Annexure "A"

TEA MODEL

ROUTE OPTIMISATION PROCESS

1 INTRODUCTION

The fundamental tenet of the Telstra Efficient Access Model (TEA) is that the efficient network design of a forward-looking, best practice, replacement copper Customer Access Network (CAN) must rely upon sound engineering principles. By definition, a network design cannot be efficient, and it certainly cannot be best practice, unless it comports with fundamental engineering guidelines.

It is impossible to accurately engineer a customer access network from the comfort of a desk, whether the engineering is for the purpose of planning construction or modelling cost. A workforce of planners and engineers must walk every street in which customers reside to observe all the obstacles to digging trenches and placing conduit. Only then can the designed network definitely be capable of supplying actual services to actual customers. Fortunately, Telstra currently operates a world class telecommunications network, supported by state of the art network systems and databases, which contain detailed information about the customer access network.

The TEA model uses the CAN cable routing information from theses databases, which reflect actual cable routes that serve real building addresses, reside in legal rights of way and account for all natural and man-made obstacles, to design an efficient CAN, which is in all ways based upon fundamentally sound, forward-looking engineering principles and best practices placement procedures. This ensures that the engineering design underlying the TEA model would work in the real world – something not assured in other models with hypothetical designs.

Besides use of previously engineered cable routes, three other processes ensure the TEA network design is forward- looking, efficient and reflective of best practices. The provisioning process employed in TEA follows in all ways the Access Network Provisioning Rules provided by Telstra's Network Fundamental Planning (NFP) department. The labour and equipment prices built into the model are taken from the Access Network Modelling Costing Information document also produced by NFP. And, the routing information derived from Telstra's network systems and databases is rationalised and optimised before it is loaded into the TEA Engineering Modules. The rest of this document describes this rationalisation/optimisation process.

Telstra's CAN has been constructed, refurbished and supplemented over the course of many decades. Every new route added to the network was provisioned and engineered according to best practices, most efficient procedures and best information available at the time it was built. As time, passed, however, it was frequently necessary to add capacity to some cable routes and, upon occasion, to strand capacity on other routes. Adding capacity to the network is not always a simple matter of pulling another cable through the existing conduit. Often, because conduits are full, main routes are exhausted or reinforcement is prohibitively expensive, capacity is added to a cable route by bringing in additional cable from a neighbouring cable route rather than reinforcing the existing route. Consequently, even though a network distribution area design had been perfectly efficient at the time it was built, it is possible that, over time, its design could have been modified by a series of "efficient at the time" additions. These additions and network reinforcements could, taken together as a whole, alter the network design sufficiently that it would no longer be representative of what an efficient provider would build today, if starting from scratch.

To ensure the TEA model's network design is efficient, forward-looking and reflective of best practices, the network design and routing information extracted from Telstra's databases is rationalised and optimised before it is loaded into Tea's Engineering Modules, which provision a forward-looking replacement CAN. The TEA model's Route Optimisation Process performs this function.

In particular, from all of the routing options that currently exist in Telstra's CAN, the route optimisation process selects a single, efficient, minimum distance set of routes capable of serving every address in all Band 2 ESAs. The route optimisation process ignores the practical constraints of exhausted cable routes, lack of conduit capacity and the cost of reinforcement because its only focus is efficient route design. Capacity and other network constraints are not an issue in the route optimisation process because the TEA model's engineering modules provision precisely the right amount of plant and equipment for each main and distribution route in a subsequent step, after the route optimisation process is complete.

Further, the route optimisation process selects routes with foresight of demand (i.e. it designs network routes necessary to meet current demand – no more, no less). Since total demand requirements are an input to the route selection process, the route optimisation process is able to optimise routing across an entire ESA at once. In this regard the route optimisation process designs a network with greater efficiency than any service provider can achieve, since service providers design networks based upon forecasts of potential future demand, not perfect foresight of current existing demand.

TEA provisions an efficient, forward looking network design based upon current customer locations and demand. Future changes in demand, due to factors such as shifts in market share between providers, migration of services to alternative technologies and the movement of customers between locations, are dealt with through the application of the engineering rules used in developing the TEA model (e.g. fill factors).

Use of actual network data provides the following advantages:

- Precise identification of points of ingress, where demand enters the CAN;
- Identification of routing within legal rights of way past virtually every address in Australia;
- Ability to design a network which takes account of all natural and man-made obstacles;
- Ability to select efficient, least distance routes from customer locations to telephone exchange buildings from a vast array of alternative paths providing virtually universal coverage;
- Access to data related to all customer locations, rather than making assumptions based upon sampling;
- Ability to model a network designed with actual, efficient engineering standards, rather than model a simulation based upon hypothetical design algorithms that never have been and never will be used in designing a real network;
- Ability to calculate the required number of network components such as pits, joint covers and manholes, rather than estimating a number based upon route miles; and
- Identification of efficient "last mile" routing for FTTN Networks.

The TEA Model's network design process begins with the current exchange buildings and pillars of the existing customer access network. The Main Network originates at the exchange building for every Band 2 ESA and feeds all of the pillars and building terminals. Building terminals are network structure points (i.e. T-Blocks) located inside a customer premise. (Note: building terminals are primarily Main Network fed, although they are sometimes fed by the Distribution Network.) The Distribution Network originates at pillars, which serve individual Distribution Areas, and feeds the network structure points in the right of way in front of customer premises needed to serve every customer in the Distribution Area. Network structure points are items of equipment, which are used in the CAN and recorded in Telstra's engineering records (e.g. pits, manholes, building terminals). Network structure points are important in the modelling process because they identify either end of the cable segments, which constitute routes, and they identify points along routes where demand changes either because routes merge together or because lead-ins join a route.

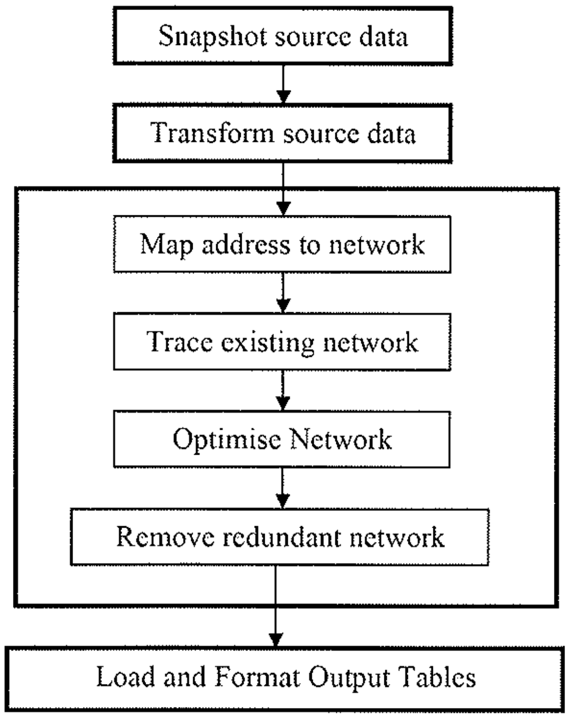
The TEA model designs and provisions forward-looking, efficient, replacement copper Main and Distribution Networks, which together comprise the CAN, in three principal processes:

1) Demand for access services and the points where demand enters the network (i.e. network structure points where lead-ins are joined to the network) are identified;
2) Routes are designed to serve the necessary demand; and
3) The types and capacity of network equipment necessary to meet the required demand along these routes is provisioned; and equipment and placement costs are calculated.

Processes 1 and 2 are completed within the route optimisation process. Those processes are documented in this paper. Process 3 is carried out by the TEA Engineering and Costing Modules. That process is described in the TEA Model Documentation, the Access Network Dimensioning Rules and related documents.

2 PROCESSING OVERVIEW

The route optimisation process has four main steps, and the core engine consists of a number of sub-steps, as shown in the diagram below. Details of each processing step are described in the following sections.



3 SNAPSHOT SOURCE DATA

TEA extracts data from two source systems:

1. Network Performance and Management System (NPAMS); and
2. Cable Plant Record (CPR2).

Snapshots of data are taken from both these sources. Details of the source tables are included in section 10.

4 TRANSFORM SOURCE DATA

The necessary tables, extracted from NPAMS and CPR2, are transformed into a structure more suitable for the modelling exercise. NPAMS and CPR2 address tables are matched so that the record of the plant serving an address (i.e. Cable name/number and pair range), resident in the NPAMS service record, can be transcribed onto the CPR2 address table.

5 MAP ADDRESS TO NETWORK

BACKGROUND

In order to determine the capacity requirements of the network and to ensure that the route design is broad enough to serve all customers, but no more expansive than absolutely necessary, the TEA model must know where the demand for services enters the Customer Access Network. This involves matching each address in the geographic serving area to the network structure point feeding that address (i.e. the point where the lead-in joins the distribution or main cable).

For addresses served by building terminals, identification of the feeding network structure points is tautologous, since the building terminals themselves are network structure points. For addresses not served by building terminals, feeding network structure points are identified geospatially.

Geospatial mapping of addresses to network structure points is done as follows:

- Each address is mapped to a single feeding network structure point
- Wherever possible an address is fed by a structure point in the distribution network (since it is engineering best practice to feed small customers from a distribution cable)

- The cable currently feeding an address (feeding cable designation) is used to identify the feeding network structure point.
- If the feeding cable designation for an address is not known, but it is possible to identify the feeding cable designation for a neighbouring address, that cable is used to identify the feeding network structure point.
- If the feeding cable designation for an address in not known and it is not possible to deduce the feeding cable, then the network structure points spatially located in the same street as the address (i.e. not a structure point located in the next street along), are used to identify the feeding network structure point.

Identification of the cable that currently serves an address enables identification of that cable's route and concomitantly the structure points the cable passes through. This in turn enables the use of tighter search parameters, when mapping the address to a serving network structure point, by constraining the set of structure points used in the mapping to those that the serving cable passes through. In like manner, constraining the set of structure points used in a mapping to those located in the same street as the address also tightens search parameters. In both cases, use of tighter search parameters improves the accuracy of the mapping process.

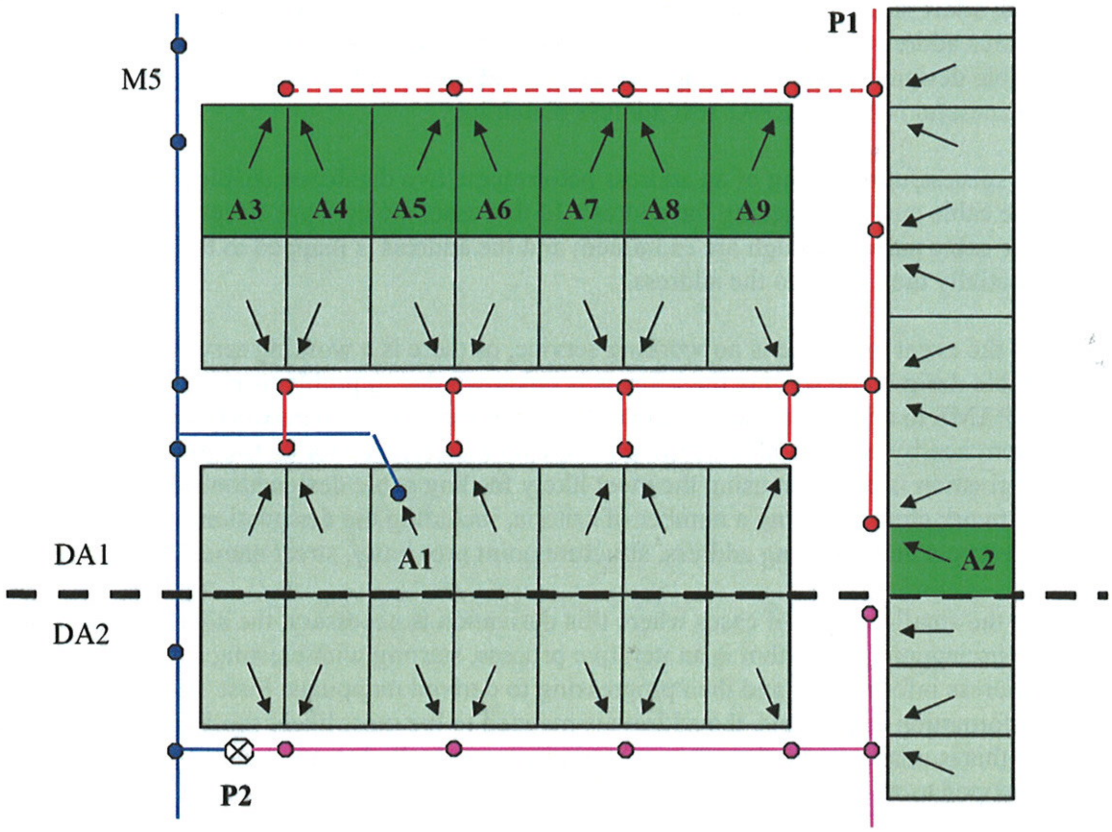
Some typical address to designation/structure point mapping principles are illustrated in the diagram below. In this diagram, there are two DAs, each with its own colour for the distribution cable. The main cable is shown in blue. An address is mapped to the structure point indicated by the arrow.

The typical cases are where the

1. cable currently serving the address is known;
2. cable currently serving the address is unknown, but the cable serving a neighbour is known; and,
3. cable currently serving the address is unknown, and the cable serving a neighbour is unknown, so network in the street of the address is used to identify potential serving network structure points.

Case 1 is illustrated in the diagram below as all light green addresses. Note that address A1 is specialized case of this type, since it is served by a main-fed building terminal (T block).

Both cases 2 and 3 are where the feeding cable designation is unknown. They are shown as darker green addresses below. Address A2 is located adjacent to an address where the feeding cable designation is known, so address A2 is also mapped to that designation. In the final example, the feeding cable designation for addresses A3-A9 is unknown, and since the neighbouring addresses in the same street cannot be used to identify a feeding cable designation, the addresses are mapped to a network structure point located in the same street as addresses A3-A9.



LEGEND

(light green square)	Address with feeding cable designation known
(dark green square)	Address with feeding cable designation unknown
(blue line)	Main cable
(red line)	P1 distribution cable serving DA1
(red dashed line)	No available record of cable feeding addresses A3-A9
(pink line)	P2 distribution cable serving DA2

MAPPING ALGORITHM

If an address has a current connected service(s), then the designation of the cable feeding that address (i.e. cable name/number and pair range) is recorded in NPAMS. Since CPR2 stores addresses and physical plant, but not service details, in order to identify feeding cable designations for working services, the address to network mapping requires a successful NPAMS-CPR2 text address matching.

A successful matching of an address between the two databases enables identification of the cable currently feeding the address. In this case, the network structure points which the cable passes through are examined; and the address is mapped to the one, which is spatially the closest to the address.

In the event that there is no working service, or there is a working service but the feeding cable designation serving the address is unknown due to problems matching an address in NPAMS to an identical address in CPR2, then the address to network mapping is derived from nearby cables and structure points, with a preference for distribution network. The derivation is based on using the most likely feeding cable designation and/or feeding network structure using a number of criteria, including the designation of the cable feeding a neighbouring address, structure point proximity, street name, DA, and pair type.

In the small number of cases where this derivation is necessary, the address to structure point mapping algorithm is an iterative process, starting with existing connected service/ address information, and then progressing to derived mappings. First, using as much information as possible, the address is mapped to the most likely serving structure point. If this is unsuccessful then the constraints are gradually loosened until the address can be mapped to a structure point that would best serve the location.

The address to feeding network structure point mapping is stored in the table named nwmod_address_struct_pt, where all address id's (tls_id's) are mapped to a feeding cable designation and feeding network structure point. It's typical for one address to be fed by one network structure point, where that feeding network structure point may feed more than one address.

Get Cable Designation Feeding an Address

Since, as explained above, an addresses' feeding cable designation is used to identify the feeding network structure point, the feeding cable designation is identified before the feeding network structure point is determined.

Where available, all actual feeding cable designations are determined first. These are then used to help derive the designation mappings of nearby unmapped addresses. Given the bias to feed addresses with distribution cable, it is firstly attempted to map an address to a distribution network, mapping to a main network only when the other approach is not feasible.

For illustrative purposes, the algorithm used to determine the feeding designation is displayed below:

```
for an address where a service exists

    -- get the actual feeding cable designation

    for network_type in (distribution, feeder) loop

        if address is T block fed addresses

            get actual feeding cable designations from the feeding cable
            designation of the block itself

        else if address is pair fed (non-block)

            get service(s) at address from matching between NPAMS
            and CPR2

            if service(s) exist

                get the actual feeding cable designation of the
                service of network_type

            end if

        end if

    end loop

end loop

if address's feeding cable designation unknown

    -- derive the feeding cable designation

    get closest neighbouring address in the same street and on the same side of
    the street where
        feeding cable designation is known, and
        street number separation of <= street number separation limit and
        in the same DA

    if neighbour feeding cable designation known
```

```
            set address feeding cable designation to neighbour designation

        else

            get closest neighbouring address where feeding cable
                designation is known, and
                is in the same street, and
                in the same DA

            if neighbour designation known

                set address feeding cable designation to neighbour
                designation

            end if

        end if
    end if
```

Modify Designation

For network structure points that are located near a DA boundary, it is possible that some structure points could be utilized by cables serving two different Distribution Areas. Without alteration, this would cause service demand at those structure points to be duplicated in two different DA's. To prevent this from happening, some address mappings need to be modified so that they only appear on the cable serving the DA they are spatially located within, so that the associated demand is only counted for that DA.

Get Feeding Network Structure Point

Once the feeding cable designation has been identified, the feeding network structure point can be determined. For addresses that are not fed by a T block, the address is mapped to nearest candidate structure_point_id on the path of the feeding cable designation. In most cases, this will be the pit/manhole in the street, out in front of the property.

For addresses that are served by a T block, the addresses are mapped to the structure point of the T block itself, as explained earlier. However, this mapping is dependant on a successful NPAMS-CPR2 service address mapping, so not all addresses served by a T block will be mapped to a feeding network structure point, and a small number may need to be derived. To prevent multiple addresses being mapped to a single in-building T block (merely because of the proximity to the T block location), an indoor block is considered to serve only that address (unless the service T block address mapping proves otherwise). Outdoor T blocks can have any number of addresses mapped.

Find New Property Developments

Recent new estate property developments occasionally can have an address in CPR2, when the development is still in the planning stage or early stages of construction. In these few instances, the addresses of a new development need to be excluded from the address to network mapping, because there is no corresponding network. Otherwise, each of the new development addresses will be mapped to a small number of network structure points near the boundary of the new estate (since it is the nearest cable to the addresses).

In the model, this would result in excessive demand being mapped to the wrong network structure points, some distance from where the addresses are actually located.

6 TRACE NETWORK

BACKGROUND

The next step in establishment of efficient cable routes is the tracing of all existing cable routes. This universe of all existing routes is then used in the optimisation process to select the single most efficient set of cable routes. As discussed above, existing cable routes are used as the best pool of available cable routing alternatives in the optimisation process for a variety of reasons including:

- They pass virtually every home and business;
- They were engineered as the most efficient design to serve the homes they pass at the time they were constructed;
- They reside within the right of way available to telecommunications providers;
- They are designed to account for natural and man-made obstacles.

Main and Distribution Networks are modelled separately and each ESA is individually processed.

Main Network

The main network is a point to point network from exchange buildings to Cross Connect Points (CCP), which are typically Pillars or Cabinets. Hence, sections of the main network can be defined by the names of the two end points – exchange buildings and/or CCPs.

For a cable designation and pair range (e.g. Cable 5 pr 300-600), the main network is traced from one named end point to another, starting at the b_end CCP and tracing toward the a_end CCP/exchange.

The main network is traced from b_end to a_end rather than a_end to b_end, because:
- Tracing in the reverse direction to the direction of the cable sections, we will reduce the frequency of branching, and hence reduce the number of branching decisions required during the trace. This is because for a given cable designation/range, branching from a common structure_point_id_a to multiple different structure_point_id_b's (i.e. bridged taps/CCP's in-multiple) is much more common than having branching from a structure_point_id_b to multiple different structure_point_id_a's.
- When tracing towards the a_end, the termination of a successful trace is a single known destination (e.g. exchange building). Whereas, in the forward direction, even though tracing a limited pair range, branching can terminate on multiple different terminating CCP at the b_end (e.g. Pillars).

Distribution Network

The distribution network is a fan-out, customer feeding network from a named CCP, and as such:
- is a directed graph (i.e. a tree branch architecture), with many branch tips.
- a branch tip may be a named T block, but the majority are simply a pit in the street, which are unnamed structure points.
- any of the structure points of a distribution network may feed an address, so when initially tracing a distribution network, all network branches and all structure points must be retained

Consequently, the distribution network is not suitable for point to point tracing as is adopted for the main network. In contrast, the distribution network is traced in the forward direction, from the CCP, independent of pair range.

In the existing network, distribution cables are always labelled with a pair type of 'O'. However, in some circumstances, other pair types can exhibit the same characteristics as normal 'O' pair distribution networks. As a result, in the model, some B pairs (Branch pairs) are treated like 'O' pairs (i.e. are treated like distribution cables).

- B (Branch) pairs treated as O pairs (B as O)

  When a DA is fed by a cabinet rather than a pillar, the cabinet B pair network feeding that DA is like a normal distribution network. In the model, these types of B pairs are treated as O pairs. This is referred to as a "B as O" network.

In these instances where the cabinet feeds a DA like a pillar, it is also likely to provide capacity to downstream CCP's, as per the typical role of a cabinet. These normal branch feeding pair ranges are excluded from the B as O trace.

TRACING ALGORITHM

Main Network

Main route tracing is primarily a matter of following the structure points, which the cable pair range serving a CCP passes through, along the route from the CCP back to the exchange and recording the results. Although not common, branches in the route add a layer of complexity.

To handle branches in the network (tracing towards the exchange) from a common parent node, tracing is a recursive function, where the new start nodes for the next level of function call are each of the children of the common parent. Consequently, a new trace will start whenever a b_end structure point has more than one a_end structure point. The recursion results in a depth first search.

When there is branching, the individual sub-traces are combined to create a single trace for a particular cable pair range from a CCP to the exchange with no branching (i.e. the original trace to the first branch plus the new trace originating at that branch to the next branch ... plus the trace terminating at the exchange). Branches not used in the final successful trace are eliminated.

Since the main is a point to point trace, a successful trace will only include one path between any two points along the route and the trace will terminate at the target structure point. In other words, there will be no branching in the resulting trace.

When complete, the tracing process identifies all routes feeding all CCPs in an exchange. When a CCP is currently fed by more than one distinct cable designations, each cable designation route is traced. Consequently the final tracing will include multiple routes feeding some CCPs. (Note: a single optimal route is subsequently identified in the optimisation process.)

Distribution Network

Distribution network route tracing involves following distribution cables from their origination at a pillar outward towards all end points. When a route branches, each branch is followed to its end point. In most distribution networks, the trace is implemented as a hierarchical query, starting at the CCP.

The process is straightforward; but there can be complexities in the distribution network, which complicate its implementation. These exceptions to the normal distribution design must be accounted for and add a great deal of extra considerations to the tracing process.

When a branching parent node reconnects to a common child structure point (after one or more cable sections), there will be a multiplicity of routes. That is, the same common child structure point will have multiple trace levels, and multiple distances to the a_end (which are likely to be different).

The more branching loops that exist, particularly if the loops are nested or daisy chained, such that they affect one another, and the more downstream network that exists after the common child structure point, the larger the exponential impact of the cross product on the routing combinations. While complicating the process, this multiplicity does not impact the distribution network trace, and all but the shortest path is removed in the optimisation of the distribution network.

7 OPTIMISE NETWORK

BACKGROUND

When necessary, the shortest path algorithm is used to alter the full route or part of a route to obtain the single shortest path network to the exchange/CCP.

The constraints/assumptions are:

- Existing feeding exchange and CCPs do not change (i.e. we do not transpose the network);
- If there is a copper feeding path and a fibre feeding path, assume the location is fed by copper;
- Retain existing CCP locations;
- Do not create routes; only use existing cable routes (as this factors in terrain etc),
- In Band 2, rationalize the main by ignoring direct main fed non-block and small block customers (i.e. customers not served by a building terminal or served by a very small building terminal), since:
    - when current engineering principles are applied, as per the model, these addresses would not be fed from main network;
    - a very small percentage of addresses are affected;
    - it is the conservative assumption; the resulting main route generally remains the same; and thus only a small cost is not factored in;
    - Services in operation at these addresses are retained in the total demand figure used to calculate unit costs.

The approach to getting the shortest path is different for main and distribution networks.

Main Network

A main network is a set of point to point networks, from one named end point to another, where route sections of one main network (pair of end points) may run in common with route sections of other pairs of end points.

The intermediate structure points (e.g. pits and manholes) of a main route merely describe the route. They are not required for any other purpose, such as mapping with an address, as in the distribution network.

Therefore, to determine the shortest main route to a CCP, any route section of the main path can be altered to use any other route section, if the substituted route section:

- allows the route to terminate at the same end name, and
- is shorter than the original route section.

In determination of the shortest main path between two end points, all existing main routes are evaluated for potential route section substitution. No routes or route sections are eliminated until after the network rationalisation is complete, in order to prevent losing information, or making the shortest path decision too early in the iteration process. This is because, when two different routes currently feed the same CCP, the route that is initially the longer may be altered to become part of the shortest main path to that CCP.

Distribution Network

Distribution cable paths are part of a fan out network with many unnamed b_end branch tips.

The distribution network is a customer feeding network, where any of the structure points along the route may feed an address. Therefore, to ensure that address serving structure points are not removed in optimizing the distribution network, path alterations do not remove any structure point from the distribution network. Path alterations only reroute sections between structure points to obtain the single shortest path to each and every structure point. Structure points that do not serve any demand are removed later in the process.

Note that although current network structure points are used to identify efficient cable routes, the TEA model does not simply count existing network structure points (e.g. pits and man-holes) when it provisions an efficient, forward looking replacement CAN. TEA calculates the number of necessary structure points through meticulous application of the Access Network Dimensioning Rules.

MAIN NETWORK SHORTEST PATH ALGORITHM

The high level steps of the algorithm:

1. Remove duplicate paths
2. Eliminate spatially parallel sections
3. Alter route sections
4. Select shortest path

Remove Duplicate Paths

Remove duplicate paths between the same a_end_name and b_end_name. A duplicate path is where there are two different feeding pair ranges between the same two a_end_name and b_end_name, with every cable section in common. (I.e. The routes pass though exactly the same network structure points.)

Eliminate Spatially Parallel Sections

Eliminate spatially parallel sections between the same two structure points where the perpendicular separation between the alternate route sections is small (e.g. the routes reside within the same right of way). For such parallel route sections, the total length between the structure points involved will be within a couple of meters of being the same length, and can be considered the same.

To prevent removing any intermediate structure point(s) which may be involved in another path, only spatially parallel sections where one of the route sections is a single cable section (i.e. two directly connected structure points) are rationalised. The parallel route section between those same two structure points may consist of one or more sections. The direct single cable section is replaced with the multiple sections so that the detail of the intermediate structure points is not lost.

Spatially parallel routes comprised of multiple sections are rationalised in the Alter Route Sections process described below.

Any network loops introduced as part of the rerouting are located and removed after the process is complete.

Alter Route Sections

Identify route sections where the start and end structure points of one route section has the same start and end structure points involved in another route, but may have any number of intermediate and different cable sections between them.

Alter the route section of the longer path to use the shorter route section.

At a high level, the algorithm has two core steps:

1. Find a start structure point (parent) and an end structure point (common child), that has more than one route between them.
2. Alter longer alternative route to use the shorter route

This "find then alter" process handles:

- A single main route having only one route section replaced,
- A single main route having two or more independent route sections altered (i.e. serial or non-nested route sections)

Theoretically, one single main route can have any number of nested route sections that need to be altered. That is, there can be one common parent-child route section, containing within it, a different common parent-child route section. To handle route section nesting, the two step "find then alter" processes are re-executed in a loop until the alternate routes are un-nested. Each iteration of the loop, progressively un-nests the path loops.

To ensure correct re-routing decisions are made, re-route the closest parent-common child un-nesting first (the inner most route sections), thereby ensuring the shortest route section to the outer common child are factored into re-routing the outer sections.

After each iteration:

- If a route section alteration results in any new duplicate routes, the duplicate routes are removed.
- Any network loops introduced as part of the rerouting are located and removed.

Select Shortest Path

Each main path is optimised using all other main paths. It is possible for one CCP to be fed from multiple sources and/or multiple pair ranges from the same source. Each of these is independently optimised, then the feeding cable designation/range with the single shortest aggregated path to a CCP is identified, and all other cable designation/ranges are considered suboptimal and removed. The result is a main network with the shortest aggregate length. (The one exception is the redundant network removal which is taken care of in the next step and described below.)

Eliminating routes feeding a CCP based on total route length at the CCP, is a similar optimisation approach to that used in the distribution network. The difference is that the main optimisation is at the cable end level (i.e. the entire length of cable between a CCP and the Exchange), rather than at the cable section level (i.e. a segment of cable between two adjacent network structure points). For the main, the network being rationalised is a directed graph with the root being the exchange and with CCP's as the nodes of the graph. For the distribution network, the root of the directed graph is the CCP, and the nodes of the graph are the structure point's involved in every cable section of the distribution network

The following three diagrams are simplified Main Network illustrations created to help explain the Optimisation process.
Diagram 7.1 illustrates an example of main network routes, which could result from the Trace Network process described in Section 6 above. It displays all existing cable routes in an imaginary Main Network, prior to the Optimisation process. The black lines depict the route followed by the two cable designations feeding Pillar 1 (Cable 8 pair range 1-200 and Cable 3 pair range 201-300). The route passes though network structure points A, B, C and D. The blue lines depict the route followed by the cable designation feeding Pillar 2 (Cable 4 pair range 1-200). This route passes through network structure points A, E, F, C, G, H and I. The red lines depict the route followed by Cable 5 pair range 1-300, which also feeds Pillar 2. This route passes through Cabinet 1.

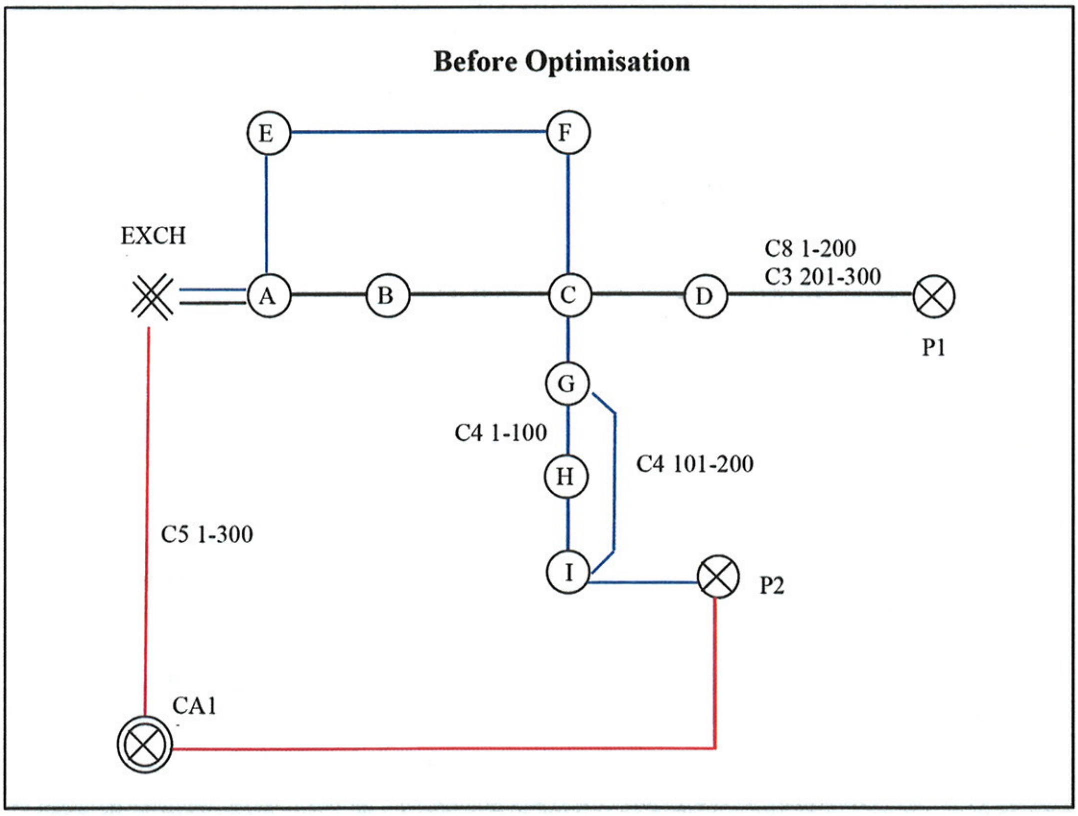


Diagram 7.1 – Before Optimisation

Diagram 7.2 illustrates Optimisation Steps 1, 2 and 3.

Step 1 – Remove Duplicate Paths:

Two different cables feed Pillar 1 along an identical route, the route depicted by the black line though structure points A, B, C, and D. The Trace Network Process identifies both cable paths. Since these paths are identical, one is removed in Step 1 of the Optimisation Process – Remove Duplicate Paths. Cable 3 pair range 201-300 is removed, as shown in Diagram 7.2.

Step 2 – Eliminate Spatially Parallel Sections:

Cable 4's path, feeding Pillar 2 along the route depicted by the blue line, diverges into spatially parallel sections between network structure points G and I. Since the perpendicular separation between the alternate sections is small, one section is removed in Step 2 of the Optimisation Process – Eliminate Spatially Parallel Sections. Section G-I is removed, as shown in Diagram 7.2, and Section G-H-I is retained so that the detail of the intermediate network structure point H is not lost.

Step 3 – Alter Route Sections:

Route sections A-B-C and A-E-F-C have the same start and end structure points (A and C respectively). Since route section A-B-C is shorter that A-E-F-C, route section A-E-F-C is altered to use route section A-B-C in Step 3 of the Optimisation Process – Alter Route Sections, as shown in Diagram 7.2.

After Optimisation Steps 1, 2 and 3

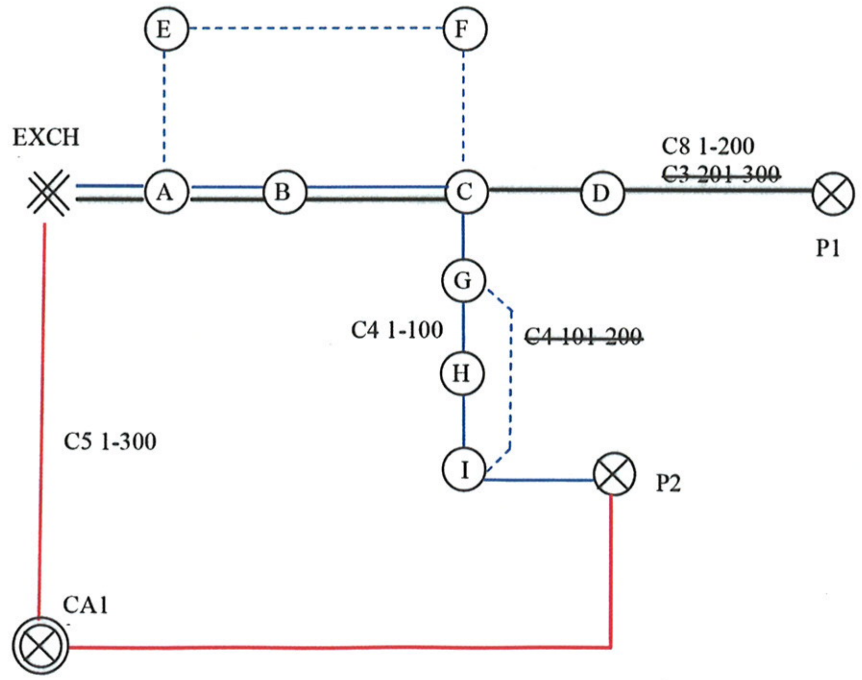


Diagram 7.2 – After Optimisation Steps 1, 2 and 3

Diagram 7.3 illustrates Optimisation Step 4.

Step 4 – Select Shortest Path:

After Steps 1, 2 and 3 of the Optimisation process, it is still possible for a Pillar to be fed by different cable designations on different routes, even though each of these alternate routes had been optimised in Steps 1, 2 and 3. Pillar 2 in Diagram 7.2 is an example of this circumstance; it is still fed by both Cable 4 along the blue route and Cable 5, along the red route. Cable 4 along the blue route is identified as the cable designation with the shortest aggregated path to the exchange in Step 4 of the Optimisation Process – Select Shortest Path; consequently, Cable 5 and the red route are eliminated.

Diagram 7.3 illustrates the optimised Main Network with the shortest aggregate length. (Note that, even though, for illustrative purposes, both the blue and black lines are still shown on the section EXCH-A-B-C, after the Optimisation Process is complete, that section is a single, combined route.)

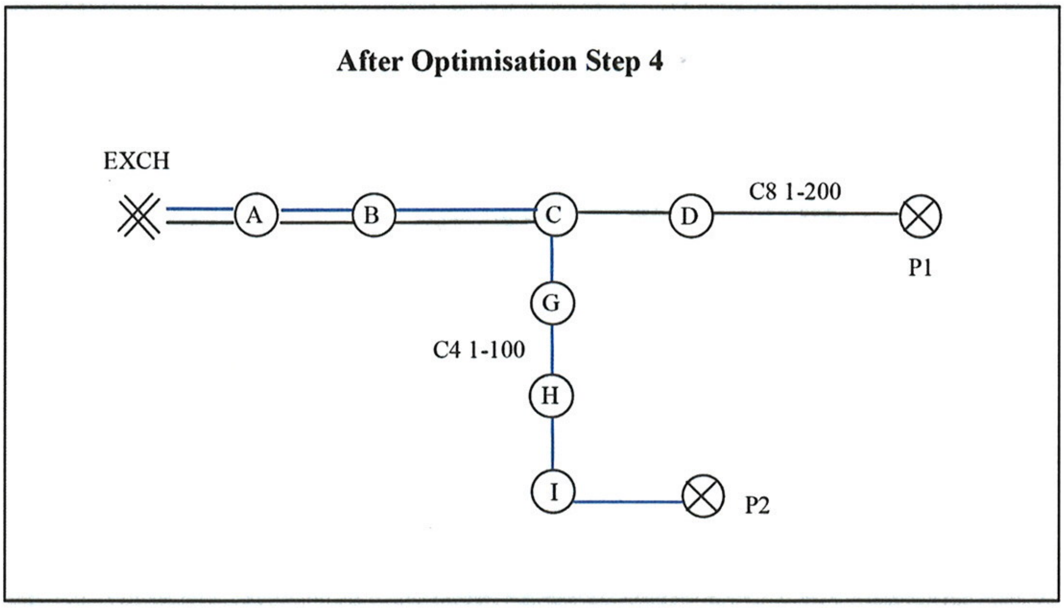


Diagram 7.3 – After Optimisation Step 4

DISTRIBUTION NETWORK SHORTEST PATH ALGORITHM

The goal is to feed to all necessary structure points, using the single shortest path to each of these structure points, independent of the current pair range that currently feeds them. This involves removing one or more cable sections, wherever there are multiple sections between the same structure_point_id_a and structure_point_id_b. For all cable sections feeding structure_point_id_b, all cable sections that are not part of the shortest path to the CCP are removed.

Note that this deletion does not remove the structure_point_id_a node, because it will be the structure_point_id_b of the previous cable section, and become the end point of the trace for that path. Structure points at the end of a route that do not serve demand are removed as the final step in the process.

8 REMOVE REDUNDANT NETWORK

After optimizing the network by cable length, there may be CCP's (including associated network cable routes) that are no longer required.

Remove network having no required distribution side network

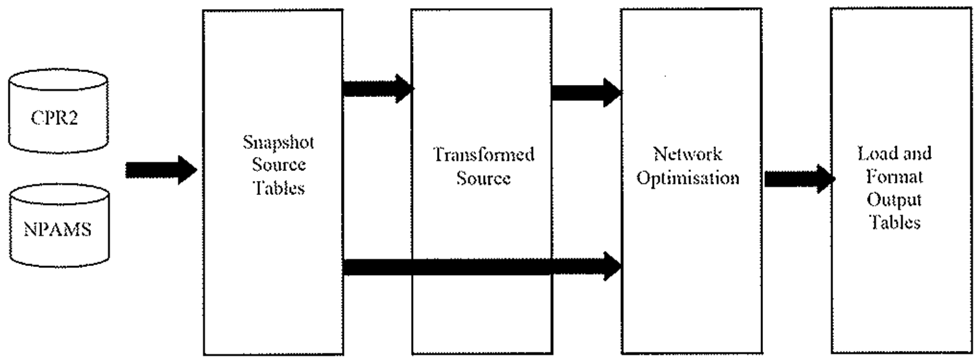
After choosing the single shortest path, there may be CCP's (i.e. cabinets) which no longer feed any other CCP, and have no distribution network. Any CCP's with no distribution side network are removed along with the otherwise unnecessary network that feeds them.

9 LOAD AND FORMAT OUTPUT TABLES

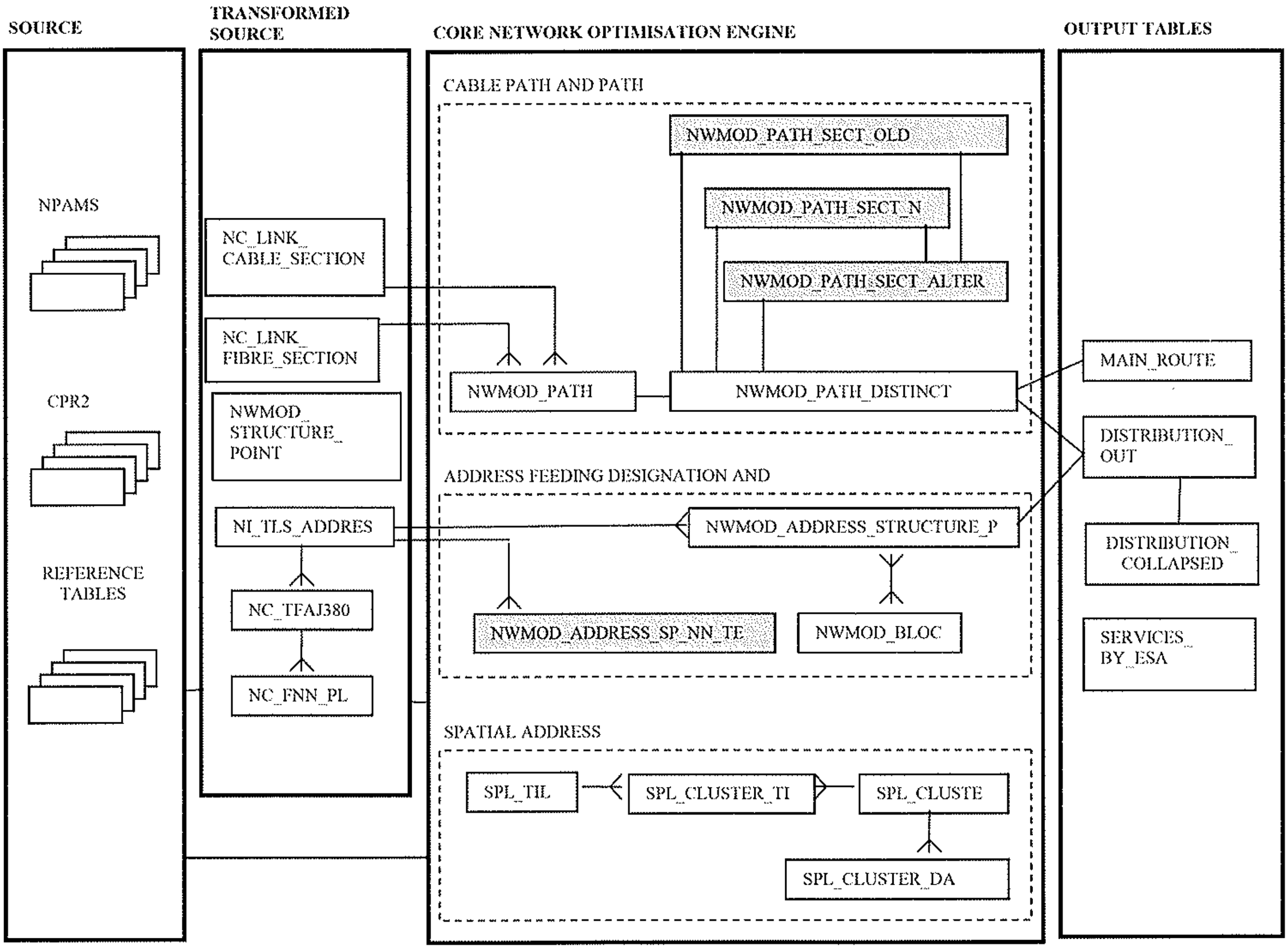
The Optimised tables generated in the Network Optimisation Process undergo some further processing and formatting to prepare them for loading into the TEA Model's Excel-based Engineering Modules.

10 DATA MODEL OVERVIEW

The data model can be grouped to align with the 5 core data flow layers. The layers are shown below:



The object relationships within the layers are shown in the following diagram. Temporary working tables are shaded grey.



The following sections list the tables in each layer.

SOURCE TABLES

NPAMS Tables

TABLE NAME
TFAJ110
TFAJ310
TFAJ380
TFAJ381
TFAJ430

TFAJ511
TFAJ516
TFAJ530
TFAJ900
TFAJ970

CPR2 Tables

TABLE NAME
NI_AERIAL_ROUTE
NI_BUILDING
NI_COPPER_CABLE
NI_COPPER_CABLE_SPEC
NI_COPPER_LINE_OF_COUNT
NI_COPPER_SPLICE
NI_MIT_CABLE
NI_MIT_COPPER_CABLE_PIN
NI_MIT_TERMINAL_ENCLOSURE
NI_NEW_STRUCTURE_EQUIPMENT_REL
NI_PAIR_GAIN
NI_POLE
NI_SERVICE_AREA
NI_TLS_ADDRESS
NI_TLS_DISTRIBUTION_POINT
NI_TLS_LOCALITY
NI_TLS_STREET
NI_TLS_STREET_LOCALITY
NI_UNDERGROUND_ROUTE
NI_UUB

Reference Tables

TABLE NAME
ESA_MATRIX
NC_TL2_LOCALITY_DBOR
WORKING_SERVICES
AREA
LIGHTENING_PROTECTION

TRANSFORMED SOURCE

TABLE NAME
NC_LINK_CABLE_SECTION
NC_LINK_FIBRE_SECTION
NWMOD_STRUCTURE_POINT_LOC
NC_TFAJ380
NC_FNN_PLT
NI_TLS_ADDRESS

TABLE NAME
VPI_NI_DA
VPI_NI_ESA

NETWORK OPTIMISATION

TABLE NAME	DESCRIPTION
NWMOD_PATH	The existing (non-optimised) path for the feeder network
NWMOD_PATH_ DISTINCT	The optimised path for feeder and distribution routes
NWMOD_ADDRESS_ STRUCTURE_POINT	Address to designation and structure_point_id mapping
NWMOD_ADDRESS_ NN_SP_TEMP	Temporary working table for storing for each address point, the set of nearest structure_point by spatial distance. Used to improve the performance of repeated nearest neighbour functions in loading the NWMOD_ADDRESS_STRUCTURE_POINT table.
NWMOD_BLOCK	T block structure_point_id, and T block attributes
SPL_TILE	All tiles covering an ESA, and the address count in that tile
SPL_CLUSTER_TILE	The cluster tile mapping table
SPL_CLUSTER	Clusters found
SPL_CLUSTER_DA	Relationship between the cluster boundary and the DA boundary
NWMOD_PATH_SECT_OLD	A temporary working table for route optimisation, which stores the old path sections
NWMOD_PATH_SECT_NEW	A temporary working table for route optimisation, which stores the new path sections to replace the old sections

NWMOD_PATH_SECT_ALTER	Temporary working table for route optimisation. Stores the altered path sections, which is a combination of the old path where that section remains unaltered, and the new path where the path is altered

TRANSFORMED OPTIMISED TABLES

TABLE NAME	DESCRIPTION
MAIN_ROUTE	File containing detailed Main route information
DISTRIBUTION_OUT	File containing detailed Distribution route information
DISTRIBUTION_COLLAPSED	File containing Distribution information summarized at the DA level
SERVICES_BY_ESA	File containing total working services and TBlock services served by Fibre summarized by ESA

11 OUTPUT TABLE FIELD DESCRIPTIONS

MAIN_ROUTES

FIELD NAME	DEFINITION
ESA_CODE	
TRANSMISSION_MEDIUM	Type of transmission (copper or fibre)
DESIGNATION	Main cable number
B_END_NAME	Name of the b_end (CCP name)
LENGTH_M	Cable section length in metres
STRUCTURE_POINT_ID_B	Cable section b_end structure_point_id
STRUCTURE_POINT_ID_A	Cable section a_end structure_point_id
DEMAND	
AGGR_LENGTH_FROM_A_END	Total length of all cable sections from current section to the a_end
MAX_DIST	
TRACE_LEVEL	Number of cable sections from the a_end

DISTRIBUTION_OUT

FIELD NAME	DEFINITION
ESA	Exchange service area code
DA	CCP Name
SEGMENT LENGTH	Cable section length in metres
CUMM LENGTH	Total length of all cable sections from current section to the a_end
LEAD-INS	Count of the number of addresses mapped to the "Current Structure"
STRUCT-TYPE	Type of structure located at "Current Structure"
BLDG-TERM	Set to "Y" if the "Current Structure" is a TBlock
TERMSIZE	Count of connected services on TBlock if BLDG-TERM = "Y"
CURRENT STRUCT	Cable section b_end structure_point_id
NEXT STRUCT	Cable section a_end structure_point_id
TRACE LEVEL	Number of cable sections from the

	a_end

DISTRIBUTION_COLLAPSED

FIELD NAME	DEFINITION
ESA	Exchange service area code
DA	CCP Name
SERVICES	Count_connected
AREA	Total area of the DA
LIGHTNINGPROTECT	Flag set to "Y" if the DA requires Lightning Protection
TRANSMISSION_MEDIUM	Type of transmission (copper or fibre)

SERVICES_BY_ESA

FIELD NAME	DEFINITION
ESA_CODE	Exchange service area code
TOTALSERVICES	Total COUNT_WORKING from NPAMS
TBLOCKSERVICES	Total of Count_connected that are served by Fibre