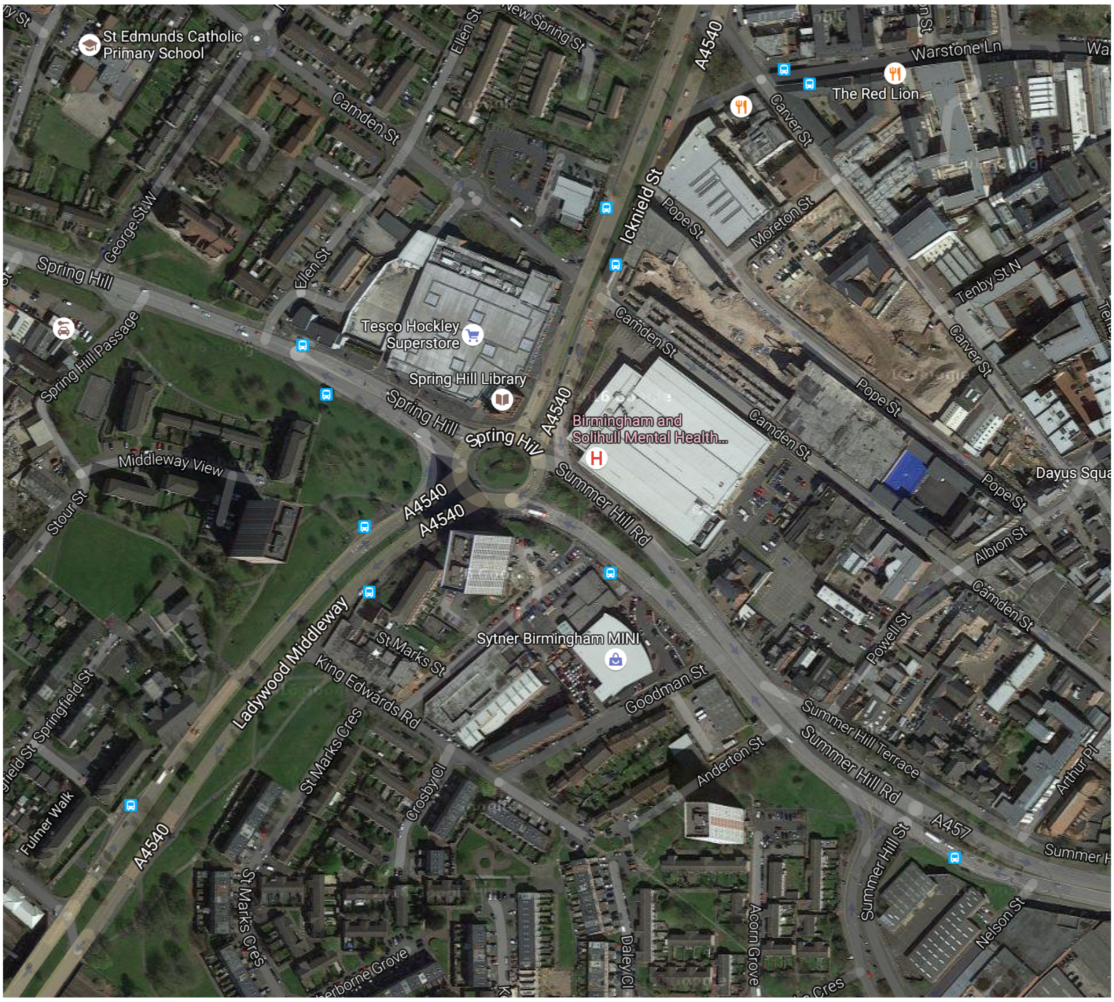
Spring into Summer: Automatic entry balancing on the Springhill Roundabout

Spring Hill Roundabout is in a particularly strategic location in the Birmingham road network. Major redevelopment both ongoing and planned in the area have made the location even more dynamic with changing traffic patterns. The site is very close to the Paradise Circus redevelopment and the NIA. It is one of the main routes to get to the Jewellery quarter and a significant daily commuter route.



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Objective

Investigate and find a solution for dealing with increased and changing traffic patterns at this roundabout to help cope with upcoming major events and roadworks around the city.

It was investigated if there should be a full signalisation scheme as this would be the most flexible solution. It was quickly ascertained that due to the amount of services in the area, the layout of the existing roundabout and cost/time constraints this was unfeasible. The project would have been large scale and caused major disruption in an area already under load from other projects. There had previously been an upgrade scheme looked into with a proposed design that investigated fully signalising the roundabout. This gave us very good insight into what would be involved without needing to spend time creating design iterations.

Design

It became apparent that the only way we were going to be able to offer any kind of control was to utilise the points of the existing infrastructure, namely entry and exit crossings on all arms. Equipment was close to end of life so was decided to upgrade all crossings and use them to gate traffic onto the roundabout. I wanted this to be adaptive and respond to demand as it happened, effectively automatically balancing each approach. This is much preferred to setting up timetabled demands and stage holds as demand was shifting around as works in the area progressed, closures were put in place nearby and major events were happening. The requirement of the system was to create gaps for approaches to maintain a desired level of occupancy, or degree of saturation on all arms by monitoring flow on the approaches.

We also produced a revised road marking scheme on the gyratory to update the spiral markings. This was a useful addition to the scheme as it improved the throughput of vehicles on the roundabout helping to achieve clearance of the circulatories more quickly. This was seen to have a big impact on the general performance of the roundabout. The previous markings were tired and there was some confusion shown by motorists, particularly with vehicles from Ladywood Middleway going straight on to Ickneild Street or turning right into Summer Hill. Design work for the road markings was completed by Derrick Witts at Aspect Traffic Solutions

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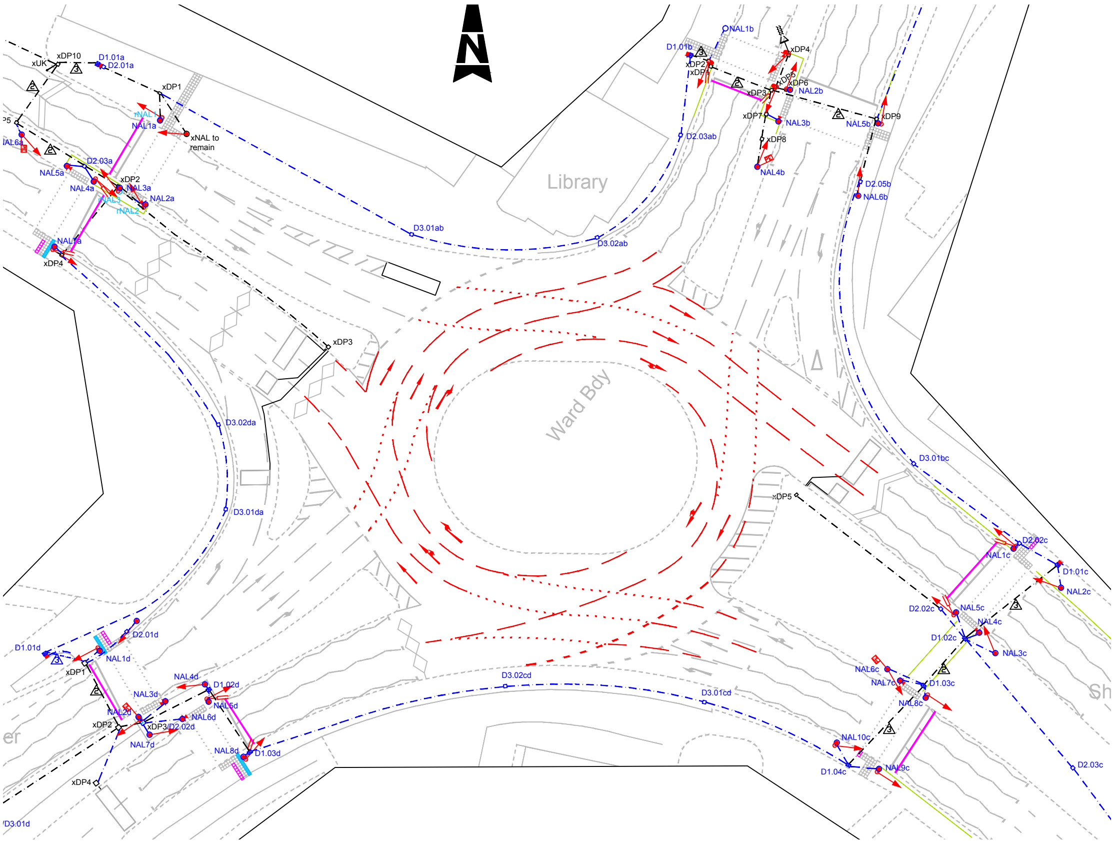


Technical.

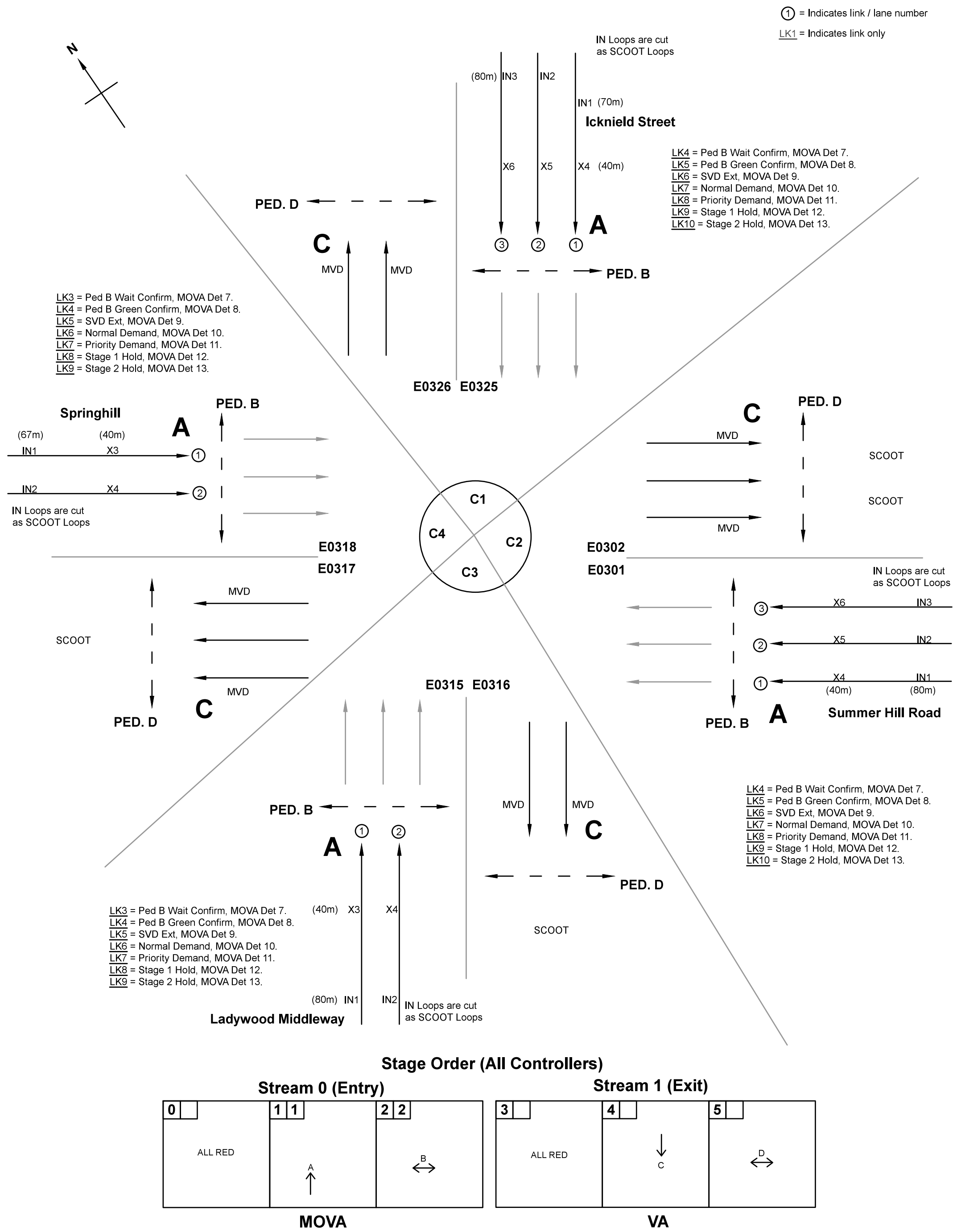
Control of the entry crossings is under MOVA control. Utilising MOVA's linking/bus priority Model to control gating. As well as being efficient it also removes the need for SD on the entry pedestrians and reduces the loop count. The priority model within MOVA is very flexible and allows for easy setup on site.

Full UTC control is available for all nodes in the event that an operator needs to take control or there is an issue on the network that requires gating above what the system is validated to deliver. SCOOT loops are also available from the IN loops for future use / data collection etc. Crossings on the exit of the roundabout run VA with above ground detection. There was little point using MOVA on these crossings given the proximity to the roundabout. There is no linking to these exit crossings though it was considered.

Indicative drawing

Springhill Roundabout

Method of Control, Detector Location, and Link configuration



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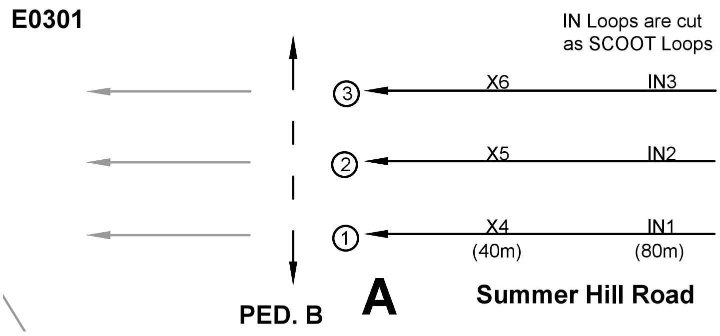
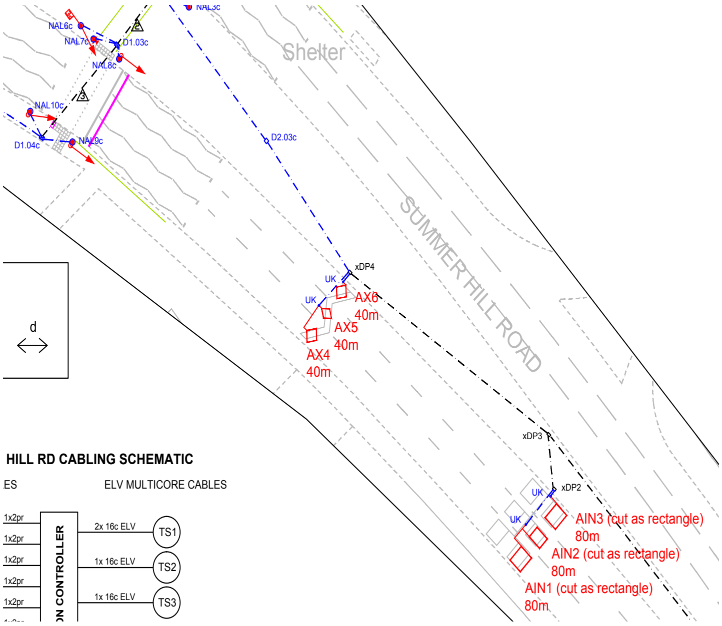
Flow, headway, speed and occupancy over loops situated 80m from the entry pedestrian stoplines is monitored through the use of RTEM SP4C-Cards. IN loops have several functions (SCOOT/MOVA/Queue/SVD/Flow) and are cut as SCOOT loops.





This data is used to determine the current level of demand and queuing. An algorithm has been designed by RTEM that can set outputs based on the average of how busy the approach is deemed to be; this is fully adjustable. Outputs from the cards are passed to the controller and used to trigger conditioning that creates demands and holds for the pedestrian stages at the upstream nodes determined by the severity of the problem. The average is taken over a minute and the output set according to the value over the last period. 2 states can be set up, named in the configuration as being either “Busy” or “VBusy” but both states can be set up to respond at any level. Each

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node can reply to and influence the 2 preceding nodes in the event that congestion is registered. If a busy output is sent, then the immediate downstream nodes pedestrian stage is demanded and held, should a very busy state output be set then the demand/hold is also sent to the next upstream node. At the local node a traffic stage hold is set to ensure that any impending pedestrian demand is not serviced while the queue is attempting to clear. If any node being effected is registered as being “Busy” or “VBusy” then gating at that node is relaxed until it falls below the set level of congestion. As all 4 nodes are connected using the same logic then the roundabout “self” balances depending on the level of congestion on each arm. Hierarchy set up on site is to balance all approaches but weighting and biasing can be applied to any node if deemed necessary.

Pedestrians are observing normal waiting times without any dis-benefit, even when a priority hold is in place to help clear the approach this is within acceptable pedestrian waiting times. There is actually some benefit to pedestrians as the green man is maintained throughout the stage hold. It was investigated if there should be an all red but it was decided that a pedestrian green was more desirable and ultimately safer. A pedestrian faced with an all red stage would be likely to cross, in this circumstance they would not be subject to on crossing extension on a change back to traffic. We could not see any particular downside of running the long green man time. Signs were put up to advise drivers that the signals may operate without pedestrian demand. This was done to reduce any occurrences of red running and advise that there was not a fault with the signals. Drivers have been disciplined and there have been no problems with adherence or signs of frustration.

It was the intention to keep the logic as simple as possible whilst allowing flexibility in setting up on site. Everything needed to be fully adjustable. Below is a brief rundown of how the logic is arranged and passed between controllers

Controller 1 sends a 1 second pulse every minute to the other 3 controllers to act as a global reference timer. This is a way of timing everything to maintain coordination and time offsets.
If an approach receives a “Busy” input from the SP4-C card it sends a “Busy” output to the node immediately counter clockwise and starts a local timer to hold the local traffic phase at ROW.
When the upstream controller receives the “Busy” input it waits until the 1 second global timer pulse is present. When the 1 second pulse is active a delay timer is started, the delay timer is used as an offset. Once the delay timer has expired a demand is set for stage 2 (pedestrian), this can be set as a normal or priority demand. Once the demand is serviced a further timer is used that holds the stage for the desired length in order to clear the immediate give way and allow gating/ghosting of the downstream node.
If the approach receives a “VBusy” input from the SP4-C card, then the upstream controller has a duplicate set of timers so that stronger action can be taken, namely a longer hold time or a forced instead of normal demand.

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On a “VBusy” state the output is also passed to the next node anti clockwise to activate that nodes timers.
If a node that is being requested to gate itself becomes congested, then the gating is at first reduced then turned off depending if the local condition is “Busy” or “VBusy”. This allows the system to balance and is essential for operation.

The excerpt below is from the special conditioning notes I created in order to form the logic functions and input/output scheme. Dave Lawrence from TCT Consultancy did an excellent job of interpreting what I wanted to create the controller configurations, making it work robustly and being easy to set up on site was particularly important.

Busy sets O/P C1Busy (raw state).

VBusy sets O/P C1VBusy (raw state).

VBusy active start timer (40s), timer running sets MDet12.

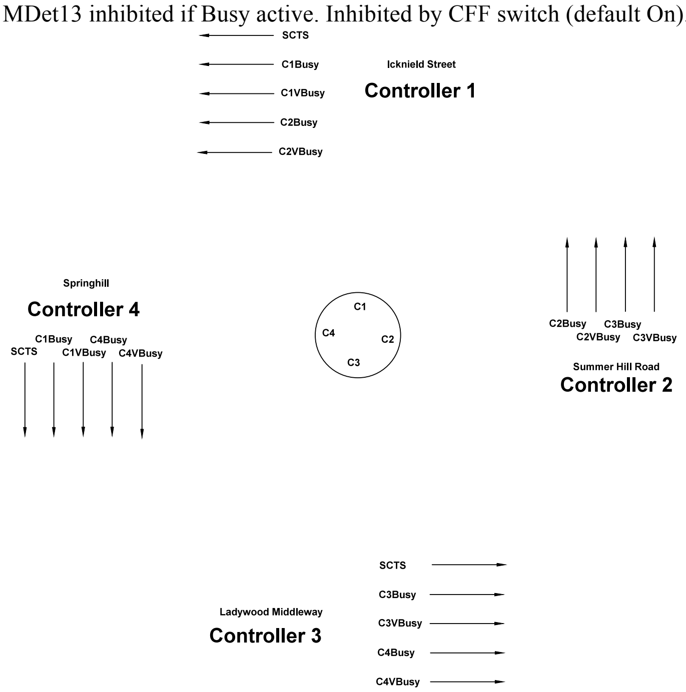
SCTS: Start timer, (90s) timer expired set pulse timer (1s). Pulse timer running sets O/P SCTS.

C2Busy active and SCTS active start timer (0s), timer expired set MDet10 for 1s pulse. MDet10 inhibited if VBusy active or CFF switch (default On).

C2VBusy active and SCTS active start timer (0s), timer expired set MDet11 for 1s pulse and start timer (20s), timer running set MDet13. Inhibited by CFF switch (default On).
MDet11 inhibited if VBusy active. Inhibited by CFF switch (default On).
MDet13 inhibited if Busy active. Inhibited by CFF switch (default On).

C3Busy active and SCTS active start timer (0s), timer expired set MDet10 for 1s pulse. MDet10 inhibited if VBusy active. Inhibited by CFF switch (default On).

C3VBusy active and SCTS active start timer (0s), timer expired set MDet11 for 1s pulse and start timer (20s), timer running set MDet13. Inhibited by CFF switch (default On).
MDet11 inhibited if VBusy active. Inhibited by CFF switch (default On).
MDet13 inhibited if Busy active. Inhibited by CFF switch (default On).



I also included SVD detection to give an output when a HGV or Bus was present, this was a bonus as the equipment and loops required were already on site to detect congestion. The SVD detection is not considered highly useful at these sites given the proximity to the roundabout however there is still some benefit during off peak periods as it prevents heavy vehicles from being placed near the dilemma zone if a pedestrian demand is present. The SVD function is automatically disabled if occupancy goes above a set threshold.

Post Validation

Setting up was interesting and did take longer than anticipated but was successful. At first I had it set up to be fairly loose on a “Busy” input, asking for normal demand of the pedestrian upstream with no hold. The forced call and hold was only used on a “VBusy” input. This wouldn’t allow enough clearance of the give way in front of the stoplines so a more robust set of actions was set up. This gave a forced call and hold to the pedestrian stage on a “Busy” input to the upstream node. A “VBusy” state gave a forced call and longer hold at the 2 upstream nodes. No offsets were used. Clearance of the give way in front of the stoplines was a concern during the design phase but with the revised road markings and a longer hold time they are clearing fairly quickly allowing the congested approach time to exit.

Following validation, the scheme was observed under a variety of conditions, one of which was during a period of extensive roadwork’s and a large concert at the NIA. The system was working well and having a positive effect during periods of excessive demand. During the daily peaks it has helped to offset the heavier flow from the ring road due to the Paradise Circus works closure. Clearly it is never going to be as efficient as a fully signalised roundabout would be but so far it has proved to be an effective tool for dealing with the shifting traffic patterns and events happening on the network.

Thanks

Like most schemes it was a real team effort to achieve the finished project. In no particular order the following people were invaluable to getting this designed and on the ground

Dave Lawrence – TCT Consultancy
Dave Lowndes & team – Siemens
Derrick Witts – Aspect Traffic Solutions
Mike Nixon – Amey BCC
Steve George - SGTi
Stuart Amphlett & team – Amey
Tim Embrey - BCC