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ADDRESSING PASSENGER NEEDS DURING UNEXPECTED RAIL DISRUPTIONS – AN INTERNATIONAL SURVEY

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ADDRESSING PASSENGER NEEDS DURING UNEXPECTED RAIL DISRUPTIONS – AN INTERNATIONAL SURVEY

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ABSTRACT

This paper explores how passenger rail transit organisations plan for, communicate with and manage passenger needs during unexpected service disruptions. It includes an international survey of practices from 80 international rail transit agencies and a case study of bus replacement approaches in Melbourne, Australia.

Results suggest only 21% of agencies had parallel transit systems available for disrupted commuters. Track intrusions, medical emergencies, weather extremes, track and rolling stock failures were common disruption causes. Bus bridging was the most common response whilst track crossovers were widely seen as critical to managing responses. Most agencies used available spare buses to source bus bridging vehicles. Only 43% actively retracted buses from existing bus services. It is rare for agencies to have a strategic reserve of buses for bus bridging purposes. The Melbourne case study explored availability and use of replacement buses which was problematic during peaks.

The use of Twitter to inform passengers about disruptions was most prevalent in high-frequency railway systems such as light rail rapid transit, rail rapid transit and suburban railway networks (93%, 66% and 70% using this approach). The real-time nature of Twitter provides the most appeal, particularly given the immediate nature of the communication. Given the bi-directional nature of Twitter, agencies can also monitor commuters' feedback including complaints.

The paper discusses the implications of the study findings for future research and practice.

Keywords: Rail, disruptions, bus bridging, social media

INTRODUCTION

Rail transit networks provide high-capacity performance in cities with high levels of road congestion (De-Los-Santos et al. 2010). Unfortunately trains do not always run on time or at all due to unexpected events (termed disruptions) such as infrastructure malfunctions and extreme weather conditions (Jespersen-Groth et al. 2009). These events can lead to the rapid degradation of service (Kepaptsoglou and Karlaftis 2009) and the impacts can be significant. "When no advance preparations are made, uncoordinated Government responses can combine with tremendous public confusion and uncertainty to leave the urban transportation system in a state of near paralysis" (Meyer and Belobaba 1982, p.1).

Following unexpected service disruptions, establishing alternative transport is one of the main actions undertaken (Boyd et al. 1998). This may include including diverting affected commuters to other operating lines or bridging stations using buses (Kepaptsoglou and Karlaftis 2010). Network topology impacts commuters' ability to transfer to other operating lines as feasible alternatives must exist. Similarly the disruption extent may impact on whether such lines still remain in operation. Alternatively, bus bridging is not affected by network topology, however, key available buses and drivers and the road network structure will dictate its effectiveness (Kepaptsoglou and Karlaftis 2009).

When a train operation is disturbed, passengers are forced to choose the best alternative, which is not easy given that information required for such decision-making is not always available (Tsuchiya et al. 2006). Kepaptsoglou and Karlaftis (2010) noted that the provision (including promotion) of alternate services is critical for both the affected commuters and for the credibility of the public transportation system. Social media has been shown to have particular advantages compared to traditional information systems in communicating with the public in emergency situations (Yates and Paquette 2011). New tools like Facebook and Twitter can enable real-time, two-way communication between large groups of people and agencies dealing with natural disasters and other emergencies (Bruns 2011).

Despite the critical impacts which rail disruptions can have, few studies examine the effectiveness of alternative ways to accommodate disrupted travellers (Janarthanan and Schneider 1984; Tsuchiya et al. 2006).

This paper aims to clarify current practices for managing passenger needs during unexpected rail disruptions using an international survey of current practices and a case study of bus replacement approaches in Melbourne, Australia. It is part of wider research program exploring the management of unexpected rail disruption and updates and expands on previous papers by the authors exploring the field (Pender et al. 2012; Pender et al. In Press).

The paper commences with a summary of relevant research literature. Survey methodology and approaches are then described including the categories of questions asked. This is followed by an outline of the major results. The paper concludes with a summary of key findings and a discussion of their implications for planning and practice.

RESEARCH CONTEXT

The operational performance of railway systems is increasingly a cause for public debate (Jespersen-Groth et al. 2009). Commuters expect to arrive at the published time, however, any service disruption can result in unsatisfied demand and trip delays (Kepaptsoglou and Karlaftis 2010). A disrupted situation is a variation from an original plan requiring significant re-planning (Clausen 2007). Schmocker et al. (2005) categorised three railway incident types: slow-moving delays, minor incidents and major incidents. The latter being the most likely to close track sections. Major incidents such as rolling stock or fixed infrastructure problems are the focus of this paper as they often require the use of alternative transport systems to restore rail connectivity (i.e. bus bridging) (Boyd et al. 1998; Kepaptsoglou and Karlaftis 2009).

Research on the effects of transit service disruption is limited (Balog et al. 2003). Work done by Kepaptsoglou and Karlaftis (2009; 2010), Codina and Marin (2010) and Schmocker et al. (2005) focussed on Metro systems and reviewed recovery strategies. Schmocker et al. (2005) and Pender et al. (2012) noted the importance of crossovers which enable trains to change tracks (Glover 2005) on recovery strategies. Kepaptsoglou and Karlaftis (2009) state that rail agencies still rely on custom-made procedures containing limited suggestions regarding substitute service establishment.

Few studies examine alternative ways of accommodating disrupted commuters (Kepaptsoglou and Karlaftis 2009). Janarthanan et al. (1984) stated that transit agencies should enter into agreements with bus companies to acquire the extra buses required during increased demand. For the successful substitution of disrupted services, rapid implementation of bus bridging routes is required. Not only does this ensure the integrity of the public transport system and the quality of the substitute services, but commuters accumulating on platforms at affected stations can also be problematic from a safety perspective. As noted by Kepaptsoglou and Karlaftis (2009) the arrival time of substitute bus services at affected stations should be minimised and this can be achieved through reserve buses located at depots or through retracting buses from existing routes.

A survey of North American transit agencies found that social media was used to provide agency news, real-time service alerts, promote contests, provide event notices and to provide static service information (Bregman 2012). Although there is an emerging body of research on the uses for social media in transit, comparatively little research exists on the design of social media technologies for emergency management in public transport. Only one recent research project considered social media in rail disruptions and established that Twitter was a better option for communication during disruptions because Facebook was considered better suited for social purposes (Outlook Research Limited 2012). This research demonstrated that trust in information was critical with some passengers commenting that tweets from other passengers to be more reliable than those from the operator. Twitter was considered an important new and growing tool but only one of many required.

A recent London Underground study (Harazeen 2011) suggests that social media is a complement to communicating with passengers during disruptions rather than a replacement. The short and quick focus of 'tweets' mean they can only address limited and immediate information needs. This study highlighted that real-time information was a major passenger need, however, data reliability was a major concern.

In a review of passenger experiences of unplanned rail service disruptions in the United Kingdom (Passenger Focus 2011), the core information needs of customers regarding delays are the length and reason for the delay and what travel alternatives exist (Passenger Focus 2011). Positive experiences were associated with reliable, up-to-date information, empathy and honesty from staff and where appropriate the injection of humour into the situation. In contrast negative experiences were associated with the lack of information and transparency, unsympathetic staff and the provision of excuses rather than information.

The importance of passenger information during service disruptions has led to a code of practice for rail operators in the United Kingdom (Association of Train Operating Companies 2012). This recommends a three step process for the provision of messages to passengers:

1. Problem – what has occurred?
2. Impact – what does it mean for passengers?
3. Advice – what should passengers do?

This code identifies responsibilities for information control and highlights that some aspects of response protocols, such as ticket acceptance, should be pre-agreed to streamline 'real time' responses. Social media is mentioned though no specific advice for its use is made.

METHODOLOGY

Survey Aims

Two surveys were undertaken; an international review of general practices (Part A) and a Melbourne case study examining bus replacement approaches in more depth (Part B).

The survey of international rail operators aims to understand current practice in managing unexpected rail service disruptions. Approaches are disaggregated by rail transit mode using the definitions identified by Vuchic (2005) including:

- **Light Rail Rapid Transit (LT):** Modified Light Rail Transit rolling stock operating on exclusive Right Of Way.
- **Rail-Rapid Transit (i.e. Metro) (RT):** Utilising high capacity electric trains it can involve different support/guidance technology other than rail.
- **Suburban Rail (SR):** Operating through the central city with short headways..
- **Inter-City Rail (IR):** Operating from key regional cities with peak-focussed timetables.
- **Country Rail (CR):** Operating from remote towns that play a commuter/tourist role.

The Melbourne case study (Part B) aims to explore bus replacement approaches in detail.

The focus of both surveys was on unexpected rail disruptions. Planned disruptions (e.g. for track maintenance) were not considered. In addition the research focussed on major incidents where the recovery time or additional timetabled 'slack' time was not sufficient to allow for service resumption (Schmocker et al. 2005).

Survey Approach

A semi-structured interview approach was used as the basis of both surveys. For the international survey of practice, participants from a total of 80 passenger rail transit agencies (representing 102 transit modes) were interviewed from North America, Europe, South East Asia and Australasia during the period of October 2011 to September 2012 (Part A). Participants were selected with the assistance of the American Public Transport Association (APTA) and the International Association of Public Transport (UITP).

For the Melbourne case study (Part B) representatives of 19 bus depots which comprise a total of six bus companies were interviewed.

Semi-structured interviews were utilised given they are usually based upon prior participant observation (Silverman 1993). Denzin (1970) offered three reasons for this preference: they allow respondents to use their unique ways of defining the world, they assume that no fixed sequence of questions is suitable to all respondents and they allow respondents to raise important issues not contained in the schedule. Semi-structured interviews allow probing by the interviewer and interpretative validity, provide in-depth information and are useful for exploration and issue confirmation (Tashakkori and Teddlie 2003). Furthermore they "provide the best opportunity to find out what someone else thinks" (Bouma and Ling 2004, p.177). Finally, the interview should be flexible enough to allow the discussion to encompass relevant areas which may not have been considered prior to the interview (Goulding 2002).

Of the interviews conducted approximately two-thirds were done in person. Given the size and the geography of the sample the remainder of participants were interviewed via email.

For the international survey the interview was structured according to eight categories:

1. Operating Environment;
2. Causes of Unplanned Service Disruptions;
3. Approaches to Unplanned Service Disruptions;
4. Impacts of Crossovers;
5. Approaches to Utilising Rail Replacement Vehicles;
6. Designing Rail-Replacement Routes;
7. Managing the Initial Disruption (Social Media Application); and
8. Challenges in Managing Unplanned Service Disruptions.

Although the authors acknowledge the importance of cost in decision-making during unplanned service disruptions given the associated issues with confidentiality it was not discussed in the survey.

As previous research suggests, cost plays a role in preparing for unplanned service disruptions, however, it generally does not factor into the 'real-time' decision making when immediate solutions are required.

The Melbourne survey focussed more on specific practices for sourcing replacement buses during rail disruptions.

Survey Participants

Table 1 illustrates rail transit agencies who participated including operating region and city. It also illustrates network and environmental characteristics that impact on the management of unexpected disruptions and their likelihood including:

- **Transit Mode** – Highlights the transit modes according to the classification system described in the previous section;
- **Operate Bus** – Identifies rail agencies that also operate a route bus network;
- **Min. 2 Track** – Documents agencies that operate on a network that consists of a minimum of two-tracks i.e. no single track sections;
- **Track Maint.** – Illustrates agencies who are responsible for track maintenance and operations; and
- **Temp. <0°** – Notes the agencies that operate in an environment that can often have temperatures less than 0 degrees.

For the Melbourne case study individual companies are not identified for confidentiality reasons. However all were contracted to provide rail-replacement services to MetroTrains Melbourne or acted to support a contracted bus company.

RESULTS – INTERNATIONAL SURVEY (PART A)

Operating Environment – Presence of Parallel Public Transport

When a rail corridor experiences a disruption, one of the first alternatives is to make use of existing public transport that mirrors the corridor. Figure 1 (a) shows that most agencies surveyed had such systems, however, it often didn't mirror the rail corridor (58%) or had capacity restraints (9%). Only a few agencies (21%) believed that their network had viable parallel alternatives.

Most feasible alternative systems were in inner city areas, and as a result many RT agencies such as the London Underground and the CTA believed that the vast majority of trips completed on their network could be performed by existing bus routes. However, as noted by New York City Transit, the parallel system was usually unable to cope with the additional demand. Other agencies commented that their bus networks were designed as feeder services and the costs associated with operating redundant networks could not be justified.

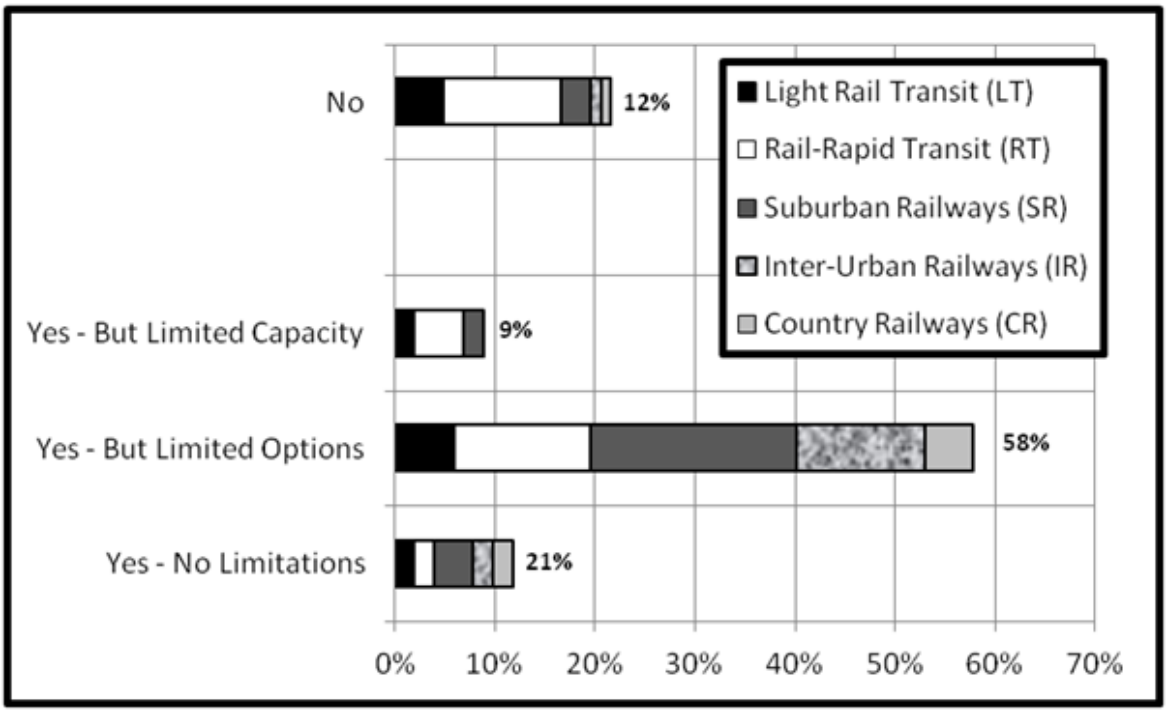
Table 1 – Passenger Rail Transit Agencies Surveyed

	Location	Operator	Transit Mode					Operate bus	Min. 2 Track	Track Maint.	Temp. <0°
			LT	RT	SR	IR	CR				
Australasia	Adelaide	Adelaide Metro			X			X		X	
	Auckland	Auckland Transport			X						
	Australia	GSR					X				
	Brisbane	Citytrain			X	X				X	
	Melbourne	MetroTrains			X					X	
	N. S. Wales	CountryLink					X	X[b]			
	N. Zealand	Tranz Scenic					X			X[e]	
	Perth	Transperth			X			X		X	
	Queensland	Traveltrain					X				
	Sydney	CityRail			X	X		X[a]		X[e]	
	Victoria	V/Line				X	X	X[b]		X	
	W. Australia	Transwa				X		X[b]			
	Wellington	Tranz Metro			X	X				X[e]	
Asia	Bangkok	MRT Bangkok		X						X	
	Kuala Lumpur	RapidKL LRT	X					X	X		
	Taipei	TRTC		X					X[c]		
Europe	Amsterdam	GVB	X	X				X	X	X[e]	
	Athens	Athens Metro		X					X	X	
	Belfast	NI Railways			X	X		X		X	
	Berlin	BVG (U-Bahn)		X				X	X	X	X
	Berlin	S-Bahn Berlin GmbH		X						X	X
	Brussels	STIB		X				X	X		
	Budapest	BKV		X					X[c]	X	X
	Copenhagen	S-Train			X				X[c]		X
	Glasgow	Glasgow Subway		X					X	X	X
	Hamburg	Hamburg S-Bahn		X						X	X
	Ireland	Irish Rail		X	X	X		X[a]	X[d]	X	
	Lausanne	Lausanne Metro	X	X				X	X	X	X
	Lisbon	Metro. de Lisboa		X					X	X	
	Lombardy	Trenord			X	X					X
	London	C2C			X						
	London	DLR	X						X[d]		
	London	East Midlands			X			X[a]	X[c]		
	London	First Capital Connect			X			X	X[c]		
	London	First Great Western			X	X		X			
	London	Greater Anglia			X						
	London	London Midland			X						
	London	London Overground			X			X[a]	X		
	London	London Underground		X				X[a]	X		
	London	Southeastern				X			X[d]		

	Location	Operator	Transit Mode					Operate bus	Min. 2 Track	Track Maint.	Temp. <0°
			LT	RT	SR	IR	CR				
Europe (Cont.)	London	Virgin Trains				X			X		
	Milan	Metro. di Milano		X				X	X	X[e]	X
	Munich	Munich U-Bahn		X				X	X	X	X
	Netherlands	NS				X	X				
	Newcastle	Tyne & Wear Metro		X							
	Paris	RATP		X	X			X	X[d]	X[e]	
North America	Atlanta	MARTA		X				X	X	X	X
	Austin	Capital MetroRail			X			X		X	
	Boston	MBTA	X	X	X			X	X[d]	X	X
	Canada	VIA Rail				X	X				X
	Chicago	CTA		X				X	X	X	X
	Chicago	Metra			X						X
	Cleveland	Grtr. Cleveland RTA	X	X	X			X	X[d]	X	X
	Dallas/Fort Worth	TRE			X					X	
	Houston	METRO Rail	X					X	X	X	
	Los Angeles	LACMTA	X	X				X	X	X	
	Maryland	MARC				X					X
	Mexico City	Mexico City Metro		X					X	X	
	Miami	Miami-Dade Transit		X				X	X	X	
	Montreal	AMT			X						X
	Montreal	STM		X				X	X	X	X
	New Jersey	New Jersey Transit			X			X			X
	New York	Long Is. Rail Road			X					X[e]	X
	New York	Metro-North Railroad			X					X[e]	X
	New York City	NY City Transit		X				X	X	X[e]	X
	New York City	PATH		X					X		X
	New York City	Staten Island Railway		X					X	X[e]	X
	Pennsylvania	SEPTA	X	X	X			X	X[d]	X	X
	Penn./New Jersey	PATCO Speedline		X					X	X	
	Portland	MAX Light Rail	X					X	X[c]	X	X
	San Diego	San Diego Trolley	X					X		X	
	Santa Clara	VTA	X					X		X	X
	Seattle	Sound Transit	X						X	X	
	St. Louis	Metro Transit	X					X	X[c]	X	X
	Toronto	GO Transit			X			X			X
	Toronto	TTC		X				X	X	X	X
	USA	Amtrak				X	X				X
	Vancouver	SkyTrain	X					X[a]		X[e]	
	Virginia	VRE				X			X		X
	Washington DC	WMATA		X				X	X	X	X

Note: [a] Buses operated by a sister/parent company; [b] Operates buses but not an option during disruptions; [c] Less than five percent of the network is single track; [d] LT and RT networks are completely double track; and [e] Parent company is responsible for track maintenance.

(a) Presence of Parallel Public Transport – Share of Agencies Surveyed by Mode



(b) Causes of Unexpected Service Disruptions – Share of Agencies Surveyed by Mode

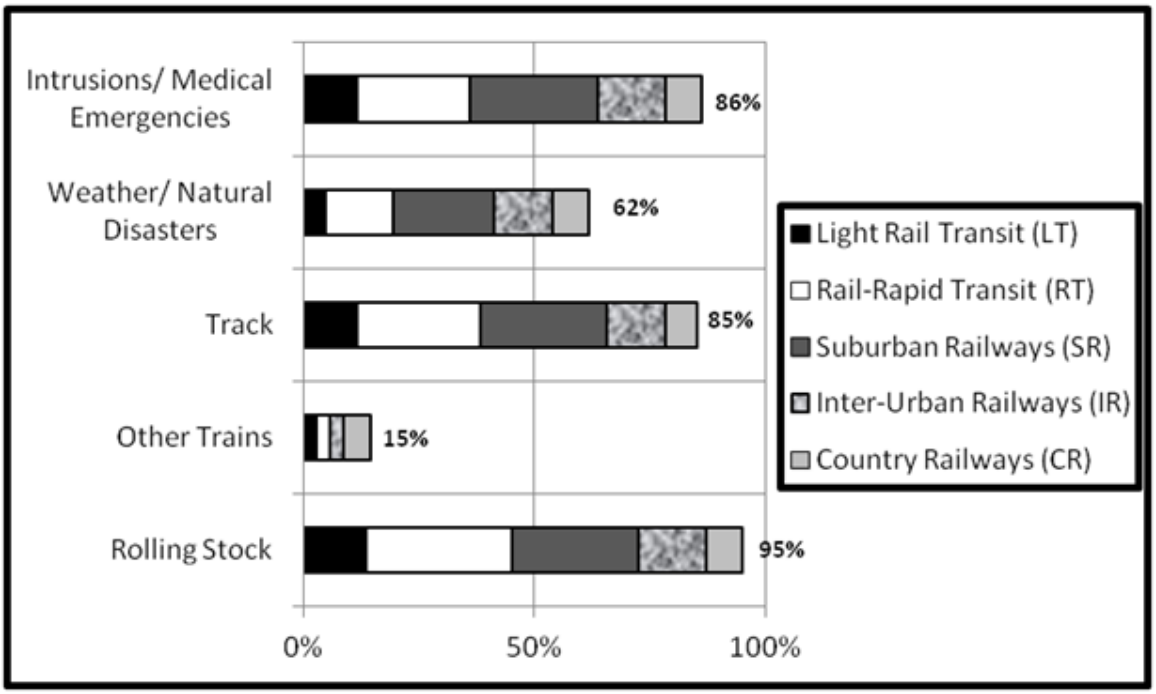


Figure 1 – International Survey Responses – Parrallel Public Transport and Disruption Causes

Figure 1 – Presence of Parallel Public Transport

In North American and European cities where the inner suburbs are serviced by a RT network and the outer suburbs by a SR network, often these networks would mirror each other in the downtown areas. Often this overlap would provide alternative public transport when one network experienced a disruption. On the rail corridor between Newark, New Jersey and Manhattan, New York, PATH Transit and New Jersey Transit will direct their commuters to the alternative provider during network disruptions.

On IR or CR networks operating between key cities and provincial towns, a highway network containing existing bus services often replicates the rail corridor. However limited hours of operation of the bus service often meant that an alternative was not available during the initial stages of an unplanned service disruption.

Causes of Unplanned Service Disruptions

Disruptions causes are summarised according to five categories:

- Intrusions/Medical Emergencies – suicides, crossing incidents and sick passengers;
- Weather/Natural Disasters – extremes of weather and natural disasters;
- Track Failure – track-related issues relating to power, signalling and crossovers;
- Other Train Failures – disruptions caused by other passenger or freight trains; and
- Rolling Stock Failures – ranges from door obstructions to train failures.

Figure 1 (b) shows that most of these causes, except for 'other train failures' were shared equally. Rolling stock and track problems are generally more likely to result in a service delay, whilst intrusions/medical emergencies and weather/natural disasters often result in a line closures. The occurrence of suicides is quite prevalent and these often result in the longest delay before service resumption given the presence of the police and coroners.

Disruptions relating to weather or natural disasters can similarly result in long periods of delay before service resumption. However, often after the initial disruption (i.e. the unplanned portion), the responses become planned. The Metro-North Railroad referred to their Port Jervis line affected by Hurricane Irene in August 2011. It was three months before normal services resumed and during the interim planned rail-replacement services were provided.

Approaches to Unplanned Service Disruptions

The approaches to unplanned service disruptions varied according to whether there was a train failure or complete line blockage. The key responses were as follows:

- Train Failure:
    - Commuters to make use of alternative transport;
    - Altering train stopping patterns;
    - Transferring disrupted commuters to the next train;
    - Sacrificing operating lines to make rolling stock available to aid disruption;

  - Using spare locomotives to move disrupted trains or 'gap trains' to provided additional service; and
  - Balancing out the frequency/headway of the remaining train service.
- Line Blockage:
  - Single tracking i.e. bypassing disrupted train/s or areas using crossovers;
  - Re-routing trains onto other operating train lines of the same network;
  - Diverting disrupted commuters to other operating lines;
  - Diverting disrupted commuters onto other parallel public transport services;
  - Improving frequencies of existing bus routes in the vicinity of the disruption;
  - Bus bridging;
  - Hiring taxis;
  - Chartering planes (option for CR networks); and
  - Suspending service and offering no alternatives to disrupted commuters.

Figure 2 illustrates the dominance of bus bridging as a solution (86%). However, it is worth noting that often agencies apply multiple approaches based on the location, time, expected disruption duration period and the incident nature (disruption characteristics).

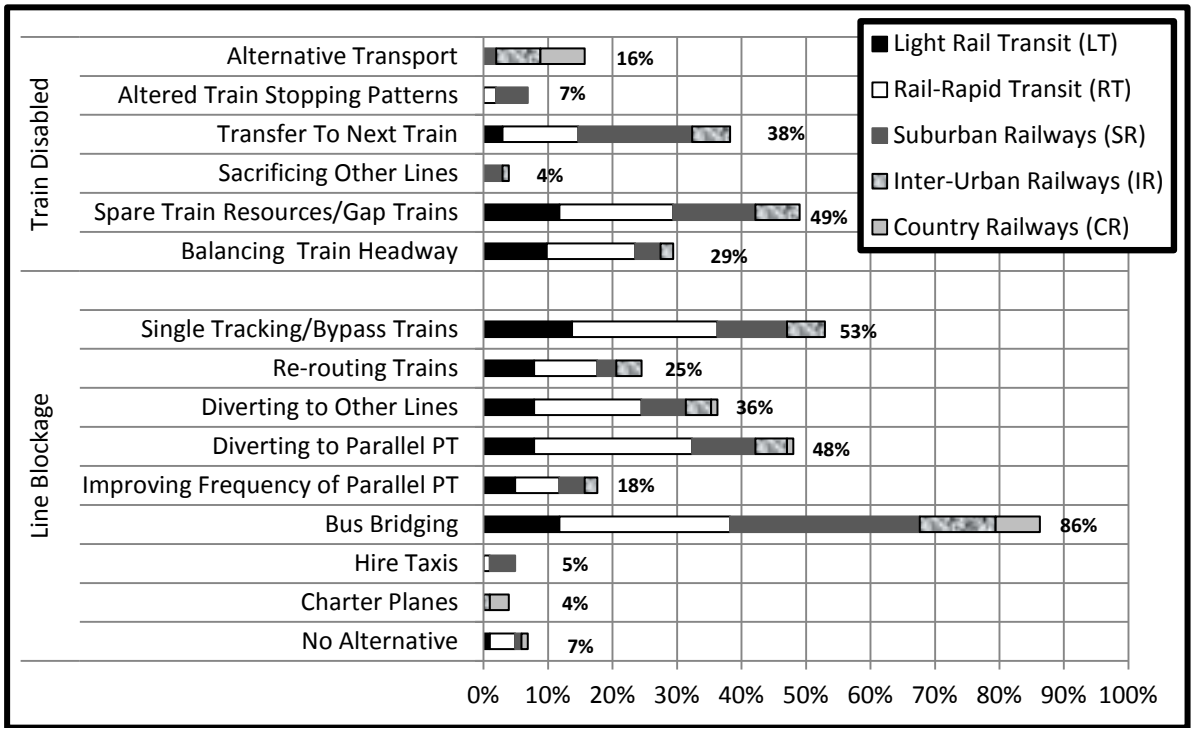


Figure 2 – Approaches to Unexpected Service Disruptions - Share of Agencies Surveyed by Mode

Australasian rail networks surveyed viewed bus bridging as the main alternative. Similarly, the SR, IR and CR networks of Europe and North America showed greater preference to bus bridging but again its utilisation depended on the disruption characteristics. These operators demonstrated a strong preference to 'bus bridge' to other operating lines. Metra noted, "to provide a replica service into downtown Chicago with buses would require significantly more resources than to provide a shuttle service to outer termini on the CTA network."

RT agencies such as the London Underground try to manage unplanned disruptions without bus bridging and when buses are required it is often to provide capacity on parallel bus routes. Similarly NY City Transit stated, "we really avoid buses, especially in emergencies. The fact is that we do not have the ability to get our hands on enough buses fast enough." PATH commented, "we will run on every portion of this railroad that we can during a disruption." Given the high service frequencies of RT networks, a common approach is to remove disrupted trains from service and then balance the frequency.

PATH Transit, TTC, WMATA and Metropolitano de Lisboa have 'gap trains' that act as an automatic replacement for train failures. Greater Anglia, New Jersey Transit and Trenord have staffed reserve locomotives, to move disrupted trains and therefore avoid the likelihood of further disruptions. Alternatively, the Docklands Light Railway and Southeastern Railway will often join a preceding service with the disrupted train to remove it from service.

Impacts of Crossovers

Recent research has illustrated the important role that track crossovers play in managing disruptions (Pender et al. 2012) because trains can alight passengers at platforms at crossovers and also maintain a to/from service to stations with crossovers because trains can "turn around" at crossover tracks at these locations. This also naturally becomes the point where replacement bus services would operate from.

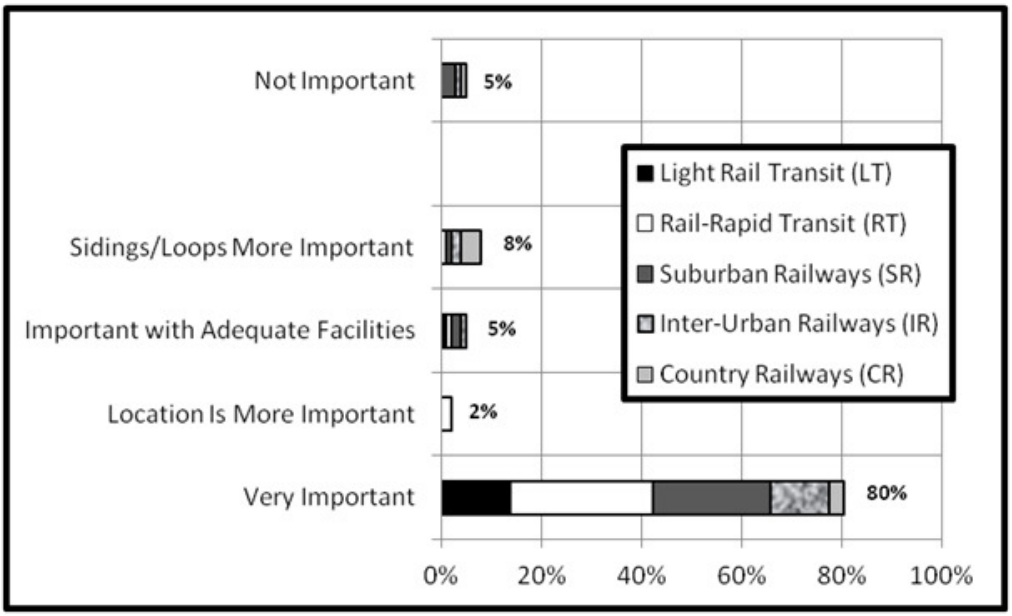
The survey corroborated this, Figure 3 (a), with 80% of respondents stating they are very important to managing disruptions.

> *"Multiple crossovers mean that a minimum of route km is lost due to individual disruptions. They allow maximum flexibility in times of disruption given that they are all designed for high frequency operations when required."*
> *(Docklands Light Railway, UK)*

Long Island Rail Road commented, "I've never met a crossover I did not like." Similarly Adelaide Metro stated: "they are critical and you can never have enough" and Auckland Transport noted: "they aid bi-directional running by allowing trains to bypass disruptions".

RT networks had a greater appreciation of crossovers given their importance in recovery techniques (i.e. single-tracking). In this context MARTA noted, "Crossovers are very important for operational flexibility. It allows you to lessen the impact of the disruption by allowing to single track instead of a bus bridge. In the event you have to perform a bus bridge, the locations allow for the shortening of the distances on the bus bridge." Australasian agencies noted the role that crossovers play when designing and implementing rail replacement routes. The operators of CityRail stated, "they are key; we can only really start and terminate replacement routes at crossover locations." However, Citytrain, commented, "but often they do not marry up with station infrastructure i.e. bus interchanges."

(a) Impact of Crossovers on Disruption Management - Share of Agencies Surveyed by Mode



(b) Likelihood of Crossovers Causing Disruptions - Share of Agencies Surveyed by Mode

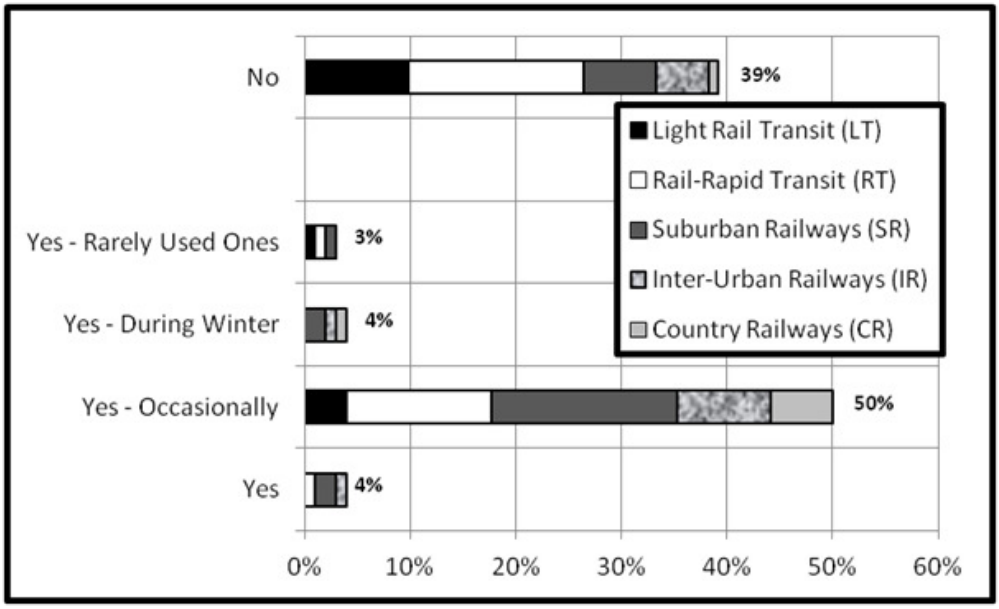


Figure 3 – Impact of Crossovers and Likelihood of Crossovers as a Cause of Disruption

Crossover provision is influenced by the balancing act that exists between the ability to respond to disruptions and their maintenance costs. SEPTA's representative stated that "some of our lines have universal crossovers so that we can go from one track to the other. They are a control centre's dream, however, they are track department's nightmare because they have to maintain them."

Figure 3 (b) demonstrates half of the respondents said that crossovers occasionally cause disruptions. STIB stated, "It's a fake argument. It's a question of maintenance." PATH surmised most agencies thoughts: "the network flexibility provided by crossovers far outweighs their failures", Long Island Rail Road noted that crossover failures only have to happen once and they are not utilised. London Underground added, "if you use crossovers that are infrequently used, invariably they might fail." Docklands Light Railway added, "less frequently-used elements are likely to fail if heavily used without preparatory maintenance. This is mitigated by regular exercising of all crossovers and regular maintenance cycles." GO Transit and Metra had experienced problems with crossovers in winter and invested in heaters, whilst NS adopts a pro-active mitigation strategy during such periods by closing line sections according to crossover location.

Approaches to Utilising Rail-Replacement Buses

Excluding MRT Bangkok which does not employ bus bridging, most agencies (90%) used buses not required in service when sourcing replacement buses (Figure 4). Reserve buses kept for this purpose are rare. WMATA keep 25 'strategic' buses to aid bus operations which often assist in disruptions. Adelaide Metro, which is currently electrifying most of its network, have 70 buses for planned closures which are utilised in unplanned disruptions. C2C's bus supplier is primarily a bus dealer and will have 25 to 30 buses available at all times.

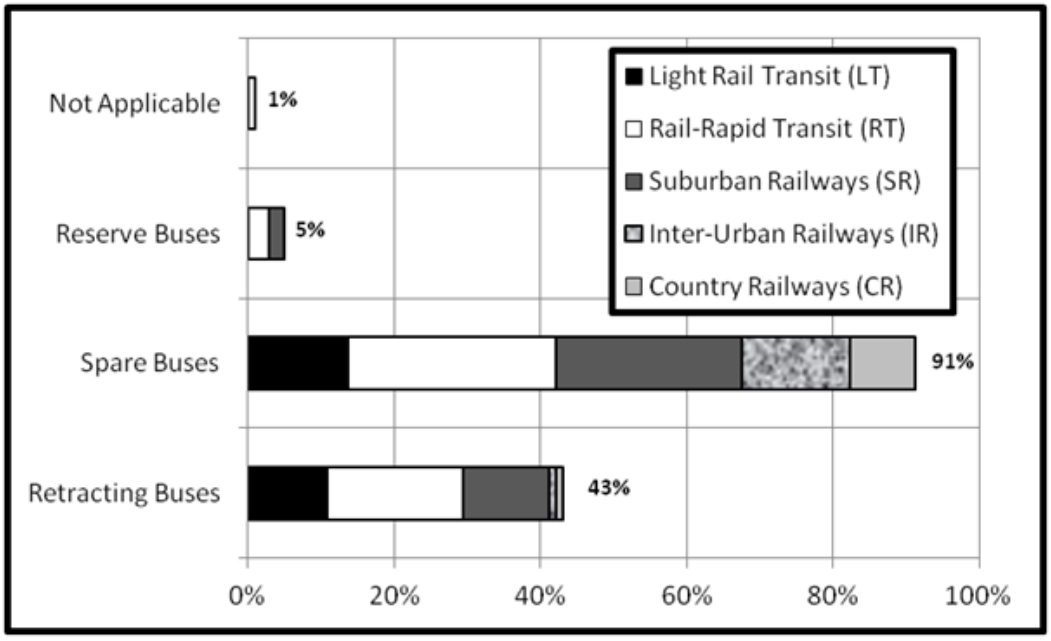


Figure 4 – Approaches to Utilising Rail-Replacement Buses - Share of Agencies by Mode

Some organisations have 'reserve standards.' STIB specifies two buses within 15 minutes of a disruption, whilst MetroTrains Melbourne specifies five buses within 30 minutes. In this respect Metro North Railroad state, "when you design the contract the expectation is that the companies have X number of buses and they are available 24 hours a day, seven days a week. That's not necessarily the case. You just do the best with the resources you have."

Sourcing buses is most problematic in peak periods. Often the only option is to retract buses from scheduled routes with high service frequencies or in close disruption proximity. This is quite common with agencies responsible for both train and bus networks, although as noted by the TTC, "you may in fact be simply shifting the problem or causing additional ones."

Designing Rail-Replacement Routes

Approaches to rail-replacement route design are influenced by network and disruption characteristics. At Transperth efforts are made to ensure those travelling the furthest travel the quickest. MetroTrains, like other agencies, often bus commuters to adjacent operating lines. Metra make use of CTA by bussing commuters to their network; thus reducing bus requirements. Most organisations preferred to minimise rail-replacement journeys at the expense of transfers. RATP commented that maximising train usage minimised bus requirements given it is impossible to replace disrupted train capacity. St Louis Metro added:

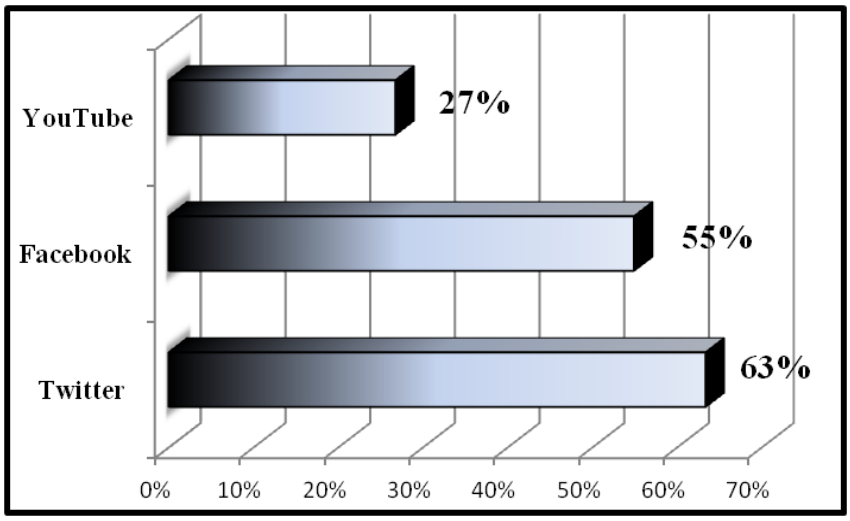
> *"Bus routes could never be a viable alternative by virtue of the loads involved. That is why, every effort is made to maintain rail service on both sides of the disruption, thus reducing the extent of the portion to be 'bridged' by the bus shuttle service. Short 'round trip cycle time' of these bus bridge shuttles is a key element in managing such disruptions and the customer experience."*
> *(St Louis MetroLink, USA)*

Customer Communication (Social Media Applications)

Figure 5 (a) illustrates social media use by agency in the management of unplanned service disruptions. The use of Twitter was preferred (63%) whilst Facebook was similarly supported (55%). The use of both would be a reflection of their real-time nature unlike YouTube (27%) which was applied predominantly to planned disruptions. Figure 5 (b) highlights that LT networks demonstrated a greater preference towards Twitter use (93%). Overall higher frequency transit modes illustrated a stronger preference to social media than CR networks where train frequencies are lower. Given these networks' high frequencies of these networks, the volume of commuters carried and the need to communicate in real-time, social media provides the perfect platform to execute this information delivery.

London Midland commented on the invaluable nature of social media, Sound Transit stated that it was integral in their communications plan, whilst NI Railways noted that there was now an increased level of expectation in respect to the information available via these sources. Social media is becoming increasingly popular. C2C is approaching nearly 5,000 followers since starting their Twitter feed in September 2011, whilst Rapid KL LRT has 70,000 Twitter followers although this is for the entire Rapid KL system including buses.

(a) Use of Social Media during disruptions - by Type



(b) Use of Social Media during disruptions - by mode

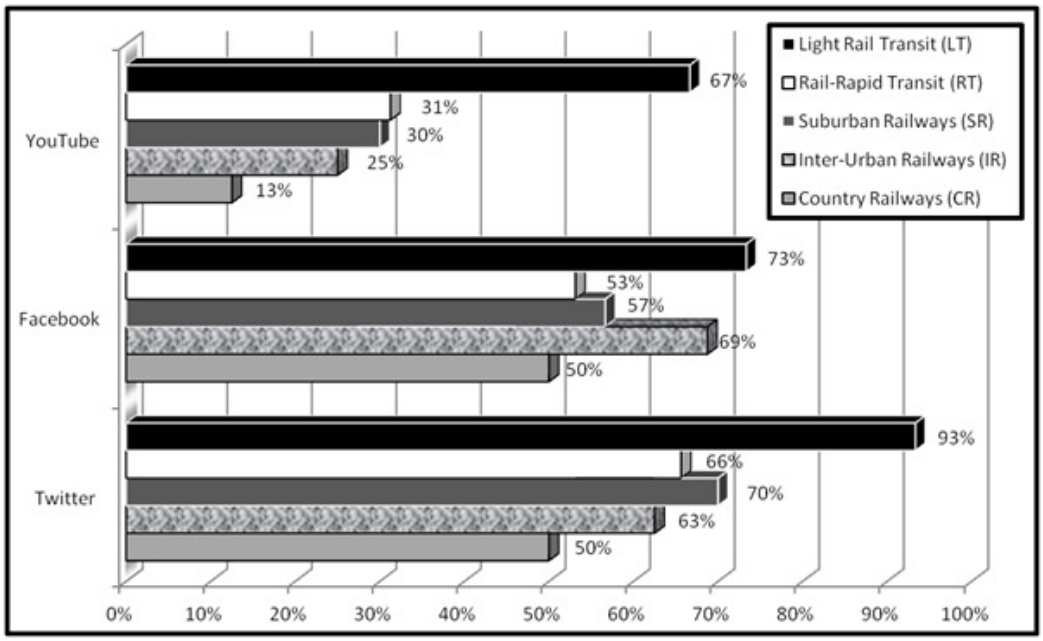


Figure 5 –Social Media Practices

MRT Bangkok noted the importance of Facebook and Twitter when communicating with commuters during the 2011 Bangkok floods. Greater Anglia highlighted that Twitter allows them to receive commuter feedback and communicate with individuals in the real-time. VIA Rail commented that when tweets are received they will assign staff to monitor these tweets and interact with commuters. Transport for New South Wales (TfNSW), highlight that their various Twitter feeds are updated manually whenever there is a disruption above a certain threshold on each mode, i.e. delays on at least five services are in excess of five minutes late. On some occasions, the commuters on the affected train may actually find out information sooner than the staff on board the train, a fact supported by Rapid KL LRT.

Transit agencies detailed the benefits of social media in terms of reducing the flow-on effects of disruptions. Long Island Rail Road highlighted this problem by stating "you can't bus a rush hour, as you cannot bus a train with 1,000 people on board, and you never will." NY City Transit added "social media allows you to evaporate your market. In the past we assumed that no matter what you did, the rush hour was going to descend on you. You can now make the rush hour go away." AM peak disruptions are often easier to manage given that people at home can more easily organise alternatives or travel to undisrupted rail corridors.

TTC noted that irrespective of the situation, the number one component is communication, i.e. making sure your customers know what their options are. Similarly TfNSW highlight that the biggest challenge in this respect is ensuring the most accurate information is conveyed in a timely manner. In a complex operational environment where there are multiple stakeholders and situations that are often changing, it is a significant challenge to have accurate and useful information given to the public in a very short period of time.

Challenges in Managing Unplanned Service Disruptions

Although numerous challenges were identified, the difficulty of effective communication was most prevalent. WMATA surmised: "it is really understanding the situation and understanding what is going to happen." Similarly PATH commented, "it is the flow of your customers and getting information to them in a timely and accurate manner. We can move trains the way we need, it is just getting the right information to customers."

Some agencies additionally noted the challenges associated with service resumption and recovery. Greater Anglia stated their key challenges as, "speed of response, being consistent and trying to get the network back to 'right time' as soon as possible", whilst RapidKL LRT highlighted that being able to resume service promptly and safely is often quite demanding. FCC also placed emphasis on the subsequent days of operation being potentially disrupted given trains may not be at the locations where required.

RESULTS – MELBOURNE CASE STUDY (PART B)

MetroTrains operate Melbourne's suburban railway network including 203 six-carriage electric trains across 830 track kilometres servicing more than 230 million annual customer journeys over 215 train stations (MetroTrains 2012). MetroTrains does not operate buses, so to manage disruptions they have divided their network into four regions and then contracted each region to a private bus operator who are responsible for bus bridging provision.

In total these four companies operate out of 17 depots dispersed throughout Melbourne's suburbs. At each of the participating depots, company representatives were asked how they source buses during periods of unplanned service disruptions to the MetroTrains network. The responses are highlighted in Table 2, which also includes two companies/depots that are commonly used to sub-contract to two of the four companies in question.

Table 2 –Share of Depots Sourcing Replacement Buses by Source Option and Time of Weekday (Melbourne, Australia Case Study)

Resource Sourcing Options		School Term Weekdays							
		5am	8am	10am	1pm	3:30pm	6pm	10pm	12am
Route Buses	Contracted	33%	-	78%	78%	-	67%	67%	56%
	Spares	22%	67%	-	-	67%	-	-	-
	Returning	-	22%	-	-	22%	56%	67%	56%
School Buses	Contracted	78%	-	56%	56%	11%	44%	22%	22%
	Spares	-	67%	-	-	56%	-	-	-
	Returning	-	33%	-	-	22%	67%	-	-
Charter Buses	Contracted	78%	-	56%	56%	11%	44%	22%	22%
	Spares	-	67%	-	-	56%	-	-	-
	Returning	-	11%	-	-	11%	56%	22%	22%
Reserve Buses		11%	33%	11%	22%	22%	11%	-	-
Workshop Buses		33%	56%	-	-	56%	-	-	-

Note: multiple choices are possible for sources so column % do not add up to 100%

The options for sourcing buses were categorised according to whether buses were designated for route, school or charter operations, as a fleet reserve for disruptions or as workshop vehicles. The categories defined route, school and charter buses were further sub-divided according to whether they were a contracted bus, an operational spare bus or a bus returning from service. In this context contracted buses refer to the maximum peak vehicles required to operate the daily operations. Therefore they are only an option for sourcing buses outside of the school term peak operating hours. Given sourcing buses is not an issue on weekends, public holidays or school vacation periods these day types were not considered.

The peak periods are the most problematic when sourcing buses. These are the only periods when 'workshop' buses may be reinstated. Reserve buses do exist at some depots. One depot has set aside five 'retired' buses in excess of their daily requirements. This has been done in accordance with the minimum disruption reserve standards, i.e. five buses within 30 minutes. Other depots use 'decommissioned' vehicles, awaiting sale and/or disposal.

During peak periods, depots will often make use of spare buses irrespective of service type, whilst during the inter-peak periods it is 'spare' contracted buses that are used. Making use of sub-contractors or other 'company' depots can also assist in sourcing the buses required during peak periods. A common approach for replacing the first few trains of a morning is to make use of school and/or charter buses that may not be required to later. This provides an immediate solution and once implemented depots will then try and replace their normal scheduled services and if not possible they will often have to retract these buses from rail-replacement duties. Buses returning to the depot from scheduled operations is a common approach to sourcing buses during the evening peak and this trend continues into the night when contracted buses that are now no longer required for services are often the first option.

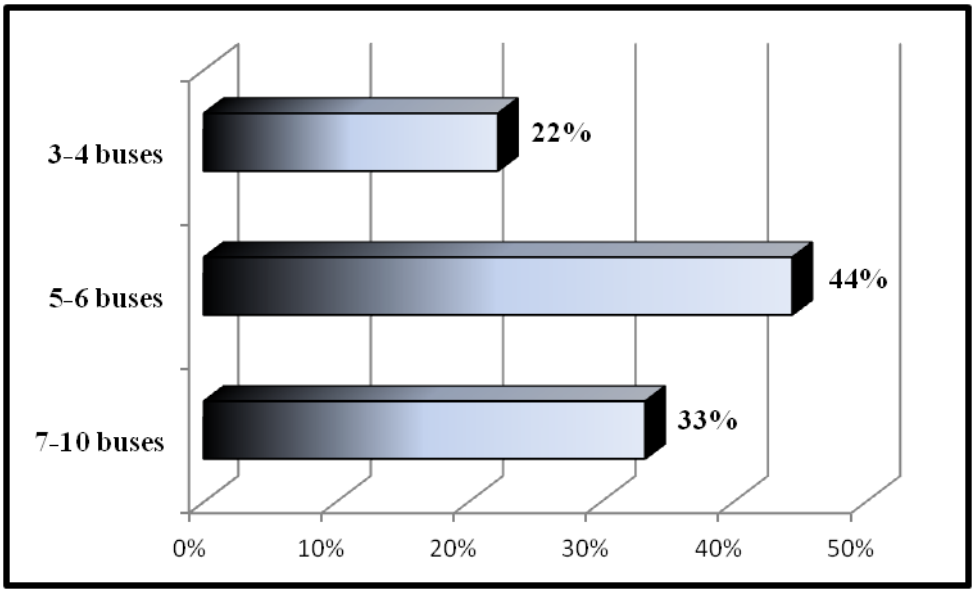


Figure 6 – Average Number of Buses Required for Bus Replacement Per Disruption
(Melbourne, Australia Case Study)

Figure 6 illustrates the average bus requirements placed upon the depots when required to provide replacement services. Slightly less than half of depots (44%) stated an average requirement was 5-6 vehicles. Given the average crush carrying capacity of one train is 1,500 commuters and the average bus capacity is 70 passengers it suggests replacement buses cater for 30% of the capacity of one train. It would be less if multiple trains are involved. It implies that a high share of disrupted rail passengers find their own means of completing journeys rather than waiting for bus replacement service.

DISCUSSIONS AND CONCLUSION

This research paper explores approaches to unexpected rail service disruption management through an international survey and a case study of Melbourne's rail network. The international survey suggests that mode type influenced service disruption approach. LT and RT networks often used parallel transport networks during disruptions and were more likely to use crossovers to bypass incidents or disrupted trains. Alternatively, IR and CR networks demonstrated a preference towards bus bridging but acknowledged that the disrupted demand was never satisfied. The vast majority of agencies highlighted the importance of crossovers and thought they were unlikely to cause disruptions; however, a number in colder climates commented on the increased failure likelihood during snowfall. Rolling stock problems and track intrusions were listed as key causes of unplanned disruptions.

Very few cities were fortunate enough to have reserve buses to replace disrupted train services. In some networks there were gap trains, whilst other networks had reserve locomotives located strategically to move disrupted trains. In respect to sourcing additional buses, retracting buses from existing routes was often a viable alternative. This tended to be common in cities where the rail transit agency was also responsible for a bus fleet.

This research paper also investigated the role that social media plays in the management of unplanned service disruptions. Twitter was found to be the most commonly used; the real-time nature of Twitter being a key reason for its popularity. The results of the survey highlighted that social media can reduce the severity and consequences of unplanned disruptions. Twitter's interactive nature resulted in affected commuters quickly relaying incident details to rail agencies. Information delivery was acknowledged as one of the biggest challenges faced by the agencies surveyed. Unfortunately very little related research has been conducted and as a result, little is known regarding information delivery to affected commuters, despite its importance. Some agencies additionally highlighted issues associated with service resumption and the flow-on effects to future days of operation.

The Melbourne case study explored bus availability for rail replacement service. Peak vehicle availability was particularly problematic and proved a time when a rail replacement fleet could be warranted. It also demonstrated that bus replacement service is designed to cater for only a share of the disrupted rail passenger market since many passengers find their own ways to complete journeys rather than wait for replacement buses.

Participants in both studies noted it is very difficult to apply a 'science' to the approaches adopted during unexpected rail service disruptions. It was, however, apparent that there were similarities between solutions adopted according to both transit mode and the disruption characteristics. Ultimately any disruption can be categorised according to type, location, time and duration and it is hoped that the work done to date will provide greater assistance in dealing with an often problematic area. Most organisations commented, "we think we do it well but we are never really sure." Unexpected disruptions by their very nature are unexpected events, however, preparations can be made to minimise their impacts.

REFERENCES

Association of Train Operating Companies (2012). Approved Code of Practice - Passenger Information During Disruption, Association of Train Operating Companies, UK. **March 2012**.

Balog, J., A. Boyd and J. Caton (2003). The Public Transportation System Security and Emergency Preparedness Planning Guide. Report DOT-VNTSC-FTA-03-01. Washington DC, USA.

Bouma, G. and R. Ling (2004). The Research Process. South Melbourne, Australia, Oxford University Press.

Boyd, A., P. Maier and J. Caton (1998). Critical Incident Management Guidelines. Report FTA-MA-26-7009-98-1. Washington DC, USA.

Bregman, S. (2012). Uses of Social Media in Public Transportation - A Synthesis of Transit Practice. Transit Cooperative Research Program. Transportation Research Board. Brighton, Massachusetts, USA.

Bruns, A. (2011). Tracking Crises on Twitter: Analysing #qldfloods and #eqnz. Emergency Media and Public Affiars Conference. Canberra.

Clausen, J. (2007). Disruption Management in Passenger Transportation - from Air to Tracks. 7th Workshop on Algorithmic Approaches for Transportation Modeling, Optimization and Systems. Technical University of Denmark**:** 30-47.

Codina, E. and A. Marin (2010). A Design Model for The Bus Bridging Problem. 12th World Conference on Transport Research. Lisbon, Portugal.

De-Los-Santos, A., G. Laporte, J. Mesa and F. Perea (2010). "Evaluating Passenger Robustness in a Rail Transit Network." Transportation Research Part C.

Denzin, N. (1970). The Research Art in Sociology. London, England., Butterworth.

Glover, J. (2005). Modern Railways - Dictionary of Railway Terms. Surrey, England, Ian Allan Publishing Ltd.

Goulding, C. (2002). Grounded Theory: A Practical Guide for Management, Business and Market Researchers, . London, England, SAGE Publications Inc.

Harazeen, S. (2011). Effects of information on decisions of passengers during service disruptions. Msc, University College London.

Janarthanan, N. and J. Schneider (1984). "Computer Aided Design as Applied to Transit System Emergency Contingency Planning." Computer Environment Urban Systems **9**(1): 32-52.

Jespersen-Groth, J., D. Potthoff, J. Clausen, D. Huisman, L. Kroon, G. Maroti and M. Nielsen (2009). "Disruption Management in Passenger Railway Transportation." Lecture Notes In Computer Science **5868**: 399-421.

Kepaptsoglou, K. and M. Karlaftis (2009). "The Bus Bridging Problem in Metro Operations: Conceptual Framework, Models & Algorithms." Public Transport **1**(4): 275-297.

Kepaptsoglou, K. and M. Karlaftis (2010). A Model for Analyzing Metro Station Platform Condition Following a Service Disruption. Intelligent Transport Systems (ITSC) 13th International IEEE. Madeira Island, Portugal**:** 189-1794.

MetroTrains. (2012). "About Us." Retrieved 15th October, 2012, from http://www.metrotrains.com.au/About-Us/Overview.html.

Meyer, M. and P. Belobaba (1982). "Contingency Planning for Response to Urban Transportation System Disruption." Journal of the American Planning Association **48**(4): 454 - 465.

Outlook Research Limited (2012). Short and Tweet - How passengers want social media during disruption. London, UK, for Passenger Focus and Abellio, UK.

Passenger Focus (2011). Information: Rail Passengers Needs During Unplanned Disruption - Qualitative Research. London, UK, http://www.passengerfocus.org.uk/media/dca7e0b50f3ad90e6475953c74997ea3c4b0fa59/pf_unplanned_disruption_report__final.pdf. (Last accessed July 2012)

Pender, B., G. Currie, A. Delbosc and N. Shiwakoti (In Press). If you fail to plan you plan to fail: a survey of passenger rail disruption recovery practices. Transportation Research Board Annual Meeting. Washington DC.

Pender, B., G. Currie, A. Delbosc and Y. Wang (2012). "Pro-Active Rail Disruption Recovery Using Track Crossover Provision and Bus Bridging." Transportation Research Record **2275**.

Schmocker, J.-D., S. Cooper and W. Adeney (2005). "Metro Service Delay Recovery: Comparison of Strategies and Constraints across Systems." Journal of Transportation Research Board: 30-37.

Silverman, D. (1993). Interpreting Qualitative Data: Methods for Analysing Talk, Text and Interaction. London, England, SAGE Publications Inc.

Tashakkori, A. and C. Teddlie (2003). Handbook of Mixed Methods in Social and Behavioural Research. Thousand Oaks, USA, SAGE Publications Inc.

Tsuchiya, R., Y. Sugiyama, K. Yamauchi, K. Fujinami, R. Arisawa and T. Nakagawa (2006). Route-choice Support Sysetm for Passengers in the Face of Unexpected Disturbance of Train Operations. Computers in Railways X: Computer System Design and Operation in the Railways and Other Transit Systems. J. Allan. Boston, USA, WIT Press.

Vuchic, V. (2005). Urban Transit: Operations, Planning and Economics. Hoboken, New Jersey, USA, John Wiley & Sons Inc.

Yates, D. and S. Paquette (2011). "Emergency Knowledge Management and Social Media Technologies: A Case Study of the 2010 Haitian Earthquake." International Journal of Information Management **31**: 6-13.