# JDiBrief - Analysis

## Interstitial crime analysis: SUMMARY (1 of 5)

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Crime on public transport can be very difficult to analyse. 'Stealth crimes' like pick-pocketing present a particular challenge because victims often have an imprecise knowledge of the location and time of the offence. In this scenario crime has typically been recorded as happening at the reporting station (often at the 'end of line') which skews any analysis of the collective crime locations.

**Interstitial crime analysis (ICA)** is a technique which overcomes this problem and improves the estimation of the spatial distribution of crime on networks when the exact location of offences is unknown. Based on the aoristic analysis technique (devised to estimate the temporal distribution of crime when only a time period is known), ICA is used to estimate the location of crimes in the interstices – the intervening spaces - of a network when the location is unknown.

ICA is situated within a family of analytical techniques which can be applied to understand crime patterns in a public transport environment. Figure 1 presents different crime scenarios alongside the most appropriate spatial-temporal technique for that situation.
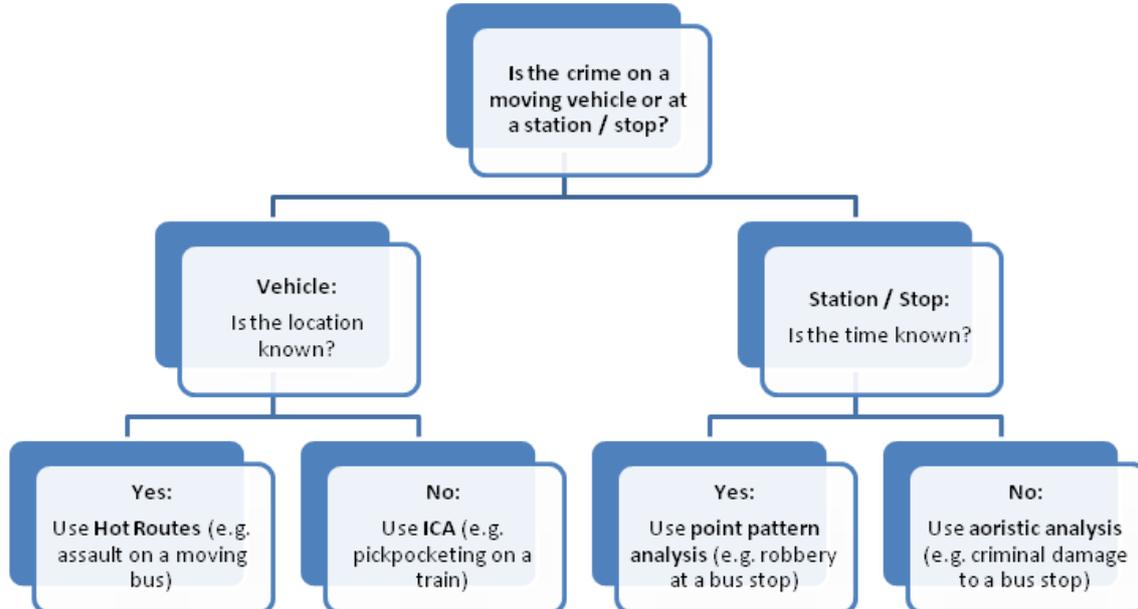


Figure 1 - Public transport spatio-temporal crime analysis flowchart

Interstitial crime analysis (ICA) allows an analyst to identify and map crime concentrations along paths (e.g. sections of a transport network) and connected nodes (e.g. stations and interchanges). Colour and line-width can be used to visualise the results - known as thematic mapping. Identifying concentrations of crime facilitates a more informed understanding of where to deploy (often policing) resources and target crime prevention efforts.

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## Interstitial crime analysis: PURPOSE & THEORY (2 of 5)

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**PURPOSE:** Crime on public transport can be very difficult to analyse. 'Stealth crimes' like pick-pocketing present a particular challenge because victims often have an imprecise knowledge of the location and time of the offence. This is complicated further by busy transport systems which can involve complex journeys between A and B with an interchange at C. Whilst victims may be able to recall the last time and location they had their possessions, their intervening journey through the transport network may have involved multiple stations and lines, therefore increasing the spatial and temporal uncertainty of their loss. In other words a crime takes place in one location whilst the victim is unaware, and is not discovered until much later, and at another location.

For that reason, the location of theft offences on UK public transport are normally recorded as the station the offence was reported at, known as 'end of line'; not necessarily where it occurred. Crime analysis with these locations results in the end journey destinations having a high concentration of crimes associated with them, when crimes may in fact be occurring elsewhere on the network. Interstitial crime analysis (ICA) is a technique which overcomes this problem and improves the estimation of the spatial distribution of crime on networks when the exact location of offences is unknown, i.e. a crime has taken place at an undetermined location between two points on a network.

Research informs us that a small number of stops and stations on the public transport system are responsible for a disproportionate amount of crime (the so-called '80/20' rule). This is important to acknowledge as the ICA technique seeks to identify the more vulnerable, or risky, sections of a linear network. In turn this facilitates a more informed understanding of where to deploy resources and target crime prevention efforts.

**THEORY**: In the case of residential burglary, victims often find they have been burgled many hours – sometimes days - after they first left their home. This presents an interval of time between the victim leaving home and returning in which the crime could have occurred. In this situation it isn't sensible to use the moment when the property was left unattended, or when the victim returned, as the time of the offence. Mid-points of the time ranges could be used but these would also be inaccurate and possibly distort the analysis. Instead it is much more meaningful to use aoristic analysis which involves interpolating (estimating) between the start and end times of the interval and calculating probabilities of when the burglary could have taken place. Interpolating over a series of crimes provides a richer more intuitive view of when it is most likely crimes could have occurred, compared to relying upon the start and end or mid-points of a given time range. This aoristic approach is the theoretical foundation for the ICA technique, which is used to estimate the location of crimes in the interstices – the intervening spaces - of a network when the location is unknown.

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## Interstitial crime analysis: METHOD (3 of 5)

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**Interstitial crime analysis** (ICA) allows an analyst to identify and map crime concentrations along paths (e.g. sections of a transport network) and connected nodes (e.g. stations and interchanges). Colour and line-width can be used to visualise the results - known as thematic mapping. In this brief we provide an overview of the method; more detailed information can be found in other publications (details of which are in the resources brief).

**DATA REQUIREMENTS:** Two data files are required at a minimum for the analysis:

a)  Crime data with accurate attributes of start node (e.g. station or bus/tram stop), end node, and if relevant, any interchange nodes used to change direction or path within a network; and

b)  A network layer representing the paths and nodes.

**ANALYTICAL PROCESS:** The following steps outline the analytical process to produce an ICA map:

1.  *Preparing the network layer.* This layer should be split into segments between adjacent nodes with unique identifiers assigned to each segment; these need to be created in a GIS.

2.  *Preparing the interstitial values.* Crimes with an unknown location need to be treated differently from those where the location is known (e.g. the theft was noticed by the victim at the time of the offence). In the case of the former, each of the segments of the journey travelled by a victim – including any nodes passed through – need to have a probability value generated for them. The known location crimes can have a value of 1 assigned to the segment or node where the crime was observed to have taken place.

The probability for all the segments is summed over all the offences, and this is totalled for each segment to generate the associated risk. Once completed you should have risk values for each segment representing all the crimes analysed (see figure 2 which illustrates the ICA calculations).
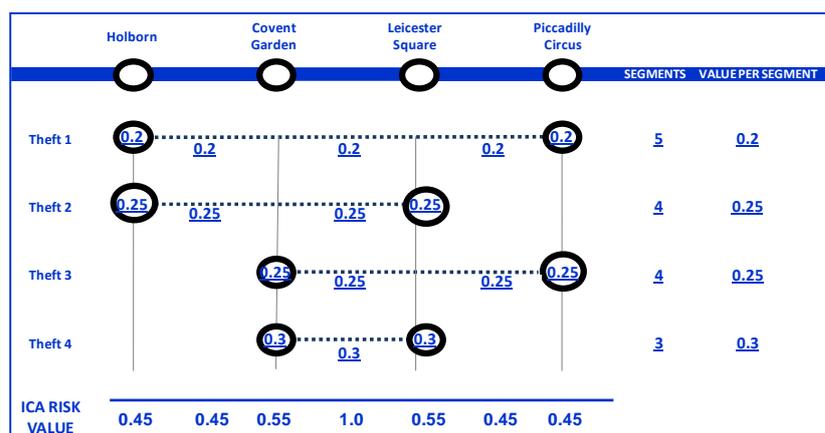


Figure 2 - Example of ICA applied to 4 fictitious thefts upon the London Underground network

**3.**  *Visualising the ICA values.* The interstitial values next need to be joined to the network layer (by the unique identifier common to both data files) in a GIS and visualised with thematic mapping settings. Line thickness and colour can be used to display the variation of ICA values (see figures 3 and 4 in Case Study brief).

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## Interstitial crime analysis: CASE STUDY (4 of 5)

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**APPLICATION**: Since early 2013, the ICA technique has been automated and applied to understand theft offences on the London Underground (LU) network. Theft represents approximately 50% of overall offences recorded by the British Transport Police (BTP) on LU, with more than 75% of these having unknown location and time. The interface (see figure 4) has been designed for ease of use by officers, enabling selections by bespoke time ranges, shift patterns, line and/or station analysis, and bi-directional flows on Underground lines (e.g. north and south on the Victoria Line). Users can also extract details for the crimes by the riskiest segments of interest to them, facilitating further research (e.g. to identify any commonalities between the crimes extracted).
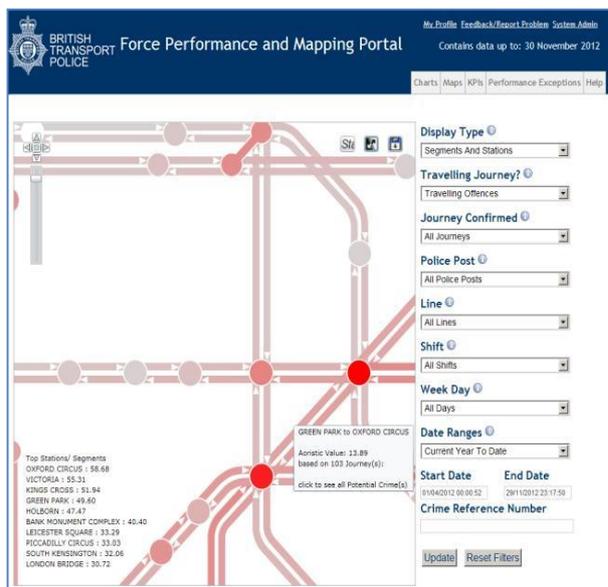


Figure 3 - BTP Force Performance and Mapping Portal
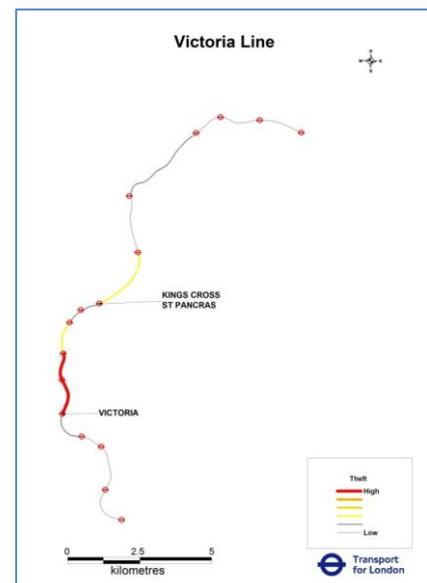


Figure 4 - ICA map

The ICA technique could easily be applied to non-transport related networks, for example, a street network where lots of on-street pickpocketing is occurring. In this instance you would treat junctions/intersections as the nodes in the network layer, and street segments between the nodes as the paths, and then require victims to have precise knowledge of where they last knew they had their belongings before they found them missing (presumed stolen). Similarly, the ICA technique can be applied to crimes other than theft where the victim was travelling along a route.

**DEVELOPMENTS:** The ICA technique can be further developed by incorporating other values to help standardise and provide context to the crime data; Newton and colleagues (details of which are in the resources brief) have done this with volume of passengers exiting and entering stations, and the results generate more representative ICA values. Alternative values could also be used to help refine the analytical model, for example, the time taken to travel between stations upon a network, as the greater the time travelled could present greater risk to victims as offenders have more time to identify a victim and select the most opportune moment to steal items.

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## Interstitial crime analysis: RESOURCES (5 of 5)

Authors: Andy Gill and Henry Partridge, Transport for London,
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**GENERAL RESOURCES**

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- Clarke, R. and Eck, J., (2005) Crime Analysis for Problem Solvers in 55 Small Steps. Washington, D.C.: Office of Community Oriented Policing Services, United States Department of Justice. Available at http://www.popcenter.org/library/reading/pdfs/55stepsUK.pdf

**A SELECTION OF ACADEMIC PAPERS AND BOOK CHAPTERS**

- Ashby, M. and Bowers, K. (2013). A comparison of methods for temporal analysis of aoristic crime. Crime Science Journal. Available at: http://www.crimesciencejournal.com/content/2/1/1

- Loukaitou-Sideris, A. (1999). Hot Spots of Bus Stop Crime: The Importance of Environmental Attributes. Journal of the American Planning Association, 65(4), 395–411. Available at http://www.uctc.net/papers/384.pdf

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- Smith, M. and Cornish, B. (2006): Secure and Tranquil Travel: Preventing Crime and Disorder on Public Transport. London: UCL Jill Dando Institute of Crime Science. Available at http://link.springer.com/article/10.1007/s10610-008-9084-5

- Tompson, L., Partridge, H. and Shepherd, N., (2009) Hot Routes: Developing a New Technique for the Spatial Analysis of Crime. Crime Mapping: A Journal of Research and Practice 1, 77-96. Available at http://discovery.ucl.ac.uk/20057/1/Hot_Routes_Tompson_Partridge_Shepherd.pdf