/hour	1,500 miles/year	\$1,200
1850	4 miles/hour	1,600 miles/year	\$1,900
1900	8 miles/hour	2,000 miles/year	\$5,000
1950	23 miles/hour	6,900 miles/year	\$12,000
2000	34 miles/hour	18,000 miles/year	\$35,000

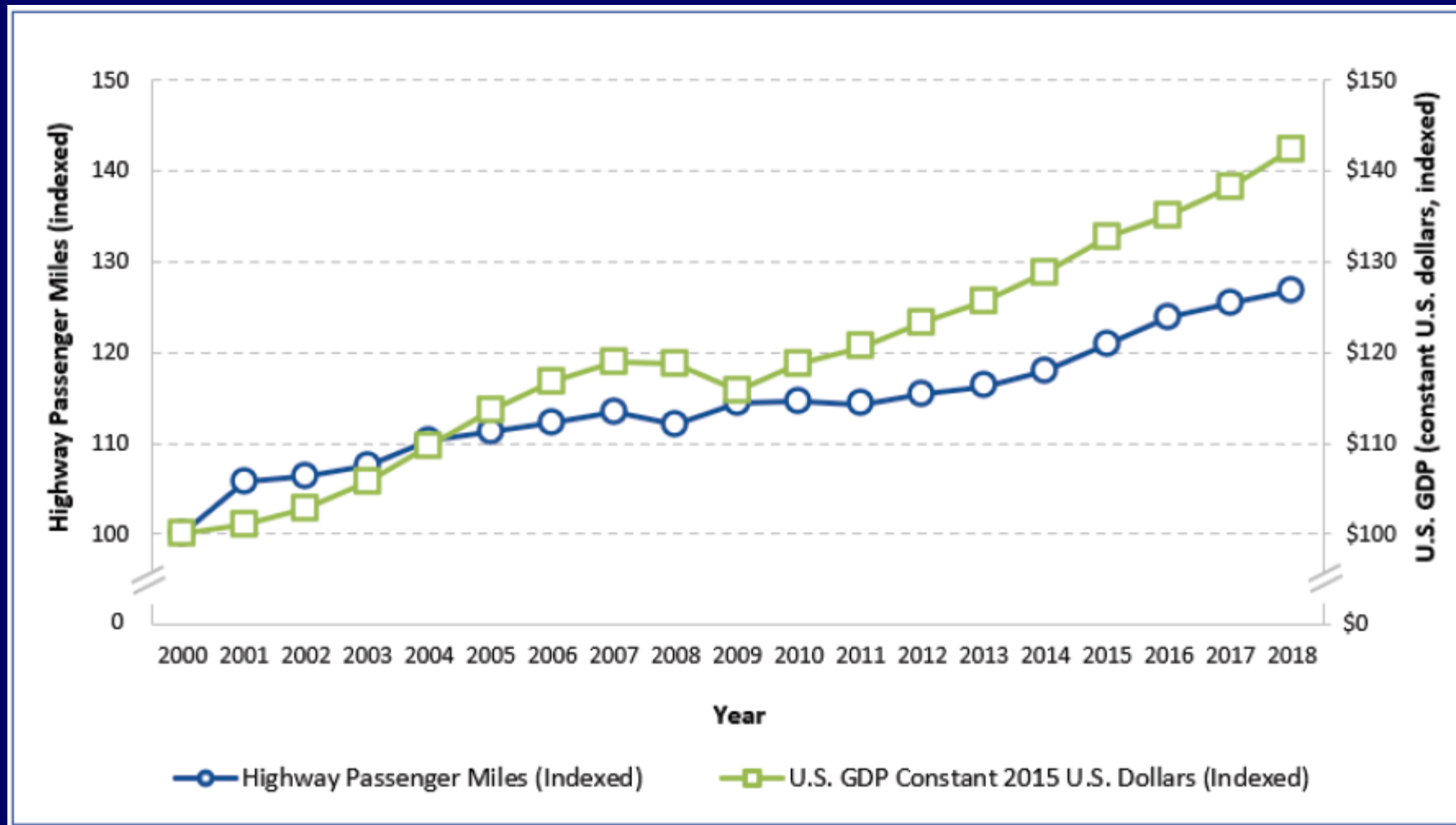
Transport networks and the economy

Development of mobility, USA, 1800-2000



Transport networks and the economy

Trends in GDP and indexed highway passenger miles in the USA (2000–2018)



Transport networks and the economy

- **Existence of motorways is a necessary but not sufficient condition for economic development.**
- **Good accessibility provided by a motorway increases the population retaining ability of the area concerned.**
- **Motorway development decreases unemployment.**
- **Investors are interested in the existence of motorways providing a competition advantage for investments.**
- **A motorway connection is especially important in case of machine industry and processing industry.**

Transport networks and the economy

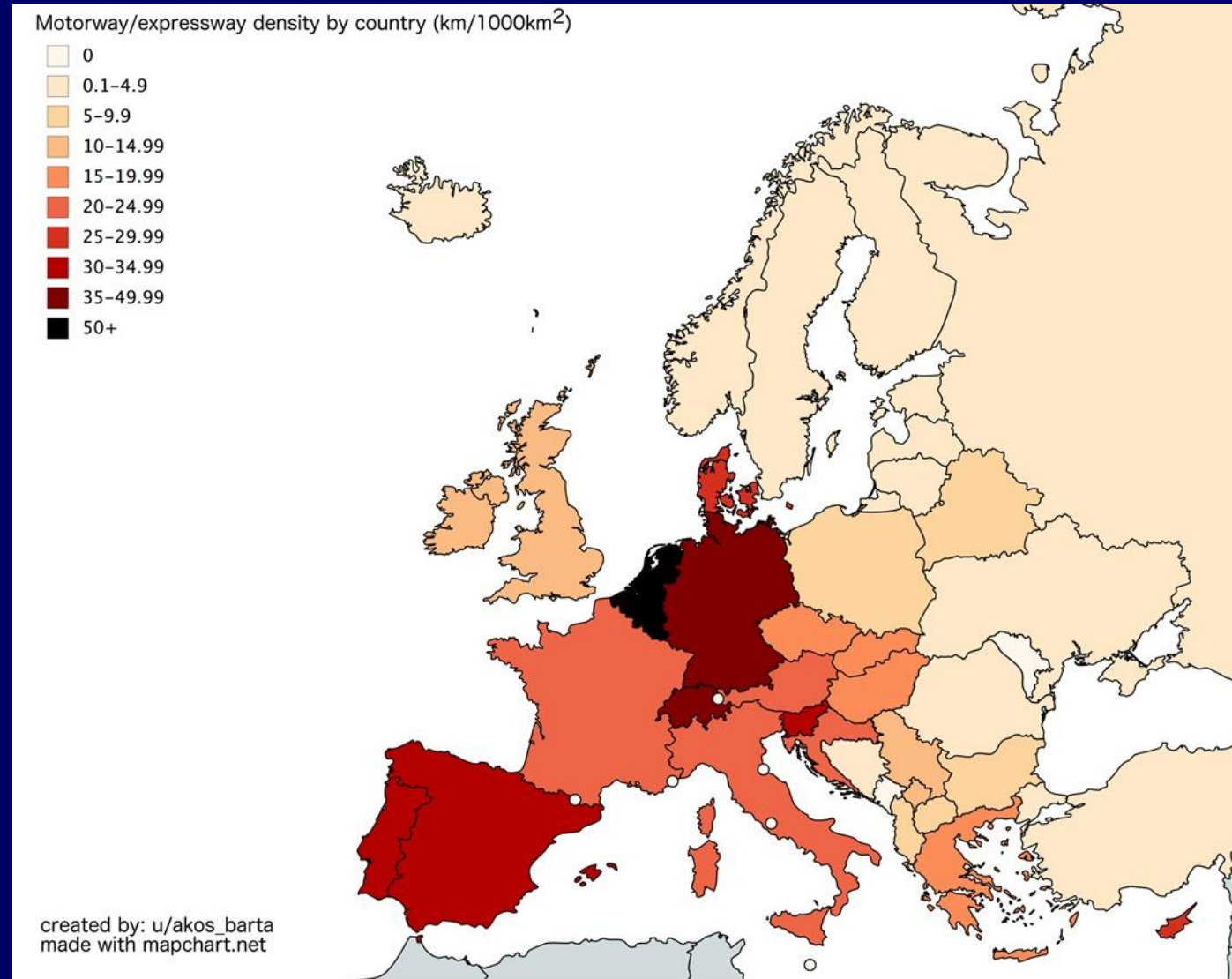
- **In the first few years after the construction of a motorway the economic development effects are constrained at a rather narrow lane but later may expand to a wider area.**
- **In Hungary there is a special problem of the spatial structure because of the very centralised situation of the capital city. Almost all main motorway routes lead to Budapest.**
- **This fact is contradictory to the expectations for spatial equalisation and creation of even chance, since network development prefers henceforward the accessibility to the national centrum.**

Transport networks and the economy



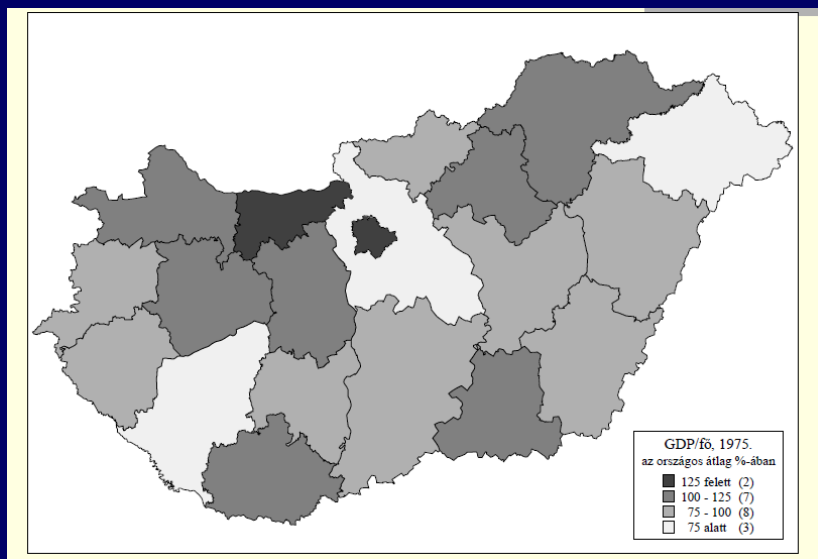
Transport networks and the economy

Density of
motorway
networks
in Europe
km / 1000 km²

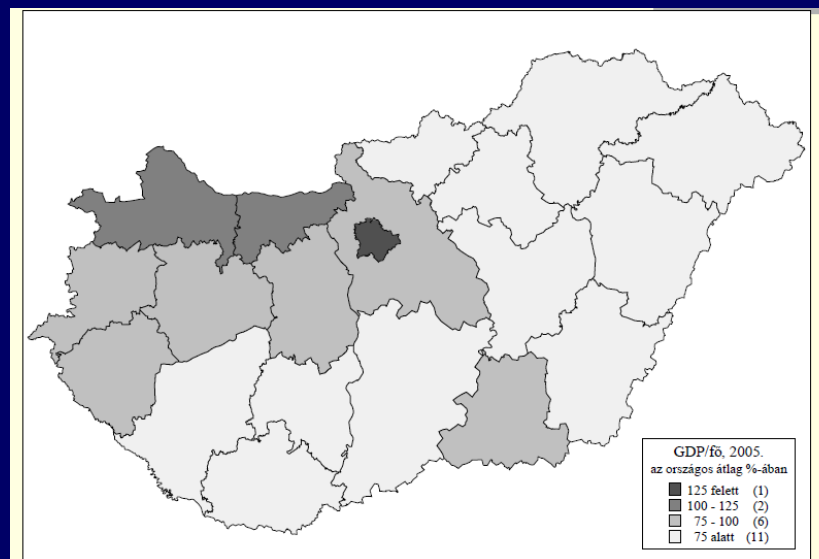


Transport networks and the economy

Hungarian spatial structure of economic development 1975.



Hungarian spatial structure of economic development 2005.

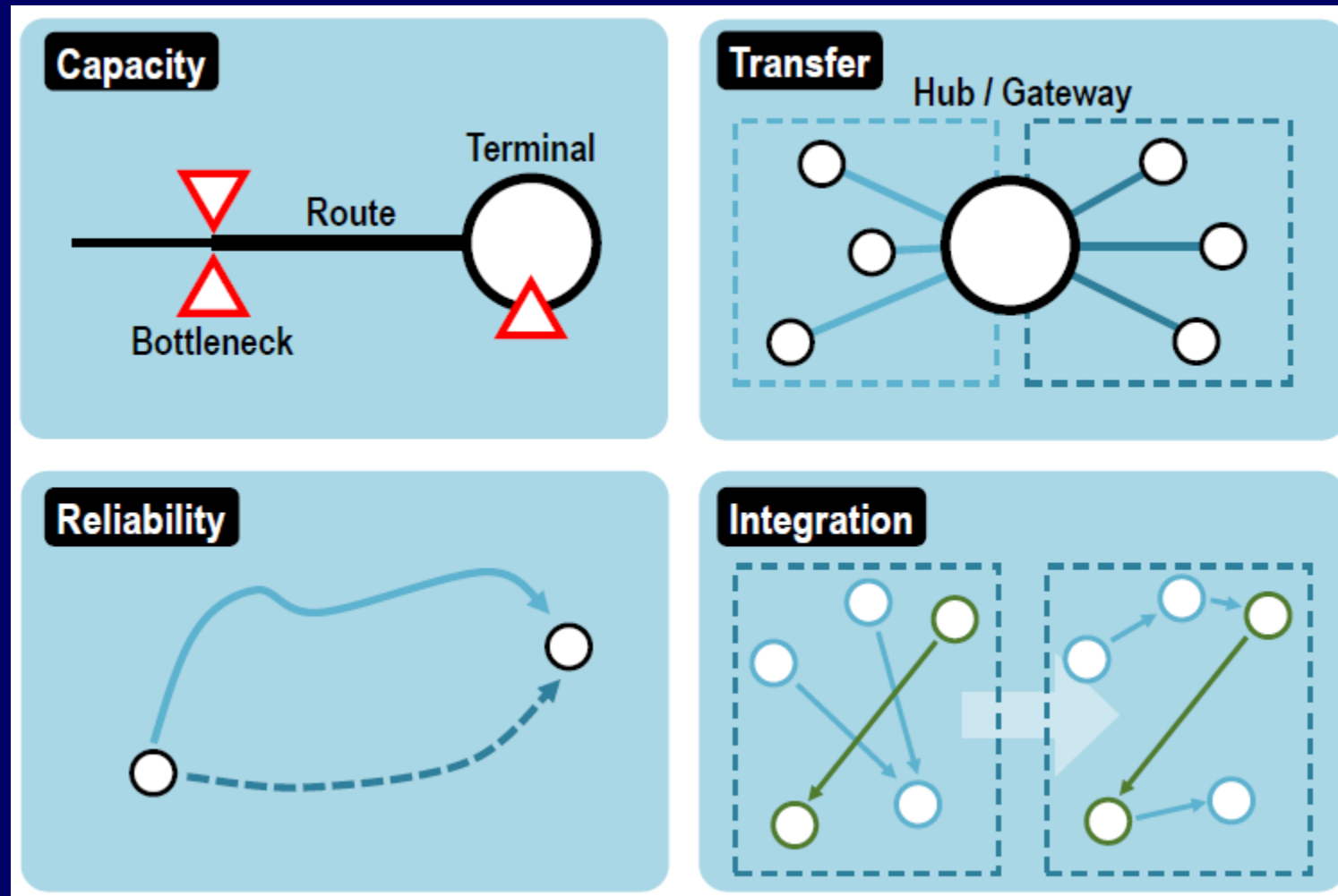


Spatial structure and infrastructure

- **Transport lines and intersections create a network. By its essence, this network is a directional graph.**
- **There are bottlenecks in the network at special places, such as rivers and bridges, mountainous areas and passes.**
- **Country borders are artificial obstacles usually increasing travel time. Fortunately within the European Union this has become a lesser problem nowadays.**
- **Nevertheless, the lack of technological unity creates a similar disadvantage, i.e., the track gauge differences on the railway network in Europe.**

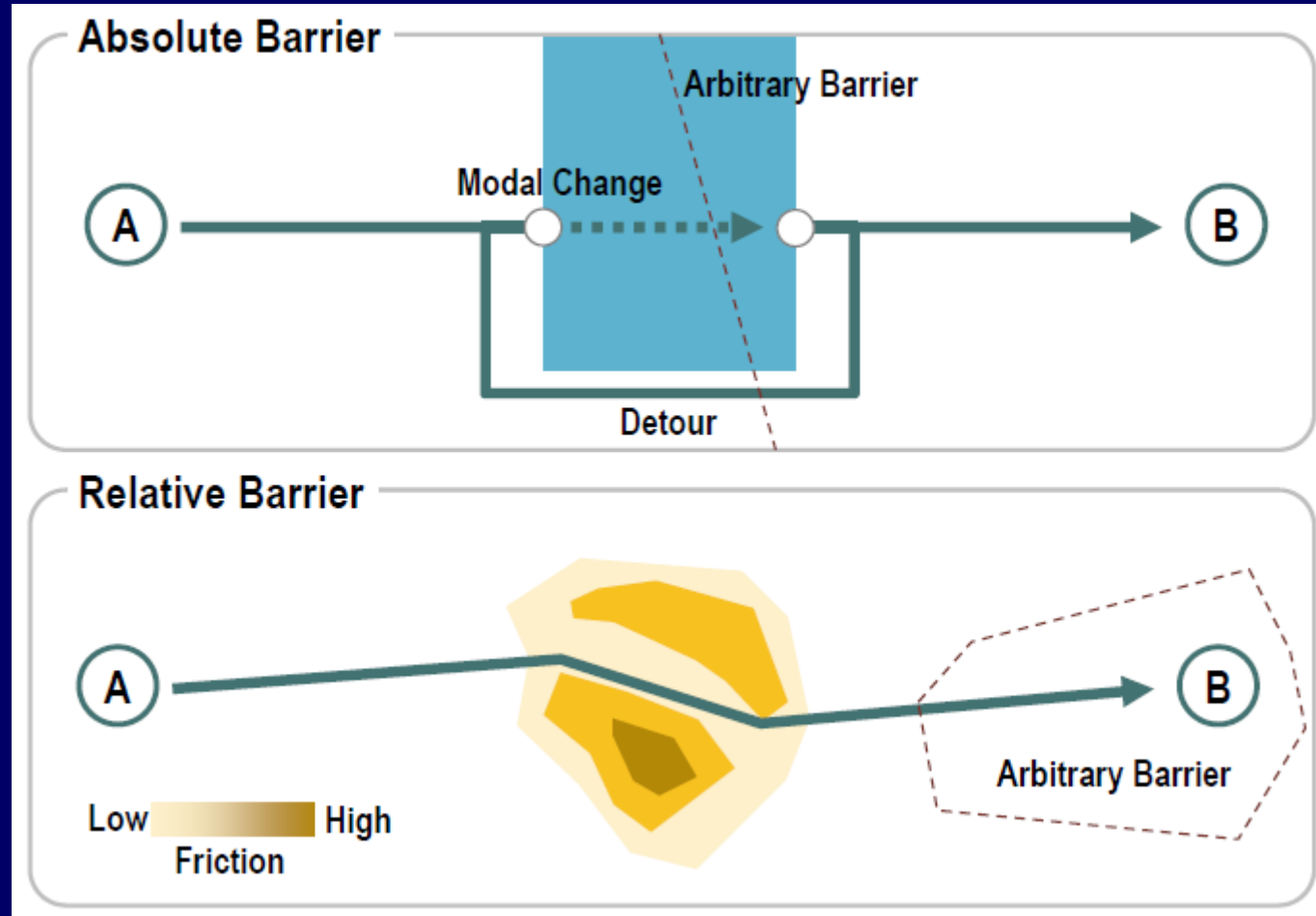
Spatial structure and infrastructure - Problems

Common problems for transport systems

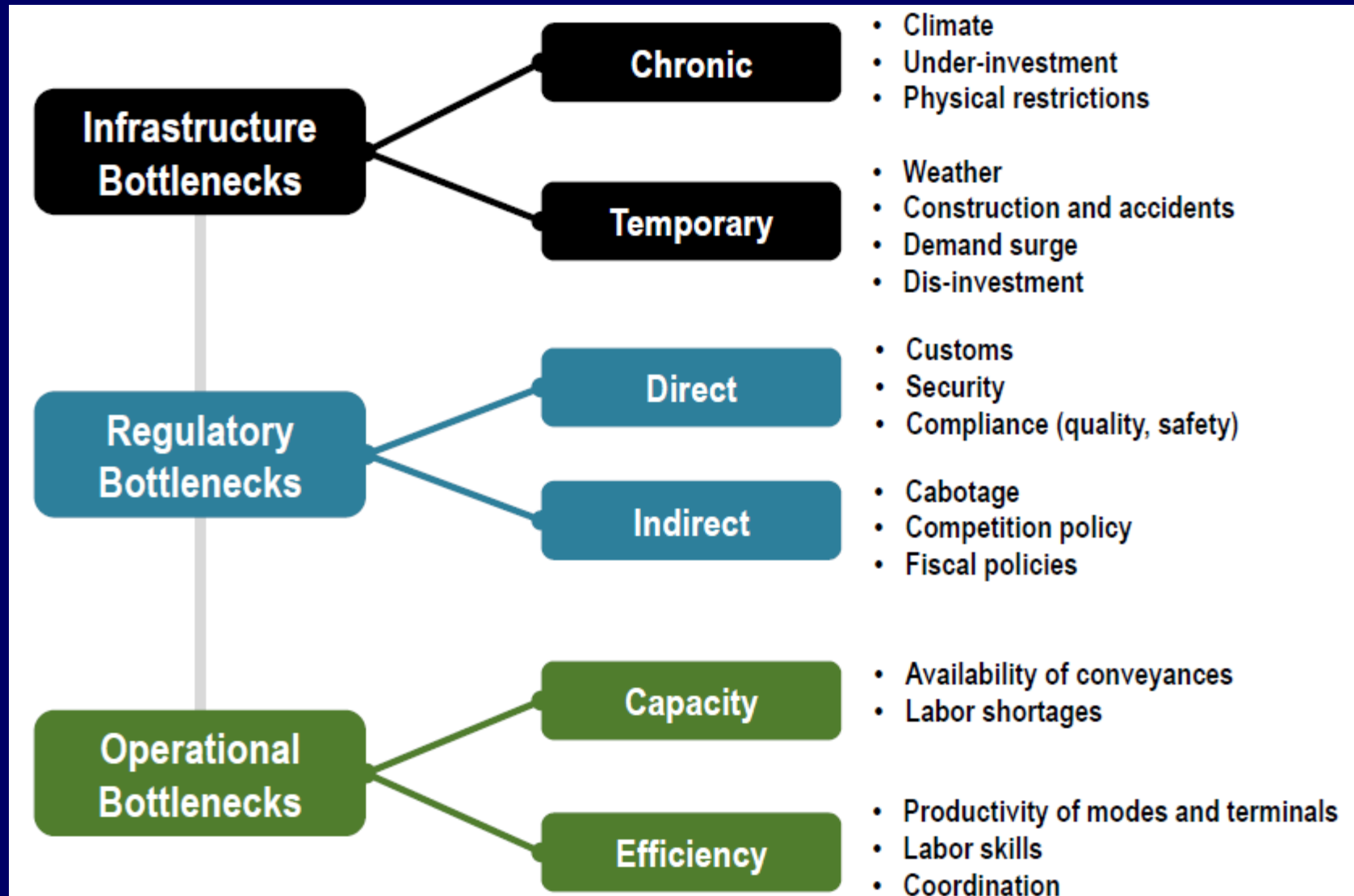


Spatial structure and infrastructure - Barriers

Absolute, relative and arbitrary barriers

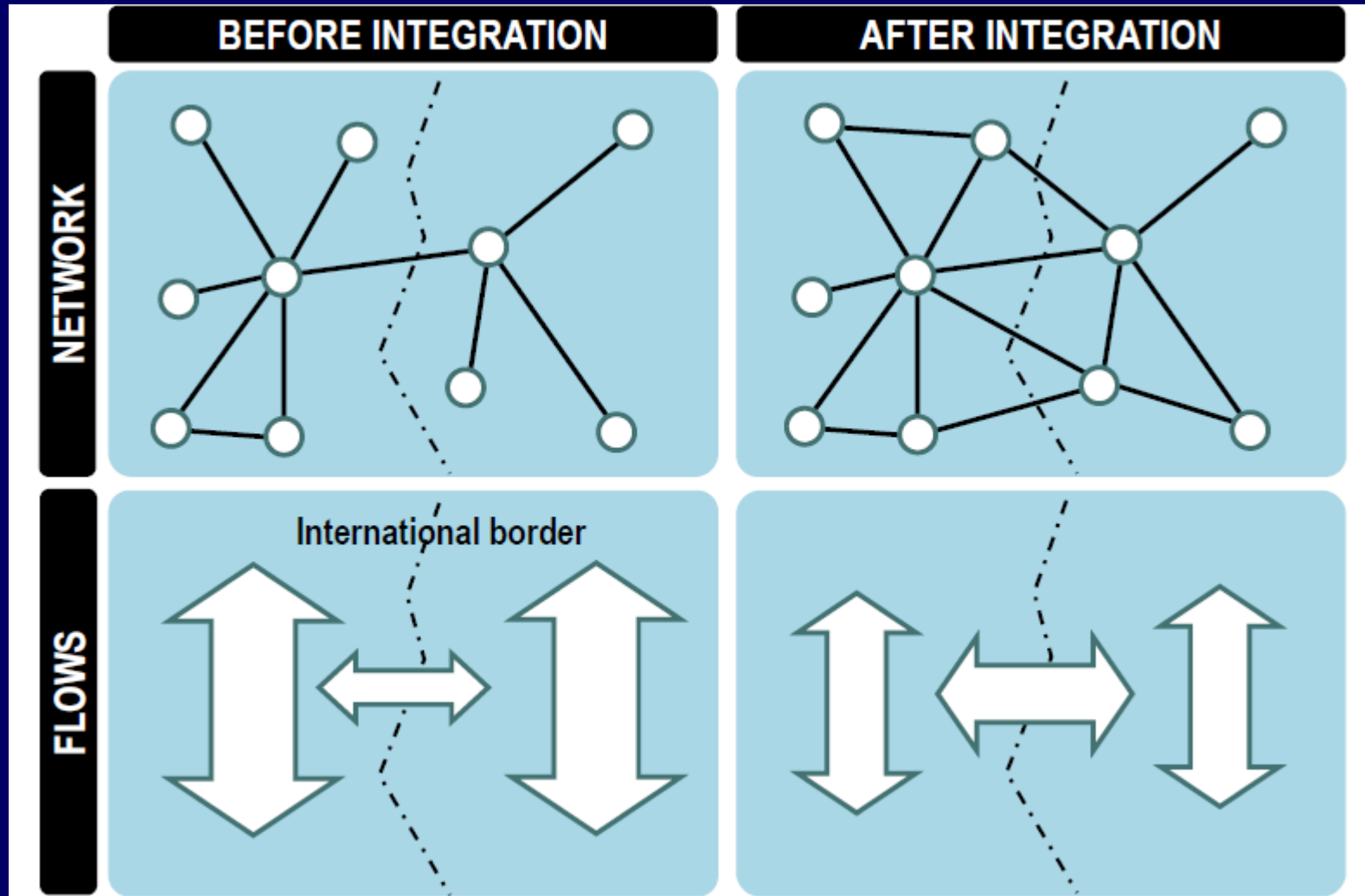


Spatial structure and infrastructure - Bottlenecks



Spatial structure and infrastructure - Integration

Impacts of integration processes on networks and flows

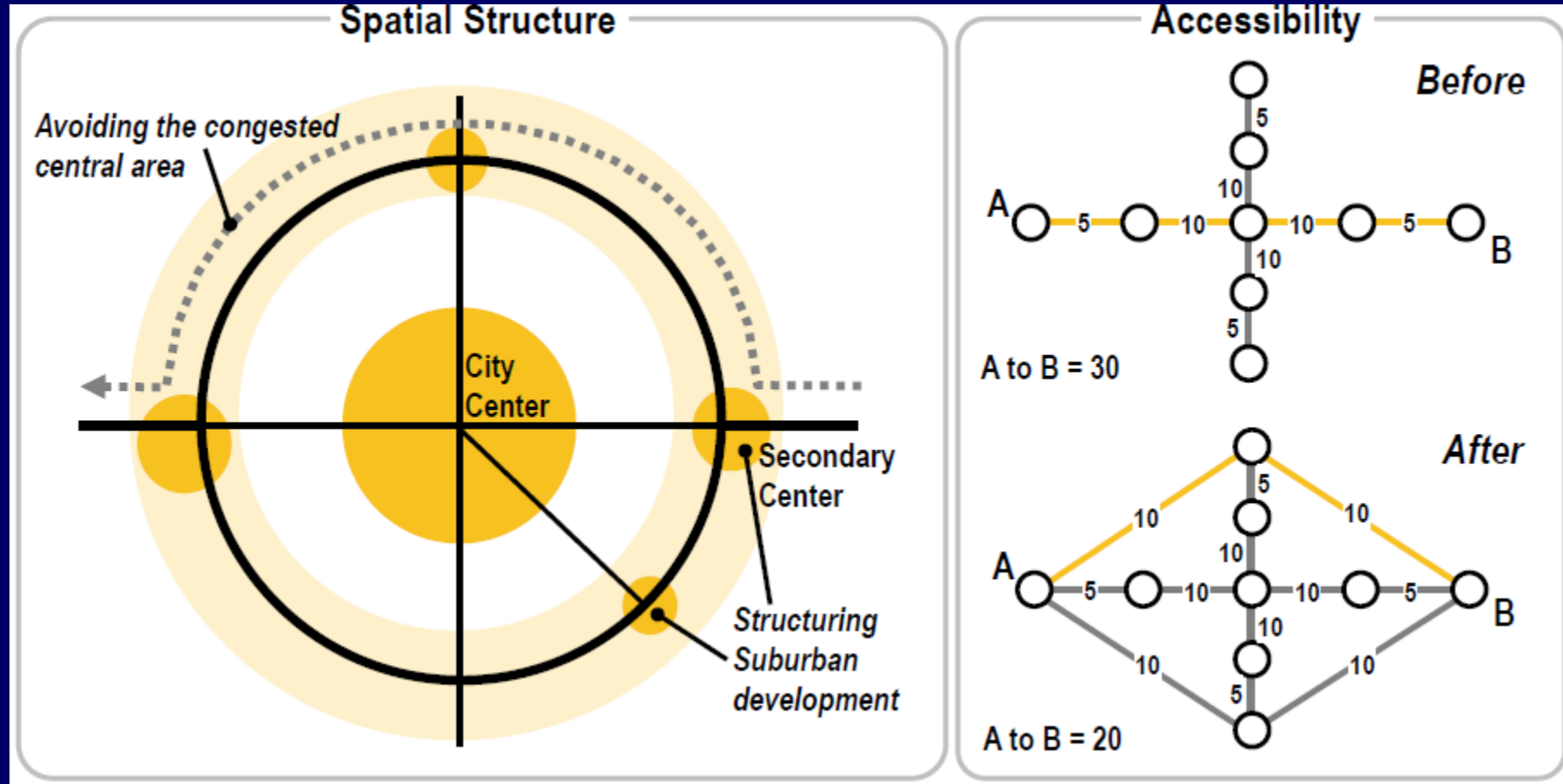


Spatial structure and infrastructure

- **Settlements and cities generate a denser transport network in their vicinity. The better transport connection in turn generates more development.**
- **The increasing traffic moving to cities on radial roads establishes a demand for ring roads and external connections. This kind of demand appears both at city and at regional or national levels.**
- **Connections between different modes of transport (i.e., railway stations, ports) may provide a significant spatial development potential.**

Spatial structure and infrastructure

The rationale of a ring road



Spatial structure and infrastructure

- **Infrastructure is the system of public works of a country, state, or region, the resources required for an activity.**
- **Transport infrastructure consists of economic conditions (i.e., road and railway networks, ports, airports, etc.) that do not participate directly in the production process but indirectly are indispensable for the production process and its development possibilities.**
- **The level of infrastructure affects the general conditions of the economic development. Low level of infrastructure in less developed countries moderates the economic development.**

Spatial structure and infrastructure

- **From the point of view of the spatial planning, the most important technical infrastructural network elements are transport network, energy network, public utilities (water supply and sewage), waste management and – last but not least – info-communication systems.**
- **The spatial structure of the economy changes in time. The development of the infrastructure, especially the transport infrastructure, strongly affect these changes.**
- **Every kind of infrastructure is a necessary but not sufficient condition of the economic development.**

Spatial structure and infrastructure

- **A simile from the world of computers may help to picture the connection between the infrastructure and the spatial development. The existence of the hardware is a necessary but not sufficient condition for the operation of a computer. In order to get proper performance from the hardware, there is a need for the appropriate software or application.**
- **Software-like conditions of the spatial development are for example the geographical situation, the existing socio-economic potential of the area, the political environment, etc. The spatial development will not be the same even in case of the same infrastructural background, because space is not homogeneous.**

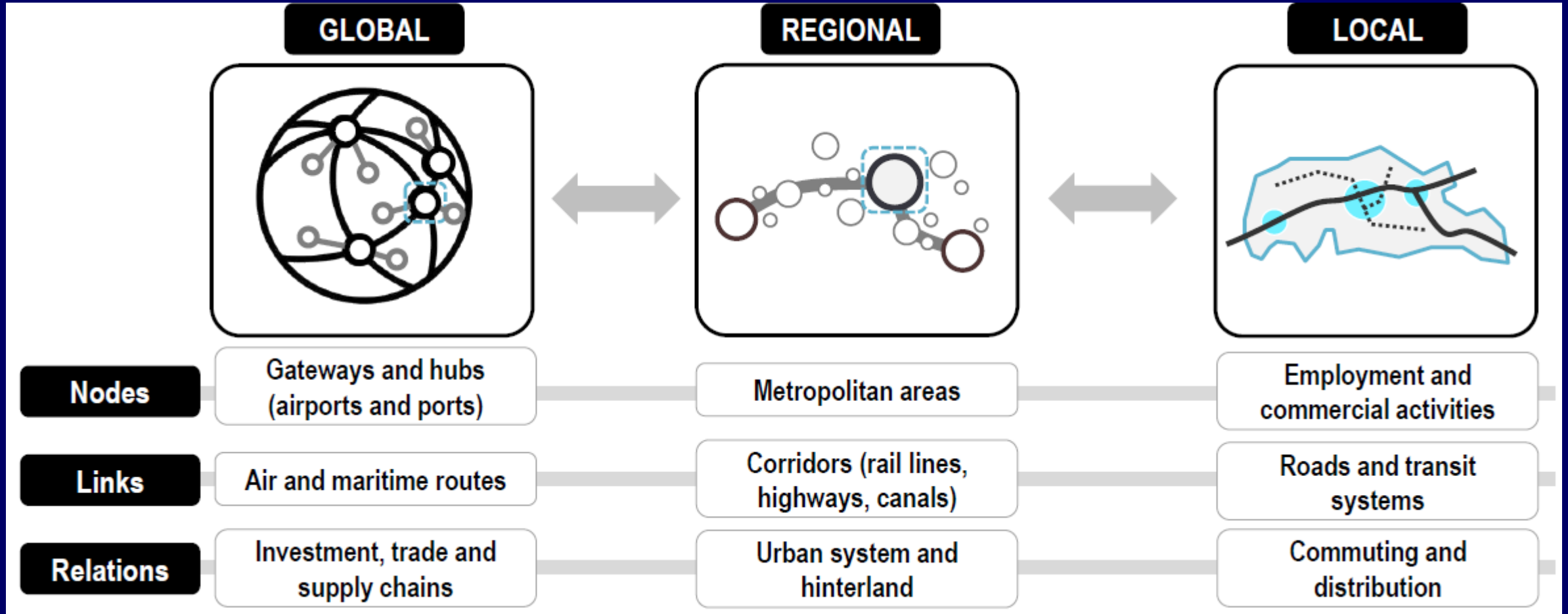
Spatial structure and infrastructure

- **Transport systems and networks serve everyday mobility demands of the population. The transport is connected in a lot of ways to different functions of society, economy and trade, satisfying physical forms of communication.**
- **Accessibility issues and transport possibilities affect the socio-economic development. Enhancement of the transport infrastructure therefore is one of the most important primer for the national economic development.**
- **Transport and telecommunication infrastructure provides connection between distant economic units in space.**

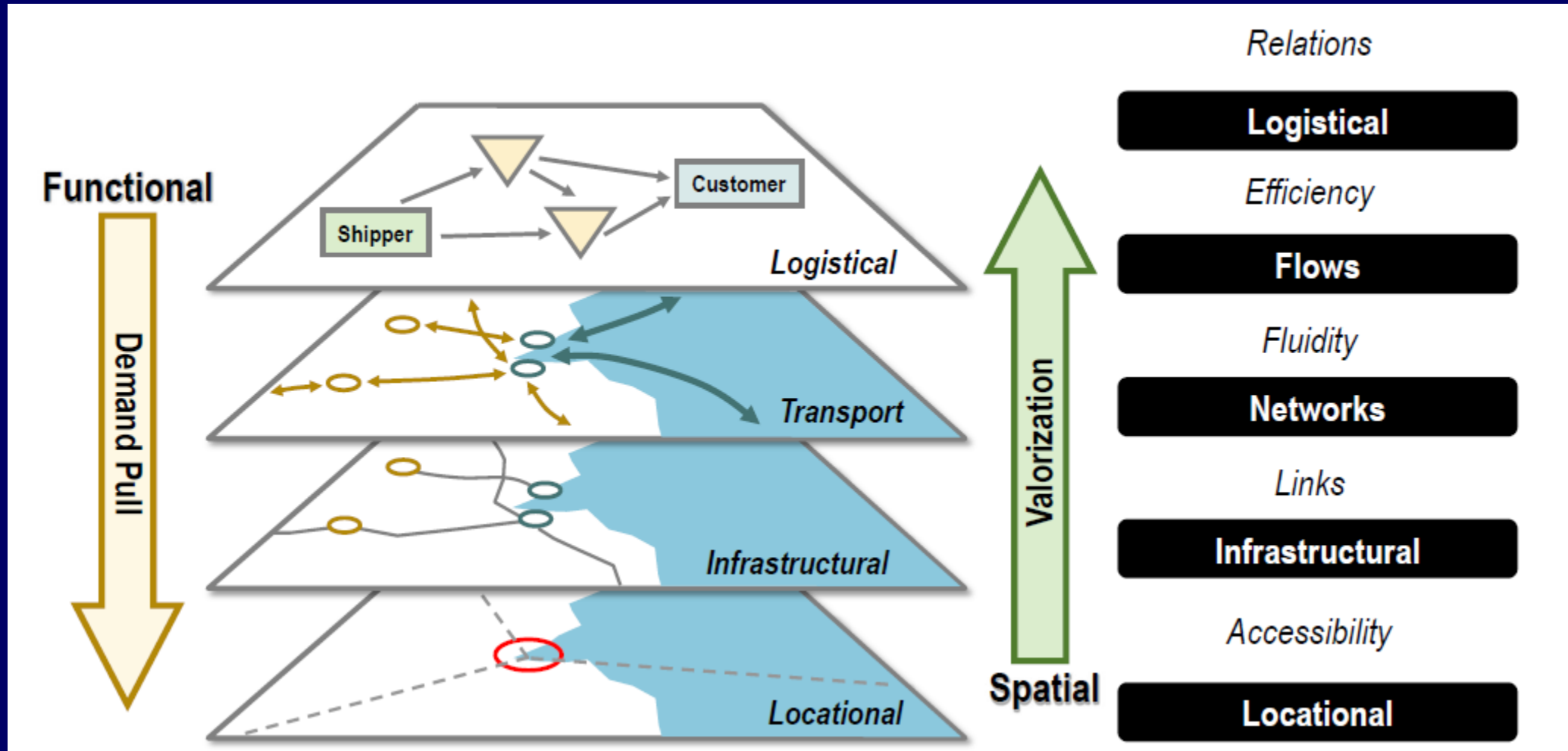
Spatial structure and infrastructure

- **Transport infrastructure elements are linear infrastructural elements, that connect areas in the space or separate areas in case of shortage, determining equal access and opportunity.**
- **Accessibility (or geographic accessibility) is a measure of the “friction of distance” or “burden of travel” between locations, whereas availability generally measures the number of services in comparison to the number of potential users of the service.**
- **Accessibility is defined as the ability to reach a place with respect to another place. Accessibility characterises the potential advantage or disadvantage of an area in transport geography.**

Spatial structure and infrastructure - Scales

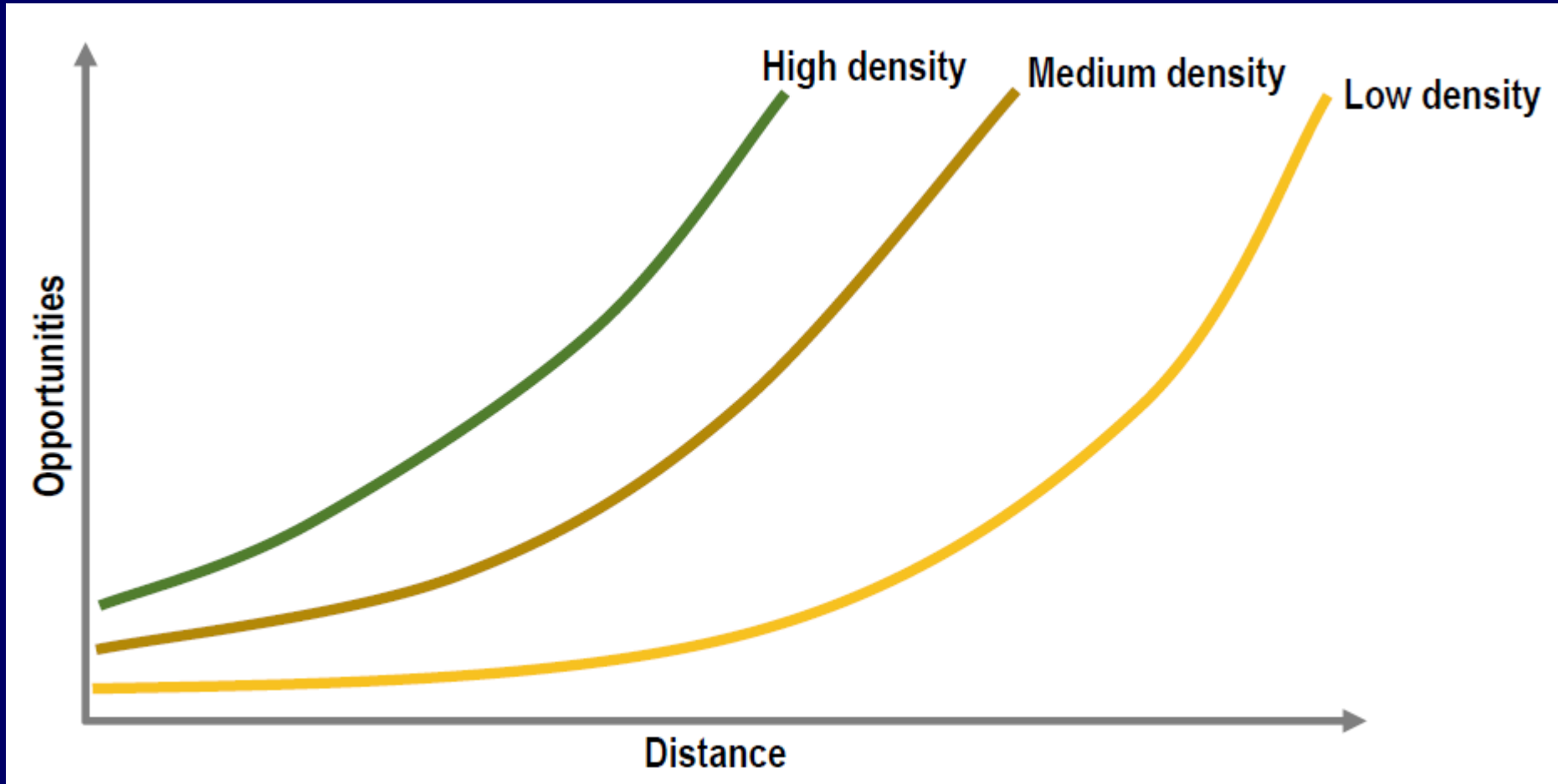


Spatial structure and infrastructure - Layers

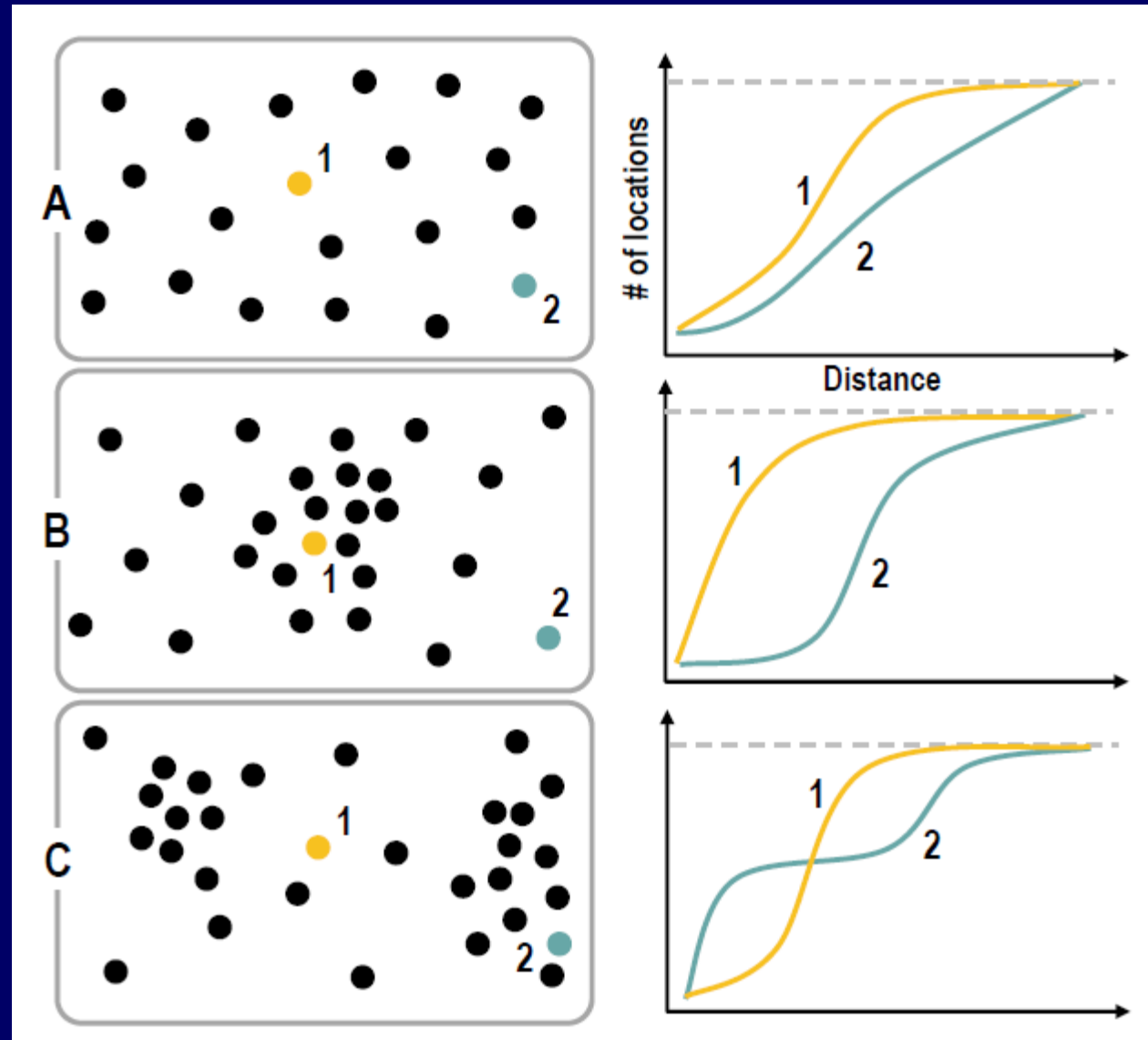


Spatial structure and infrastructure - Opportunities

Relationship between distance and opportunities



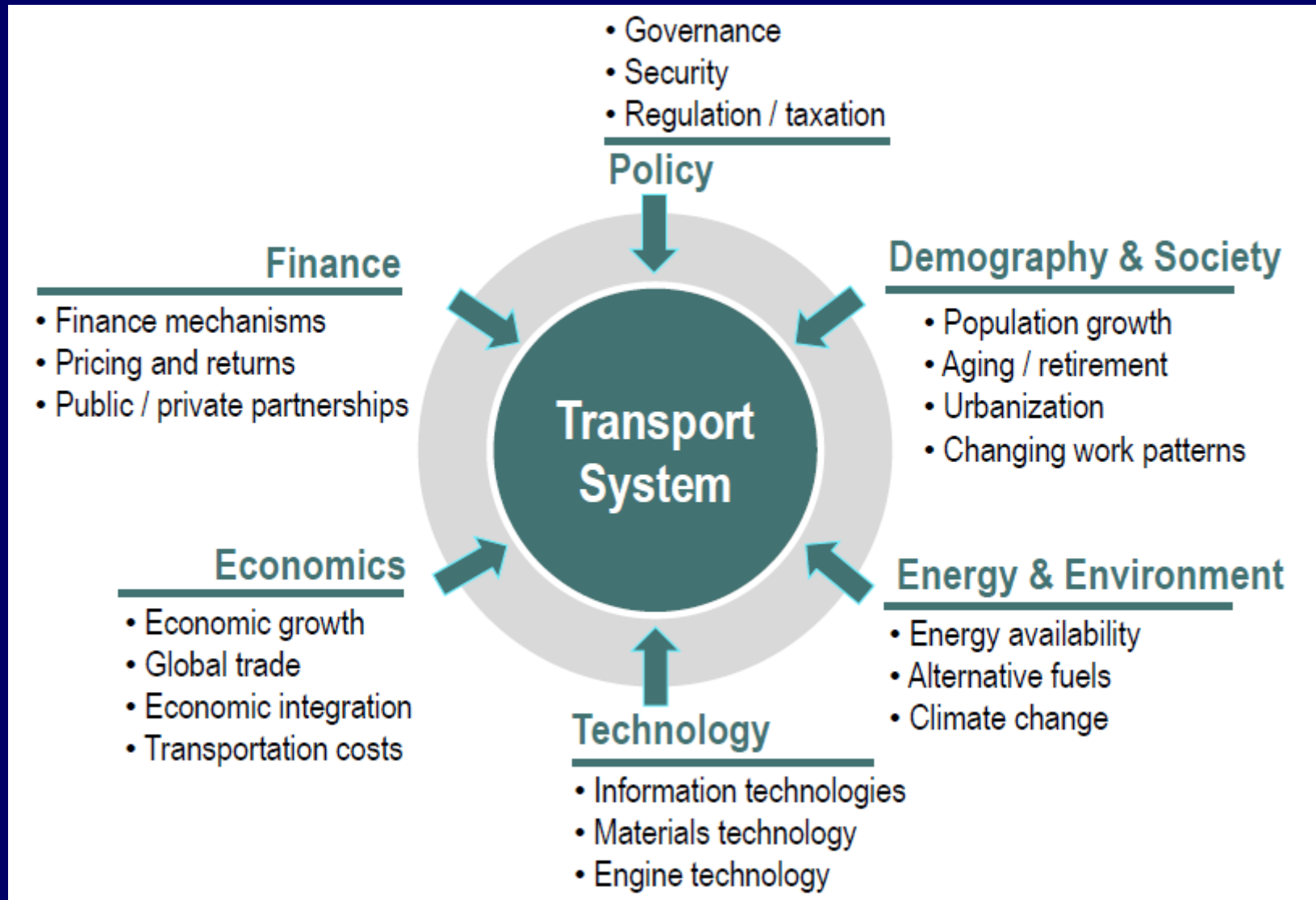
Spatial structure and infrastructure - Distances



Spatial structure and infrastructure - Future

- **The future of infrastructural development is characterised by the always new types and modes as the development of science and technology advances. New types of infrastructure basically affect the socio-economic development of the world, modifying the available space.**
- **Current info-communication revolution provides huge prospect for spatial development as well, while in case of traditional infrastructures the main goal is the increasing of their efficiency.**
- **In the future the existing infrastructural systems require a special resource management in order to promote the long-term sustainable spatial development.**

Spatial structure and infrastructure - Future



Main types of transport networks

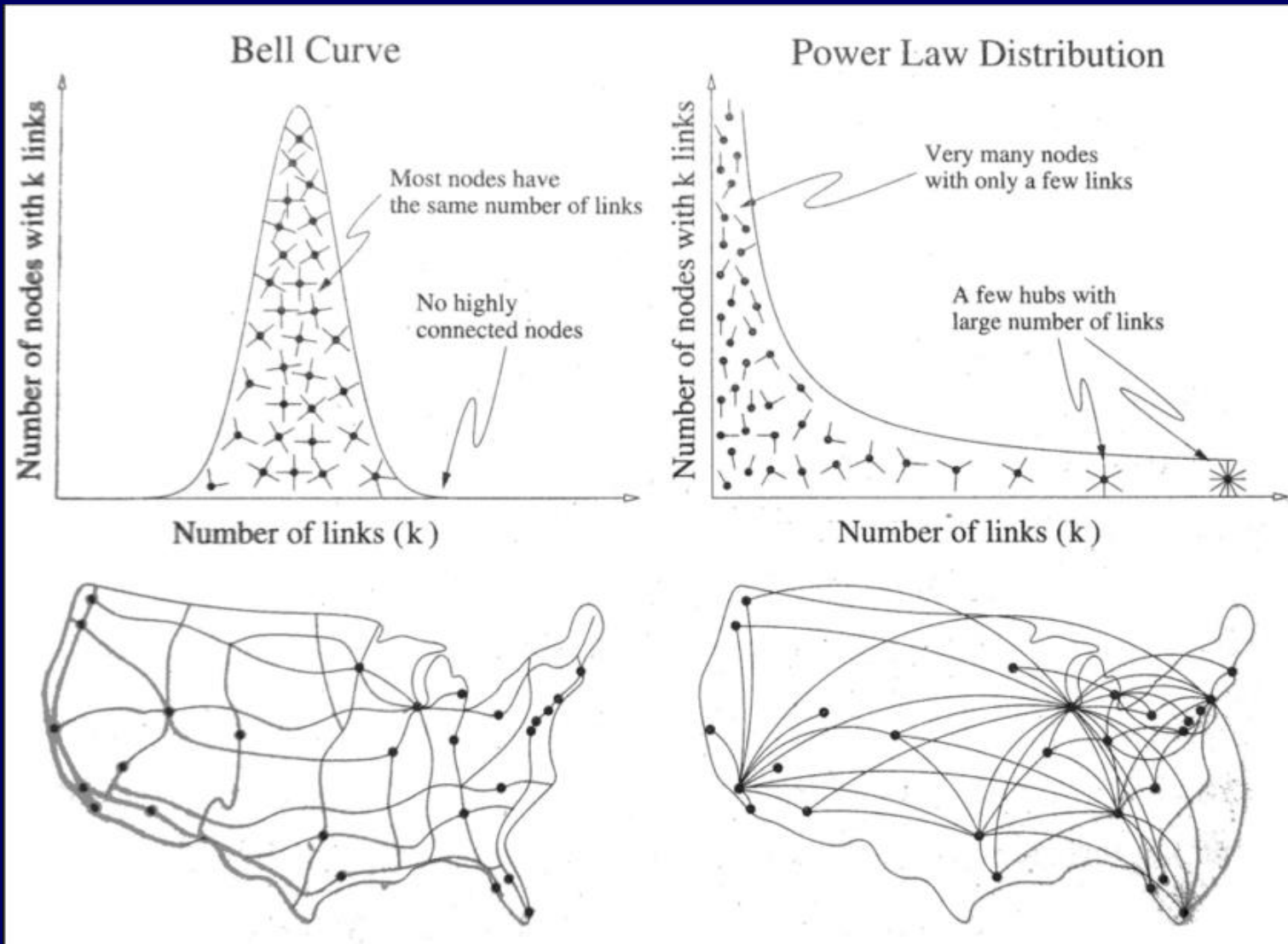
- **Road transport network – on the road map intersections (nodes) and road sections (links) are the connected elements. This network is rather balanced, every large city is connected to the motorways by one or more nodes but there is no city connected to dozens of motorways.**
- **Road transport network nodes are more or less similar with almost similar number of links, therefore bottlenecks may occur.**
- **This balanced type of network is called a random network where most nodes have the same number of links and there are no highly connected nodes.**

Main types of transport networks

- **Air transport network – the map of airways is significantly different from the road network map (especially outside Europe).**
- **In the air transport network major nodes (hubs) are airports connected by direct lines. The much of airports are small nodes with only a few or one line (spokes) to the major nodes.**
- **Unlike the road map where nodes are almost equal, the airway map has got a few major central node connected to hundreds of small nodes, showing a power law distribution.**
- **There are very many nodes with only a few links and a few hubs with large number of links.**

Main types of transport networks

National highway network

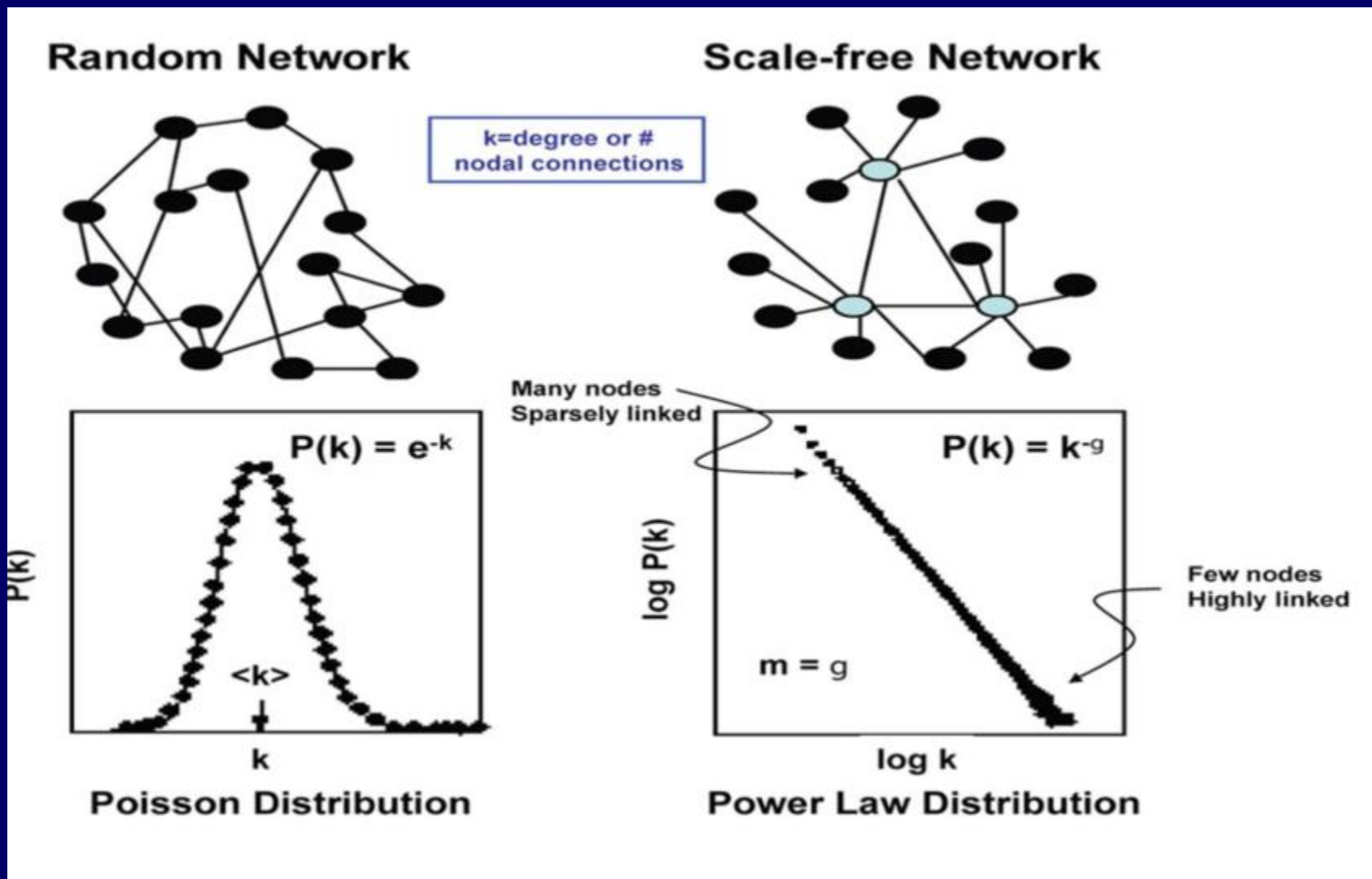


Airline traffic network

Main types of transport networks

- **Power law functions mathematically define the fact that in the real large networks the majority of nodes have only a few connections while there are some big nodes obtaining an unusual high number of connections.**
- **This kind of network is called a scale-free network.**
- **In the telecommunication the Internet is a scale-free network.**
- **The relatively sparse hubs provide the connectivity of the entire network, protecting the real network from disintegration. This kind of network has less sensitivity for disturbances.**

Main types of transport networks



Spatial characteristics of transport networks

- **Assessment aspects and methods of transport infrastructure**
- **Assessment aspects:**
 - **accessibility on different networks at district and regional level**
 - **changes in quality and quantity data of road and railway networks**
 - **spatial characteristics of passenger and freight traffic**
- **Assessment methods:**
 - **establishing a complex accessibility metric**
 - **graphical presentation and analysis (GIS software)**

Spatial characteristics of transport networks

Characteristic	Metric	Spatial unit
Road transport		
Change of road network length	length of existing road network + newly constructed roads, km	country, county, district, settlement
Density of road network	specific length of road network, km/100km²	country, county, district
Pavement condition of road network	distribution of pavement condition, %	country, county, district
Number of road vehicles	specific number of road vehicles, piece/1000 fő	country, county, district, settlement
Categories of road vehicles	distribution of road vehicle categories, %	country, county, district
Bicycle road network	length of existing and newly constructed bicycle roads, km	country, county, district
Accessibility on road	accessibility of the county centre from settlements of the county, accessibility of the district centre from settlements of the district, hour and minutes	country, county, district

Spatial characteristics of transport networks

Characteristic	Metric	Spatial unit
Railway transport		
Change of railway network length	length of existing railway network + newly constructed railways – abandoned railways, km	country, county
Density of railway network	specific length of railway network, km/100km²	country, county
Electrified railways	length and proportion of electrified railways, km; %	country, county
Single line and double track railways	length and proportion of single line and double track railways, km; %	country, county
Railways with automated signalling system	length and proportion of railways with automated signalling system, km; %	country, county
Accessibility on railway	number and proportion of settlements with railway stations, piece; %	county, district

Spatial characteristics of transport networks

Characteristic	Metric	Spatial unit
Water transport		
Freight traffic by ports	freight traffic of open ports in operation, thousand tons	country, county
Combined transport		
Combined transport by water and railway	capacities of combined transport, number of units, types of transported vehicles	country
Terminals for Combined transport	number and capacity of terminals	country
Transport in general		
Freight and passenger performance of transport modes	proportion of freight and passenger performance of a given transport mode, %	country, county

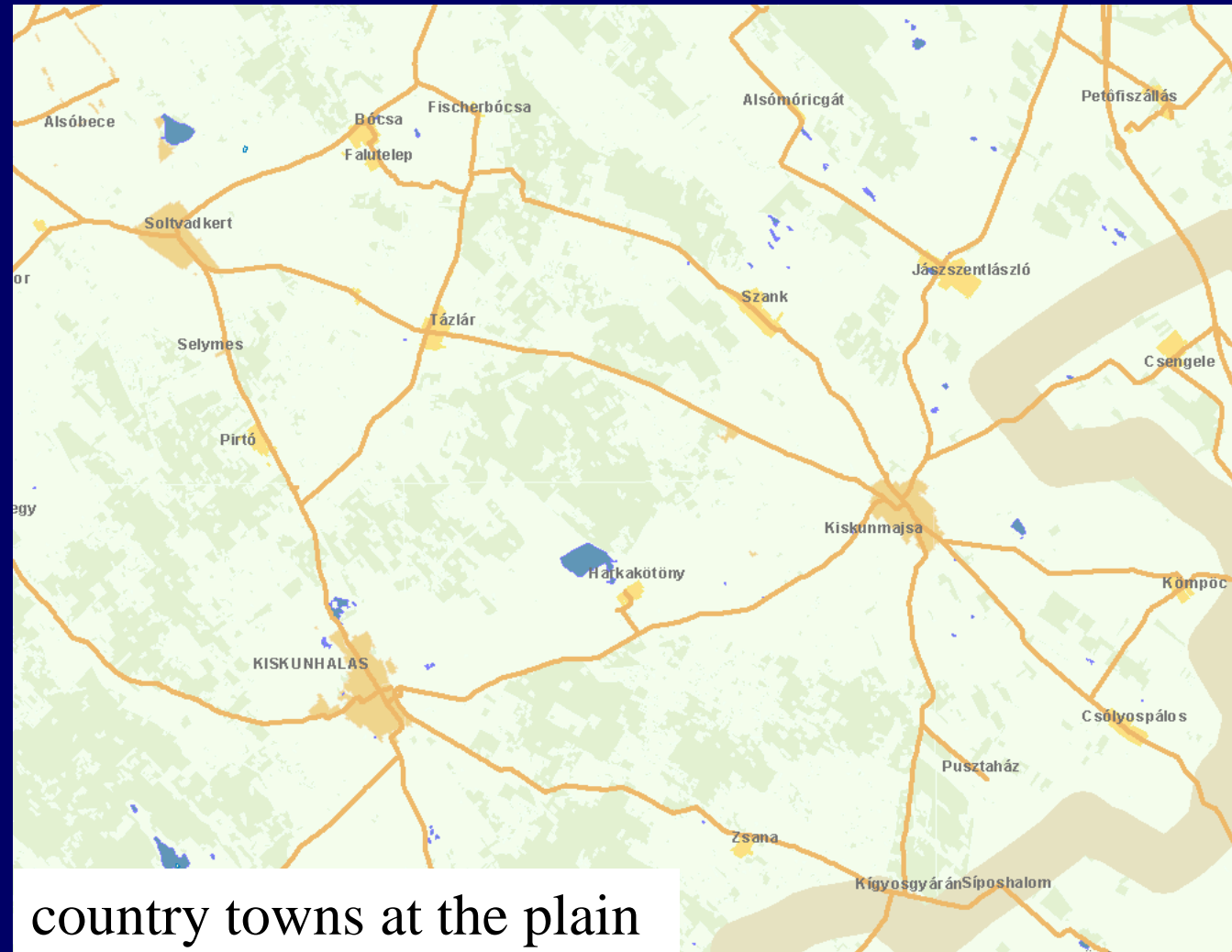
Spatial characteristics of transport networks

- **Role of transport infrastructure at other (non-technical) sectors**
- **economic processes**
 - performance of economy
 - foreign capital investment
 - sectoral policy
- **social processes**
 - health status
 - settlement comfort
- **environmental situation**
 - quality of air, soil and water

Settlement structure and transport connections

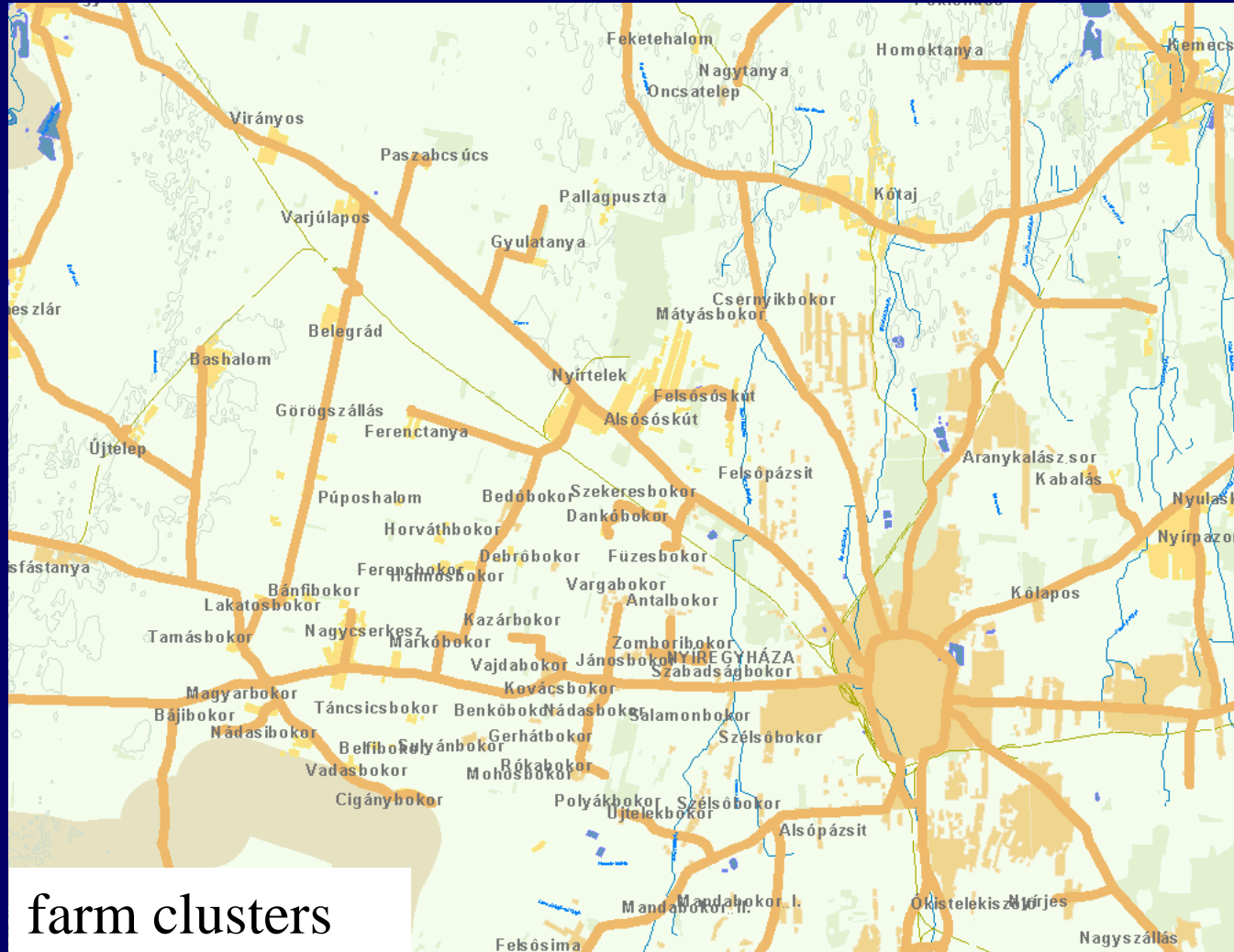
- **Based on the geographical circumstances, the location and density of settlements and their connections require different road network structures.**
- **At plain areas settlements (country towns) are larger and the road network is rather sparse. In case of farm clusters there are some dead-end connections as well.**
- **At hilly and mountainous areas there are smaller villages with a rather dense road network. Roads are usually aligned parallel to valleys while transverse sections are rare and dead-end connections may occur.**

Settlement structure and transport connections

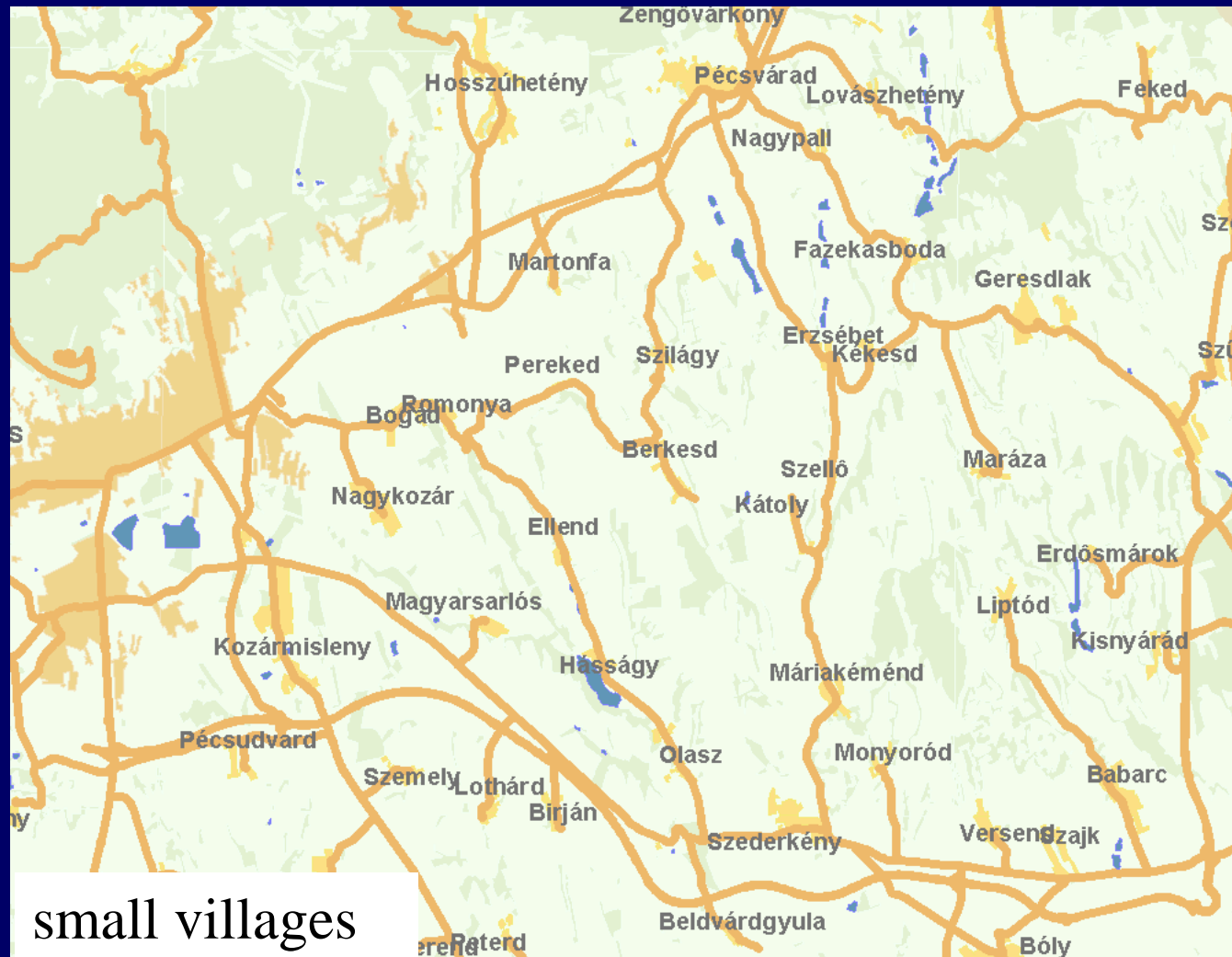


country towns at the plain

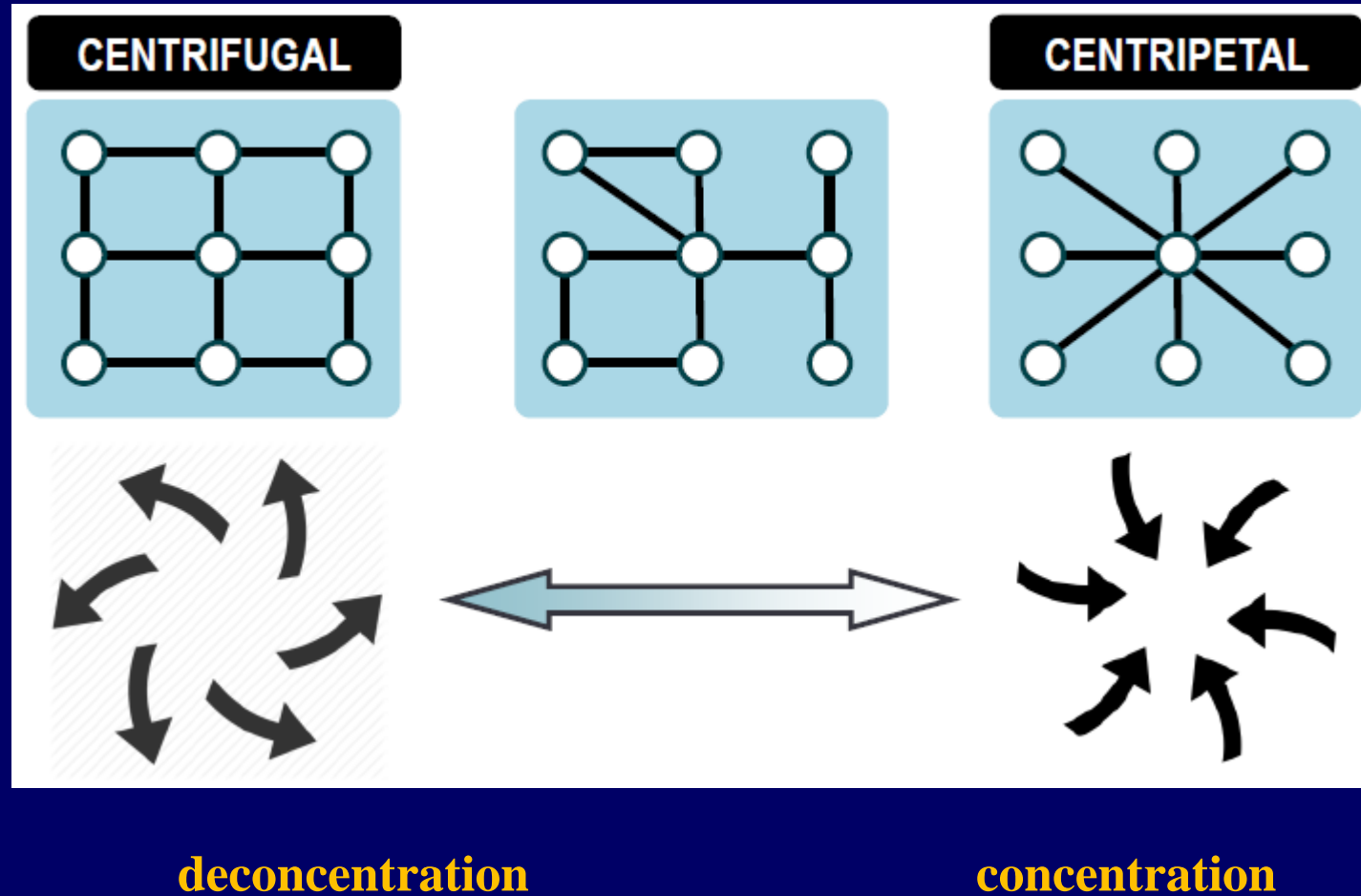
Settlement structure and transport connections



Settlement structure and transport connections



Settlement structure and transport connections



deconcentration

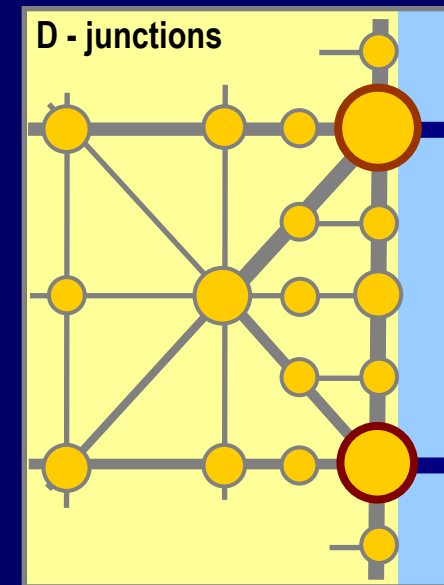
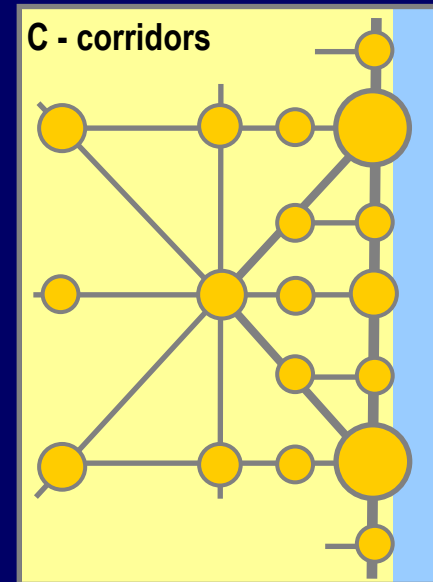
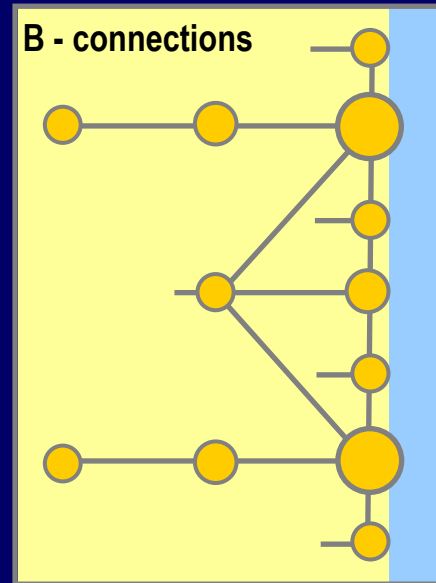
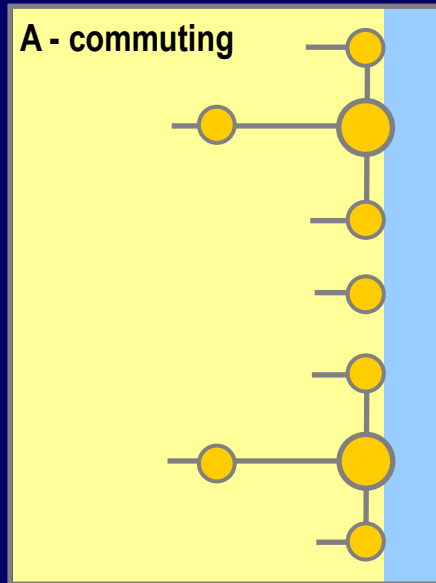
concentration

Settlement structure and transport connections

- **Transport corridors are formed where the traffic and the infrastructure are denser. Transport corridors always contain more than one transport mode.**
- **Transport corridors are formed due to economic and technical development as well as the enhancement of trade and service connections.**
- **The role of a transport corridor is more important when there is a water transport connection or a high-speed railway line. Big cities usually attract various transport corridors.**

Settlement structure and transport connections

Transport corridors are aligned with the development of the spatial structure.



Internal transport networks of settlements

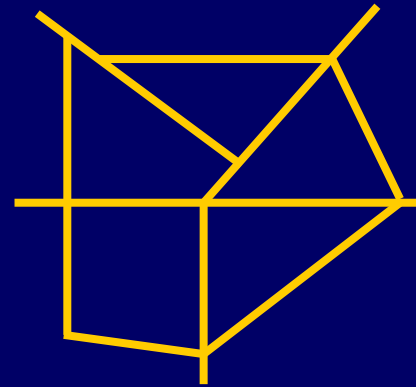
- **Basic types of a road network structure in settlements:**
 - **Heap-like structure**
 - **Linear (one or more axis) structure**
 - **Ring-radial structure**
 - **Grid (perpendicular) structure**
- **Land-use development and road network development shall be performed always in a co-ordinated way. The internal structure of a settlement and its road network structure mutually determine one another.**

Internal transport networks of settlements

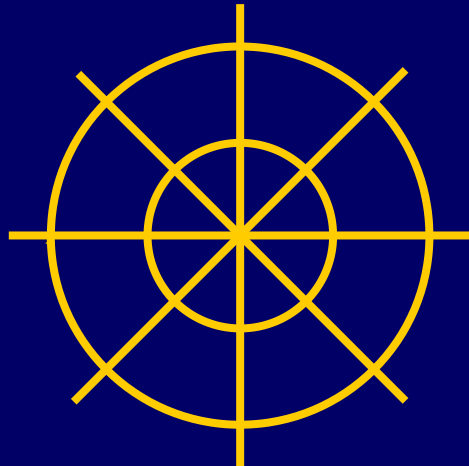
linear



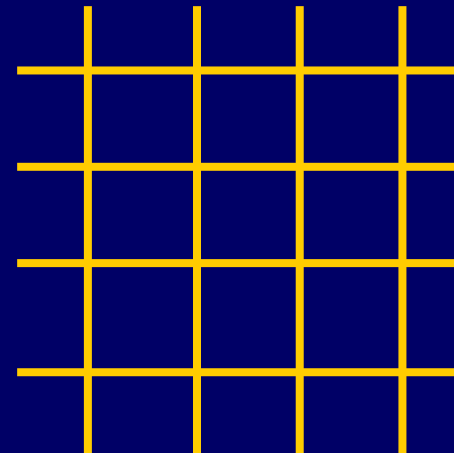
heap



ring-radial



grid



Internal transport networks of settlements



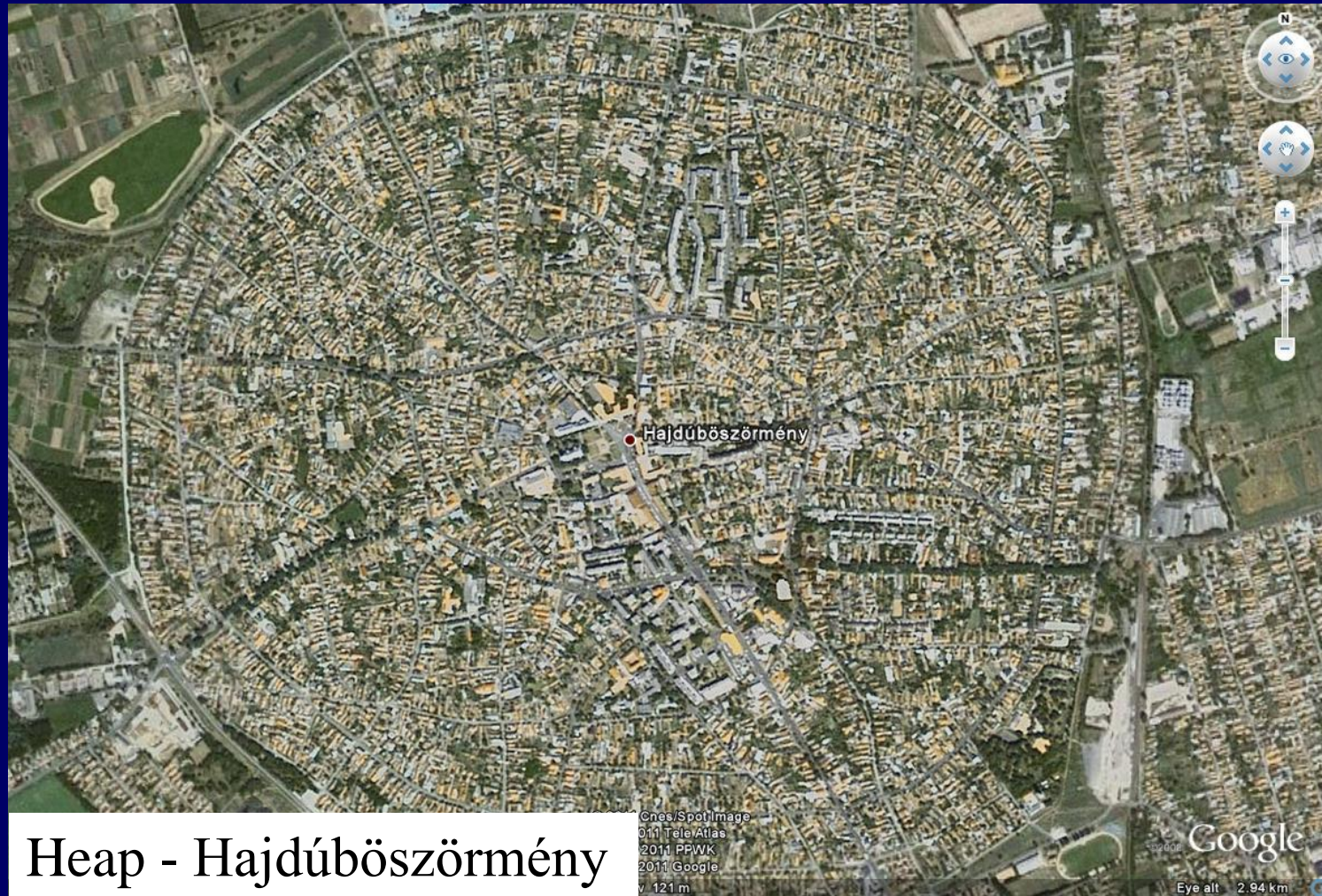
Linear - Leányvár

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Eye alt 2.22 km

Internal transport networks of settlements



Heap - Hajdúböszörmény

Internal transport networks of settlements



Ring-radial - Szeged

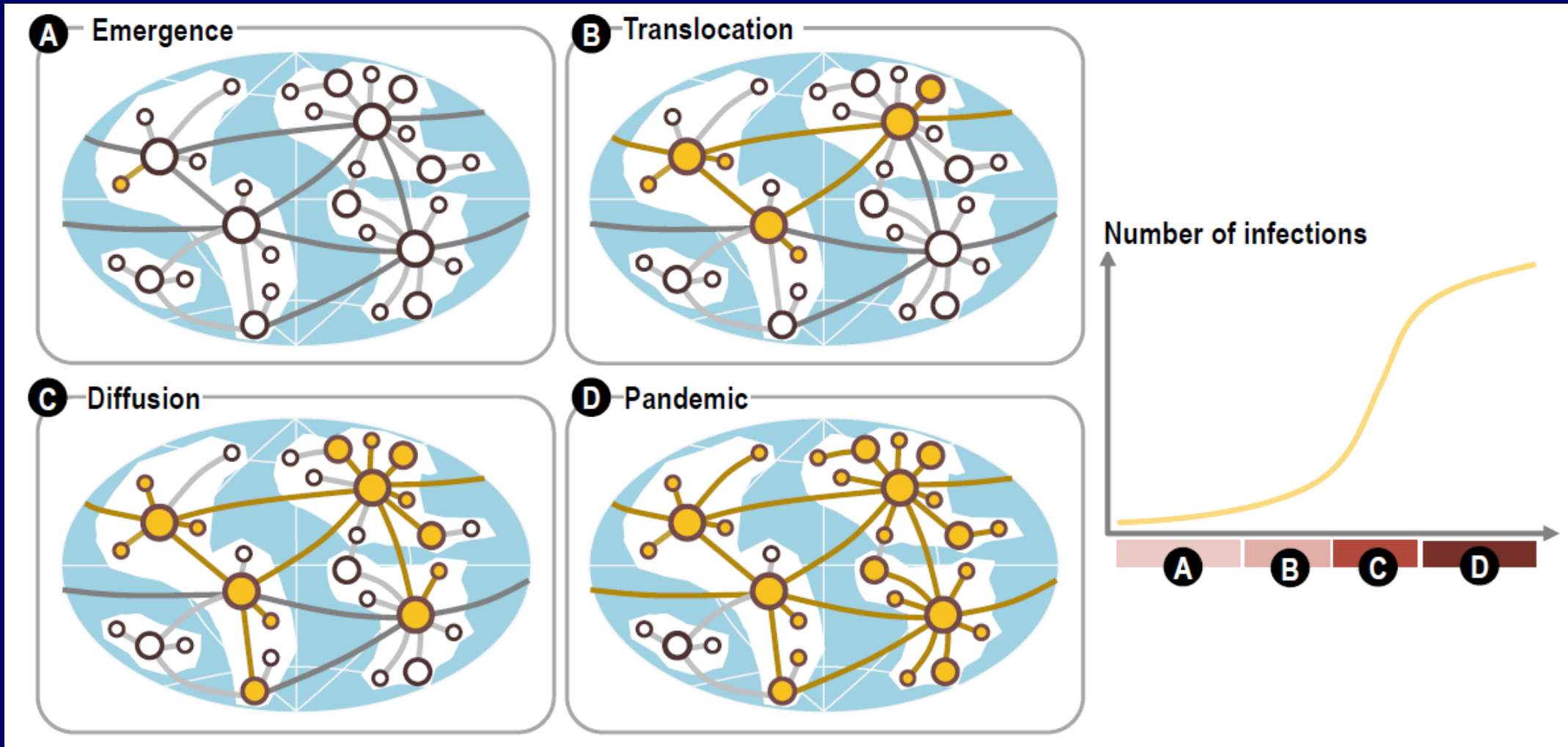
Internal transport networks of settlements



Grid - Pestszentimre

Global transportation network

Diffusion of a pandemic through a global transportation network



Summary

- **Density of transport networks and their traffic volume are in strong correlation with economic development.**
- **Transport lines and intersections create a network. By its essence, this network is a directional graph.**
- **Settlements and cities generate a denser transport network in their vicinity. The better transport connection in turn generates more development.**
- **Based on the geographical circumstances, the location and density of settlements and their connections require different road network structures. There are also various types of a road network structure within settlements.**

Thank you for your attention!

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