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| RESEARCH ARTICLE

Hub-Based Transportation Planning: Network Architecture and Configuration Governance

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| ABSTRACT
Direct transportation, where freight moves on a single leg from origin to destination, is the most intuitive planning model but is rarely the most cost-effective at scale. Hub-based transportation planning offers an alternative: by routing freight through intermediate consolidation points, shippers can exploit economies of scale on high-volume trunk lanes, reduce vehicle underutilization on low-density last-mile segments, and enable intermodal mode changes that would be impossible under direct-only planning. This paper examines hub-based transportation planning in enterprise transportation management systems, covering the network architecture that enables it, the decision logic by which the transportation proposal algorithm evaluates hub versus direct routing, the master data configuration that makes hub planning operational, the multi-stage planning sequence that coordinates inbound and outbound legs, and the cost-benefit framework that governs when hub routing delivers genuine value. We draw on logistics network design literature and enterprise systems implementation experience to argue that hub planning is not simply a routing variant but a distinct planning paradigm with its own configuration requirements, tradeoff structure, and governance implications. Poorly configured hub networks yield results worse than direct planning; well-configured ones systematically outperform direct planning in network cost and vehicle efficiency. The difference lies entirely in the quality of the configuration.

| KEYWORDS
Hub-and-spoke networks; Logistics network design; Multi-stage transportation; Transshipment location; Transportation proposal

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1. Introduction
Ask a transportation planner to describe their network, and you will almost always get a map with lines connecting shipping points directly to customer locations. Direct transportation is how most people intuitively understand logistics. It is also, at sufficient network scale, an increasingly expensive way to plan it.

The problem with direct planning is utilization. A plant shipping to 80 customer locations across three states must either send 80 separate vehicles or consolidate shipments in ways that increase route distance and complexity. Neither outcome is optimal. Eighty vehicles are rarely at capacity; consolidated routes add transit time and require sophisticated planning to construct. Below a certain volume threshold per lane, direct transportation is fine. Above it, something has to change.

That something is a hub. A hub, in transportation planning terms, is a transshipment location: a physical facility through which freight passes without being the final destination. Freight arrives from multiple origins, is cross-docked or temporarily stored, re-sorted, and dispatched on outbound vehicles to final destinations. The inbound vehicles carry consolidated loads from multiple origins; the outbound vehicles carry consolidated loads to multiple destinations. Economies of scale operate in both directions. Hub-based planning has been a staple of logistics network design for decades, with foundational work by O'Kelly (1987) and subsequent extensions by Alumur and Kara (2008) establishing the mathematical properties of hub-and-spoke networks. What enterprise transportation management systems add is the ability to execute hub planning operationally, not just strategically. The system evaluates hub routing for individual freight orders against direct routing alternatives, makes the routing decision based on configured cost parameters, and automatically creates the necessary multi-stage freight orders. This paper examines how that operational execution works and what configuration it requires.

The paper proceeds as follows. Section 2 reviews the scholarly literature on hub location, vehicle routing, and enterprise planning systems. Section 3 describes the methodology. Section 4 covers the hub network architecture and the concept of transshipment location. Section 5 analyzes the transportation proposal mechanism that drives hub routing decisions. Section 6 examines the master data configuration that enables hub planning. Section 7 covers the multi-stage planning sequence. Section 8 addresses cost-benefit dynamics and the conditions under which hub planning delivers value. Section 9 discusses practitioner implications, and Section 10 concludes.

2. Literature Review

The scholarly foundation for hub-based transportation planning rests on three bodies of work: the hub location literature in operations research, the vehicle routing literature that governs operational planning, and the enterprise systems literature that addresses how planning capability is embedded in software and sustained in practice.

The hub location literature begins with O'Kelly (1987), who formulated the location of interacting hub facilities as a quadratic integer program and established the mathematical structure of hub-and-spoke networks, in which flows between many origins and destinations are routed through a small set of hubs to exploit economies of scale on the trunk links between them. Subsequent work extended the formulation to covering, median, and center variants. Kara and Tansel (2003) developed models and a linearization for the single-assignment hub-covering problem, in which every origin must reach every destination within a service bound, a formulation directly relevant to networks governed by delivery-time commitments. Alumur and Kara (2008) surveyed the field comprehensively, classifying studies by allocation structure, capacity treatment, and objective function, and their review remains the standard map of the strategic hub location territory. The strength of this literature is its analytical rigor in answering where hubs should be located and which origins they should serve. Its limitation, for the present purpose, is that it treats network design as the endpoint: the models assume that once hubs are located, flows will follow. They say little about the operational machinery through which individual shipments are routed through or around a hub on a given day.

The vehicle routing literature addresses that operational layer. Laporte (2009) traces fifty years of vehicle routing research, and Toth and Vigo (2014) consolidate the problem variants and solution methods that underpin modern routing engines. Barnhart and Laporte (2007) collect the transportation applications of this modeling tradition across modes. Most directly relevant to hub planning is Drexl (2012), whose survey of vehicle routing problems with multiple synchronization constraints formalizes precisely the difficulty that hub routing introduces: routes on the inbound and outbound legs are planned separately yet must be synchronized in time and space at the transshipment point. This literature supplies the algorithmic core of operational hub planning but generally treats the network as a given input. Lanes, costs, and hub parameters are assumed to exist, whereas in enterprise practice they are configuration objects that must be constructed, calibrated, and maintained.

A third body of work connects planning models to enterprise software and management practice. Stadtler et al. (2015) describe how advanced planning systems embed optimization within enterprise data structures and business processes. Ballou (2004) and Mangan et al. (2020) place network design, consolidation, and hub operations within the broader logistics management discipline, including the cost and service tradeoffs that motivate hub routing in the first place. Davenport (2000) documents a recurring lesson from enterprise systems implementations: capability delivered in software translates into business value only through disciplined configuration and ongoing governance. Taken together, this literature establishes the strategic case for hubs and the algorithms for routing through them. Still, it leaves the configuration layer underexamined, in which strategy and algorithm meet inside an enterprise TMS. That configuration layer is the subject of this paper.

3. Methodology

This paper follows a qualitative, conceptual research design that integrates two sources of evidence. The first is the published literature reviewed in Section 2, spanning hub location theory, vehicle routing with synchronization constraints, and advanced planning systems. The second is implementation experience from enterprise transportation management system deployments in which hub-based planning was configured, tested, and operated for production freight networks.

The analysis proceeded in three steps. First, the planning concepts established in the literature were mapped to the system mechanisms that execute them in an enterprise TMS: the transshipment location, the path finder, the transportation proposal, and the vehicle scheduling and routing optimizer. Second, the configuration objects on which each mechanism depends were traced into an explicit dependency chain, identifying the master data and parameter settings that must exist, in sequence, for hub routing to function. Third, the cost conditions under which hub routing outperforms direct routing were derived from the system's comparison logic, and these conditions were examined against the failure patterns observed in practice.

The findings of this analysis are presented in Sections 4 through 8, and their implications for practitioners are discussed in Section 9. Because the study is analytical rather than empirical, it does not report primary shipment data from a specific implementation. The benefit ranges summarized in Section 10 are drawn from implementation experience and the cited literature and should be read as indicative rather than statistically generalizable.

4. Hub Network Architecture and the Transshipment Location

4.1 The Transshipment Location as the Hub's System Representation

A hub in the physical world is a warehouse, cross-dock facility, rail terminal, port, or any location where freight changes modes of transportation without reaching its final destination. In the enterprise TMS, this physical facility is represented as a transshipment location: a location master record of a specific type that indicates the facility is available for intermediate handling.

What distinguishes a transshipment location from any other location in the network is its assignment relationship. A transshipment location is assigned to a specific origin location or, more commonly, to a transportation zone. When assigned to a zone, the hub becomes available as an intermediate point for any origin that falls within that zone. This zone-based assignment is what makes hub planning scalable: instead of explicitly defining which hub serves which origin, the zone assignment allows the system to evaluate the hub for all relevant origins automatically (Stadtler et al., 2015).

The path finder algorithm, which underpins the transportation proposal, depends entirely on this assignment structure. Without the transshipment location assignment, the hub is invisible to the path finder and will never appear in routing proposals regardless of how attractive the hub-routed cost would be. This is the single most common configuration mistake in hub planning implementations: the transshipment location exists in the system but has not been assigned to the appropriate zones or locations.

Without the assignment, the hub does not exist for planning purposes.

The transportation lanes complete the architecture. For each hub, two sets of lanes are needed: inbound lanes from origins (or origin zones) to the hub, and outbound lanes from the hub to destinations (or destination zones). Each lane specifies the transportation mode and vehicle type permitted on that leg, constraining which resources the optimizer may assign. A hub that serves as a rail-to-road interchange will have inbound lanes marked with rail mode and outbound lanes marked with road mode. The system can therefore plan an intermodal route through the hub without any special configuration beyond the lane definitions.

HUB-BASED TRANSPORTATION PLANNING: END-TO-END PROCESS FLOW

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1. Sales Order Or Delivery Created

Transportation-relevant business document created in S/4HANA. The system detects the need for transportation and triggers the creation of a freight unit.

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2. Freight Unit Created

The freight unit building rule applies split logic, weight and volume ceilings, and incompatibility checks. One or more freight units are produced per order.

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3. Transportation Proposal Requested

Planner triggers a proposal from the transportation cockpit, or the system triggers one automatically. The path finder scans the network for every valid route, direct and hub-connected.

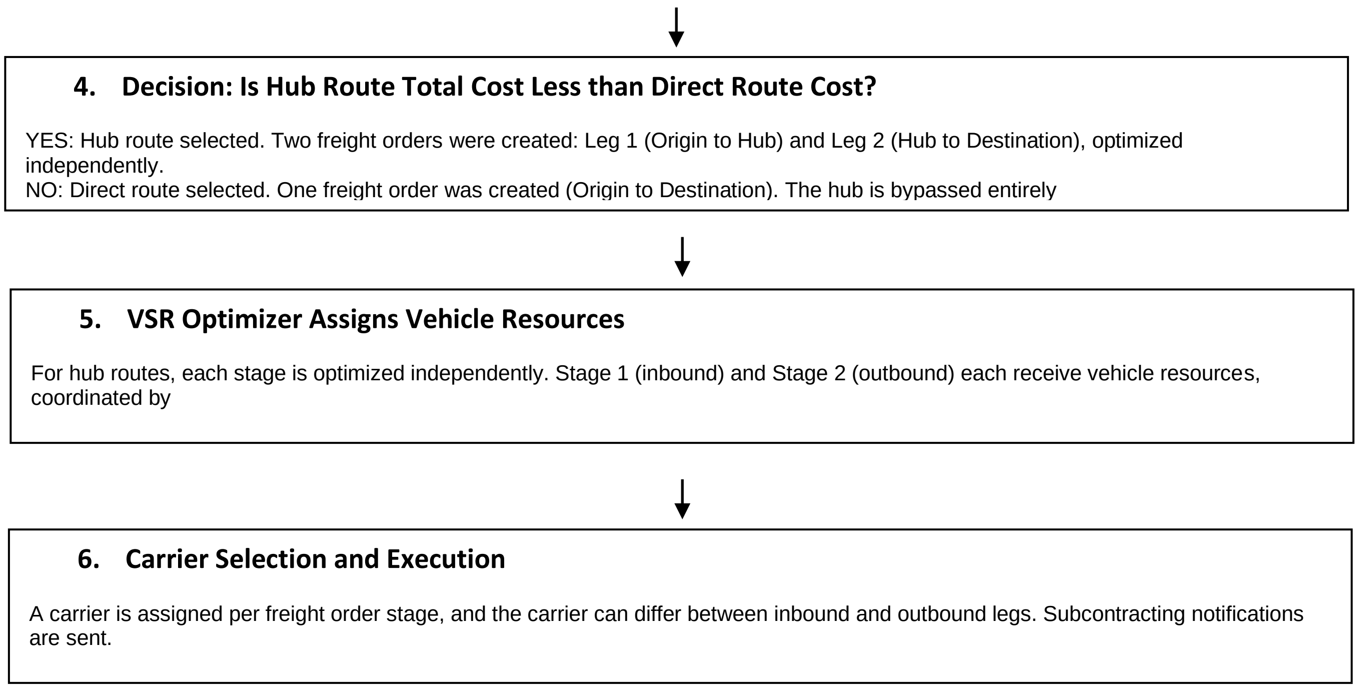


Figure 1. Hub-based transportation network architecture showing the consolidation hub as an intermediate transshipment point between multiple origins and destinations. The VSR optimizer evaluates hub routing versus direct routing based on the configured cost parameters and automatically selects the lower-cost option.

4.2 Hub-and-Spoke vs. Point-to-Point: The Network Design Decision

The decision to implement hub-based planning is fundamentally a network design decision, not a systems configuration decision. The system's configuration follows from the design; it cannot substitute for it. Organizations that implement hub planning without a coherent network design rationale typically find that the hub configuration is technically correct but operationally counterproductive: the hub is configured for the wrong locations, with the wrong capacity parameters, or at the wrong level of zone granularity.

The economic case for hub-and-spoke over point-to-point rests on three conditions. First, there must be sufficient volume on the trunk lanes (origin-to-hub and hub-to-destination) to support larger vehicles at high utilization. Second, the hub-handling cost must be low enough relative to the transport cost savings to yield a net positive contribution. Third, the additional transit time introduced by the hub stop must be acceptable within customer delivery windows and service-level agreements (Kara & Tansel, 2003).

When these conditions hold, hub planning delivers material cost improvements. When they do not, hub planning adds cost and complexity without benefit. The enterprise TMS optimizer tests these conditions implicitly by comparing the hub route total cost to the direct route cost for each freight unit. But this comparison only works correctly if the cost parameters are calibrated to reflect actual business economics: planning costs on the hub location, freight rates on the legs, and penalty costs for late delivery.

5. The Transportation Proposal: How the System Evaluates Hub Routing

5.1 Entry Points and Trigger Conditions

The transportation proposal is the mechanism through which the system evaluates routing alternatives for one or more freight units and presents ranked options to the planner. It can be triggered from two entry points: from within the transportation cockpit by selecting one or more freight units and requesting a proposal, or from a forwarding order by defining a route on the actual route tab. In both cases, the path finder runs first, identifying all valid connections between the freight unit’s origin and destination, including any routes that pass through configured transshipment locations.

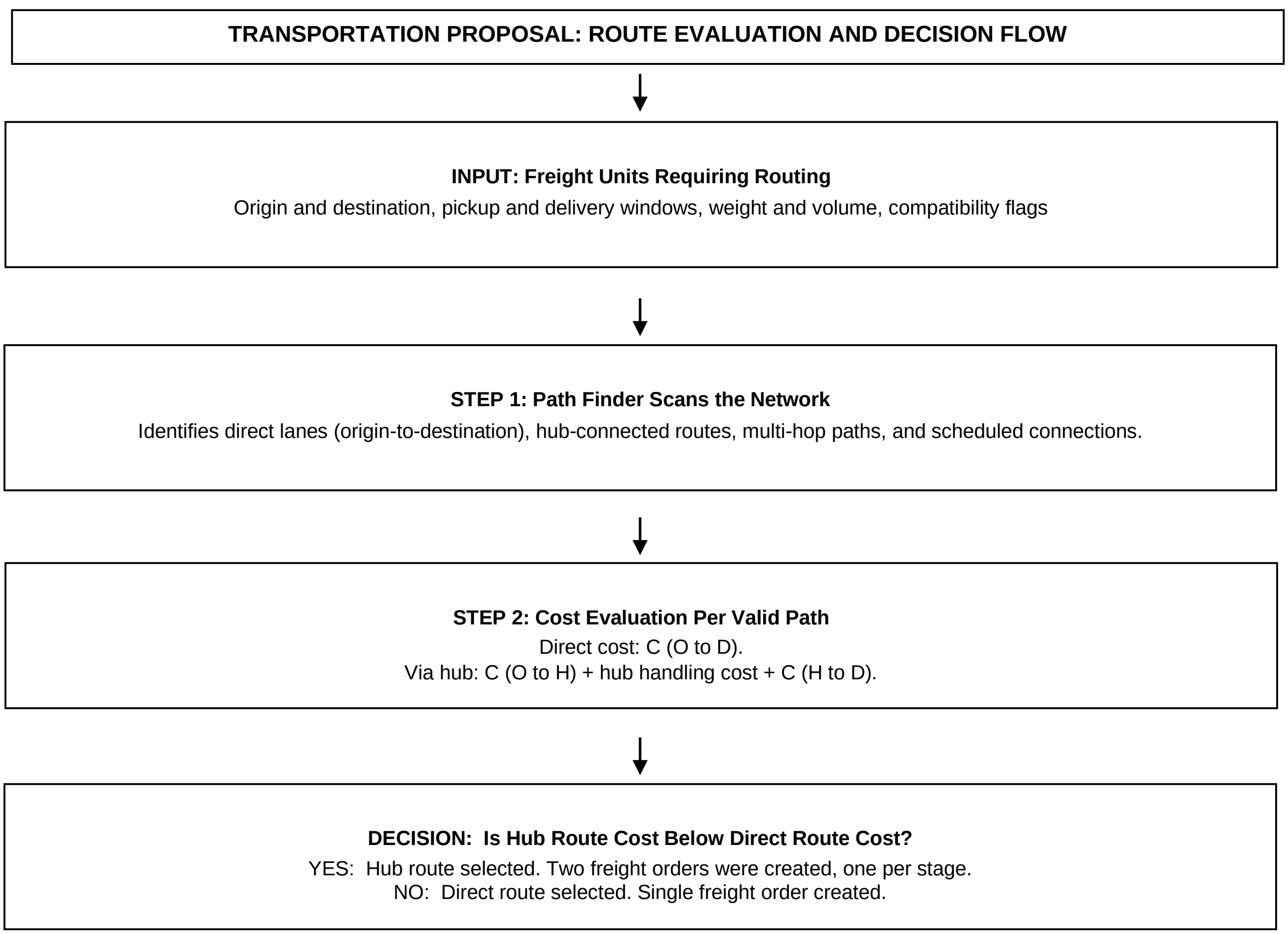
The transportation proposal is distinct from the VSR optimizer, and confusing the two is a persistent source of implementation issues. The VSR optimizer assigns freight to vehicle resources and schedules the resulting freight orders. The transportation proposal determines the routing: how many stages, through which locations, using which modes. The transportation proposal runs before the VSR optimizer. Its output, the selected route, becomes the framework within which the optimizer subsequently assigns resources and schedules. A freight unit routed through a hub under the transportation proposal will have two stages; the VSR optimizer then schedules each stage independently (Toth & Vigo, 2014).

5.2 The Path Finder and Route Evaluation

The path finder algorithm examines the transportation network to find all valid paths from the freight unit's origin to its destination. A valid path is a sequence of connected transportation lanes that collectively cover the full origin-to-destination journey, where each connection point is either a transshipment location or a scheduling location (a location where a carrier schedule provides the connection). Cost evaluation is outside the Pathfinder's scope. It identifies only topologically possible paths, leaving cost comparison to the transportation proposal layer above it.

Once the path finder has identified valid paths, the transportation proposal evaluates each path's cost. For a two-stage hub route, the total cost is the sum of the inbound leg cost, the hub handling cost, and the outbound leg cost. For a direct route, it is simply the cost of the direct lane. The system ranks paths by total cost (or by other criteria if the planner has configured preference-based ranking by carrier, mode, or time) and presents the ranked list for the planner to review and confirm (Laporte, 2009).

A single transportation proposal can cover multiple freight units simultaneously when those freight units are competing for the same capacity, for example, multiple deliveries bound for the same destination region that share an outbound leg from the hub. In this case, the proposal evaluates routing combinations that produce a valid overall assignment, not just optimal individual routes. This combinatorial evaluation is one reason the transportation proposal can yield results that appear suboptimal for individual freight units yet are collectively efficient.



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OUTPUT: Ranked routing options presented to the planner in the transportation cockpit. The planner reviews, selects, and confirms. Freight unit stages and freight orders are saved, and the VSR optimizer then independently assigns vehicle resources to each stage.

Figure 2. Transportation proposal decision logic: the path finder identifies valid hub-connected and direct routes; the cost evaluation compares total path costs; and the system creates either a two-stage hub route or a single direct route based on the cost comparison.

6. Master Data Configuration for Hub-Based Planning

6.1 The Configuration Dependency Chain

Hub planning in an enterprise TMS operates through a strict dependency chain. Each element must exist and be correctly configured before the next element can function. Understanding this chain is essential for diagnosing why hub routing proposals are not appearing when expected.

The chain begins with the location master record for the hub facility. The location type must indicate transshipment capability. The location must then be assigned to the appropriate transportation zones or origin locations. Transportation lanes must exist for both inbound and outbound legs, with the correct modes of transport. Opening hours must be defined if the hub has restricted operating times. If the hub has constrained handling capacity, handling resources must be configured and assigned. Planning costs must be defined for the hub location if hub handling costs are to be factored into the routing evaluation. Only when all these elements are in place will the hub appear in transportation proposals as expected.

6.2 Configuration Parameters and Their Planning Impact

Several configuration parameters warrant particular attention because their misconfiguration can lead to difficult-to-diagnose consequences after the fact. The length-of-stay parameter defines the minimum and maximum time a freight unit may spend at the hub. The minimum ensures sufficient time for cross-docking operations: unloading inbound freight, sorting, and loading outbound vehicles. If the minimum is set too short, the system may create technically valid plans in which the outbound vehicle departs before inbound freight has been unloaded, resulting in execution failures at the hub. The maximum prevents excessive dwell that could cause delivery delays for customers. Setting the maximum too tight eliminates viable hub routes that would otherwise be cost-effective (Mangan et al., 2020).

A parameter in the planning profile sets a ceiling on the number of intermediate stops the system will consider per route. For most land transportation networks, one or two transshipment hops are the practical limit. Setting this value too high causes the path finder to explore exponentially more paths, degrading proposal-generation performance without adding any usable routing options. Setting it too low may exclude legitimate multi-hub routes in complex networks.

TRANSSHIPMENT LOCATION: MASTER DATA CONFIGURATION		
Configuration Layer	**Object / Field**	**Purpose and Planning Impact**
Location Master	Location Type = Hub / Transshipment	Identifies the facility as a transit point. Required for Pathfinder to include this location in multi-stage routing proposals.
Location Assignment	Assign location to transportation zone.	Makes the hub available to all origins in the assigned zone. Reduces the number of explicit transshipment assignments needed.
Transportation Lane (Inbound)	Origin → Hub lane with means of transport	Defines valid inbound legs. Without this lane, the optimizer cannot route freight from the origin to the hub.
Transportation Lane (Outbound)	Hub → Destination lane with means of transport	Defines valid outbound legs. Must exist for every destination the hub serves. Mode can differ from inbound (intermodal hub).
Opening Hours	Calendar and shift pattern assignment	VSR optimizer respects hub opening hours as hard constraints. Arrival before opening or after closing generates a constraint

		violation.
Length of Stay	Min/max dwell time at hub location.	Controls how long freight may wait at the hub. Minimum ensures handling time; maximum prevents excessive dwell that increases delivery lateness.
Handling Resource	Loading/unloading capacity definition	Limits the number of freight units that can be processed concurrently. Prevents the optimizer from routing more freight than the hub can physically handle.

Figure 3. Transshipment location master data configuration: the seven configuration layers required to make a hub location fully operational in multi-stage transportation planning, from location type through handling resource capacity.

7. Multi-Stage Planning: Coordinating Inbound and Outbound Legs

7.1 Stage Architecture and Independence

When a freight unit is routed through a hub, the system creates two freight unit stages: Stage 1, covering the inbound leg from origin to the hub, and Stage 2, covering the outbound leg from the hub to the destination. Up to a point, the VSR optimizer treats each stage as a separate planning problem. Independent planning means that different vehicle resources, different carriers, and different departure schedules can be assigned to each stage. This independence is what enables the mode flexibility described earlier.

But the stages are not fully independent: they share a scheduling constraint at the hub. The outbound departure of Stage 2 must occur after the inbound arrival of Stage 1 plus the minimum length of stay. If the VSR optimizer assigns an outbound departure too close to an inbound arrival, the plan is infeasible at the hub level even if each stage looks feasible in isolation. The system enforces this coordination through the hub scheduling constraints, but only if those constraints have been correctly configured on the hub location.

7.2 Planning Horizon and Sequence

The planning sequence for a hub scenario follows a defined order. The transportation proposal determines the route and creates the stage structure. The VSR optimizer then runs to assign vehicle resources and create freight orders for each stage. Carrier selection subsequently runs per stage, potentially assigning different carriers to the inbound and outbound legs. Finally, execution processes (delivery creation, event management, carrier notifications) operate on each freight order independently while tracking the freight unit's end-to-end journey.

From the planner's perspective in the transportation cockpit, a hub-routed freight unit appears with its two stages visible in the stage list. The planner can see the inbound freight order, the hub stop with its dwell window, and the outbound freight order. Modifications to either stage, including changing the hub departure time, reassigning a carrier, or adjusting capacity, propagate through the scheduling constraints to the other stage, maintaining end-to-end feasibility (Drexl, 2012).

MULTI-STAGE HUB PLANNING: SEQUENCE BY SYSTEM LAYER					
System Layer	**Phase 1** **Freight Unit Creation**	**Phase 2** **Transportation Proposal**	**Phase 3** **Route Confirmation**	**Phase 4** **VSR Optimization**	**Phase 5** **Carrier Assignment**
Business Layer	Sales order or delivery triggers FU creation	Planner requests a proposal from the cockpit or FO	Planner reviews ranked routes and confirms	not active in this phase	not active in this phase
TMS Planning Engine	FUBR applies split rules; weight/volume	Pathfinder scores all valid paths	Stages created: Stage 1 + Stage 2 per hub route	VSR assigns vehicles per stage independently	Carrier ranking built; action triggered
Hub Facility	not active in this phase	not active in this phase	Hub dwell window calculated (min/max LoS)	Hub capacity checked against inbound schedule	not active in this phase
Carrier /	not active in this	not active in this phase	not active in this	not active in this	Carrier notified per

Execution	phase		phase	phase	stage; subcontracting doc created

Figure 4. Multi-stage planning sequence for hub scenarios: the five sequential planning steps from freight unit creation through carrier assignment, showing which planning function operates at each step and the data handoffs between steps.

8. When Hub Planning Delivers Value

8.1 The Break-Even Logic

Hub planning delivers value when the cost savings from consolidation exceed the hub handling cost plus any lateness penalty arising from the added transit time. This is a straightforward algebraic condition, but it plays out differently across different freight characteristics, network geometries, and volume profiles.

Volume is the dominant variable. A hub that handles 50 freight units per day achieves a dramatically lower handling cost per unit than one handling 5. This is not just a function of how busy the hub is; it is also a function of how well the inbound and outbound volume profiles match. A hub that receives large consolidated inbound loads but dispatches many small outbound deliveries must run more outbound vehicles at lower average utilization, eroding the inbound savings. Optimal hub economics require volume balance across both legs (Ballou, 2004).

Weight and dimensional density matter for a related reason. A hub serving shipments that are dense (high weight-to-volume ratio, good vehicle loading factor) will achieve better economics than one serving light, bulky freight that cubes out vehicles before the weight limit is reached. Hub planning configuration should account for these characteristics by defining appropriate freight unit building rules that create freight unit sizes aligned with typical vehicle-loading profiles for each leg.

8.2 Risk Factors and Mitigation

Three risk factors consistently undermine hub planning performance in practice. The first is over-configuration: defining hub zones that are too broad, pulling freight through the hub from origins where direct delivery would be cheaper. The VSR optimizer will catch this when planning costs are correctly calibrated. Still, if hub handling costs are set too low, the optimizer will select hub routing even when it is genuinely more expensive. Correct cost calibration is the primary defense.

The second risk is insufficient volume. A hub that was cost-justified at projected volumes becomes expensive when actual volumes are lower. This is particularly acute in hub planning because the overhead is largely fixed: the hub facility, the inbound frequency, the outbound schedule. Below the break-even volume, hub planning imposes fixed costs without delivering consolidation savings. Regular monitoring of hub utilization metrics and willingness to reconfigure or deactivate underperforming hub assignments is essential for maintaining network efficiency over time (Barnhart & Laporte, 2007).

The third risk is the accumulation of dwell time.

When outbound vehicle capacity or departure schedules do not align with inbound arrival patterns, freight waits longer than planned at the hub. This increases the risk of lateness and adds handling costs. Configuring the maximum length of stay aggressively and monitoring actual versus planned dwell times in the transportation cockpit allows planners to identify hubs where outbound capacity needs to be increased or departure schedules adjusted.

HUB-BASED PLANNING: COST-BENEFIT ANALYSIS AND CONFIGURATION CHECKLIST		
Factor	**Hub Route Advantage**	**Required Configuration**
Freight Consolidation	LTL shipments consolidated at the hub reduce per-unit transportation cost by 15-35% on outbound legs	Transshipment location assigned to origin zone; inbound and outbound lanes defined; minimum dwell time configured
Vehicle Utilization	Larger inbound vehicles (FTL) serve multiple small-destination shipments; outbound vehicles are sized to the delivery radius.	Vehicle resources and means of transport are defined per leg; capacity dimensions are aligned to the freight unit building rule.
Mode Flexibility	Origin-to-hub may use one mode (e.g., rail); hub-to-customer uses another (e.g., road), enabling cost-	Transportation lanes per leg carry the correct mode of transport; the path

	optimized intermodal planning.	finder is configured to allow mode change at the hub.
Network Simplification	Reduces O x D lane combinations to O + D lanes (hub-and-spoke eliminates the need for a direct lane per origin-destination pair)	Transportation zones are assigned to the hub; zone-to-zone lanes via the hub replace direct location-to-location lanes.
Cost Control	VSR optimizer only selects the hub route when the hub total cost is below the direct cost; the decision is automatic and auditable via the explanation log	Planning costs defined on hub location; penalty costs configured; optimizer maximum transshipment count set in planning profile
Risk: Dwell Cost	Hub adds transit time and handling cost; if demand volume is low, per-unit hub overhead may exceed savings.	Minimum load factor threshold; length of stay limits; monitoring via transportation cockpit KPIs

Figure 5. Hub-based planning cost-benefit analysis and configuration checklist: six planning dimensions showing the advantage delivered by hub routing, the volume and network conditions required, and the specific configuration elements needed in the TMS.

9. Practitioner Implications

9.1 Start with Network Design, Not Configuration

The single most important guidance for organizations implementing hub-based planning is this: configure the TMS hub parameters only after the network design is complete, not as a way of doing the network design. Hub-and-spoke network design is a strategic exercise that requires analysis of shipment data, customer delivery windows, hub facility costs, and carrier rate structures across the network. The TMS configuration should faithfully implement a design that has been validated externally; it cannot substitute for that analysis.

In practice, many implementations proceed in the reverse order. The project team configures transshipment locations because the system has the capability, without establishing whether the hub will actually deliver cost savings at the anticipated volumes. When the go-live reveals that hub routing is generating more expensive plans than direct alternatives, the project team adjusts the configuration to suppress hub routing rather than reconsidering the network design. The result is a system with hub capability that nobody uses because the network design never justified it.

9.2 Calibrating Costs and Governing Configuration

Planning cost calibration for hub locations deserves the same discipline as rate calibration for transportation lanes. Hub handling costs are often set to nominal values during implementation and never updated. As hub facility costs change, handling efficiency improves or degrades, and volume profiles shift, planning costs should be updated to reflect current economics. A planning cost that was accurate at go-live can be substantially wrong two years later, causing the optimizer to make systematically incorrect hub routing decisions.

Hub configuration governance should be treated as a regular operational process. Quarterly review of hub utilization metrics, comparison of planned versus actual hub costs, and annual reconciliation of planning costs against facility cost data are the minimum governance activities for a hub network intended to deliver ongoing value. Organizations that implement hub planning and then neglect the configuration consistently see hub planning performance degrade over time as the gap between configured costs and actual costs widens (Davenport, 2000).

The transportation cockpit's explanation tool is the most valuable diagnostic resource for hub planning issues. When a planner questions why the system routed freight through or bypassed a hub unexpectedly, the explanation tool shows the cost calculation that drove the decision: the direct-route cost, the hub-route cost per leg, and the hub-handling cost. This transparency converts hub planning from an opaque algorithmic process into an auditable business decision that planners can understand, validate, and challenge when necessary.

10. Conclusion

Hub-based transportation planning offers logistics networks a path to materially lower unit transportation costs, higher vehicle utilization, and flexible mode integration. But it delivers these benefits only when the underlying network design is sound, the master data configuration is complete and correctly calibrated, and the planning costs reflect actual economics. None of these conditions can be assumed.

This paper has examined hub planning from the ground up: the transshipment location as the system's representation of a hub facility, the transportation proposal mechanism that evaluates hub versus direct routing for each freight unit, the configuration dependency chain that must be fully satisfied for hub proposals to appear, the multi-stage planning sequence that coordinates inbound and outbound legs, and the cost-benefit conditions that determine when hub routing genuinely outperforms direct alternatives.

Two conclusions stand out above the others. First, the path finder is the make-or-break component. If the transshipment location assignment structure is incomplete, hub routing does not happen regardless of how well everything else is configured. Validating the pathfinder output for a representative set of origin-destination pairs should be one of the first tests in any hub-planning implementation. Second, cost calibration is not a one-time setup task. It is an ongoing governance responsibility. Hub planning configuration that was correct at go-live will drift from accuracy as facility costs, carrier rates, and volume profiles change. Organizations that build calibration reviews into their regular planning governance cycle will sustain hub planning performance over time; those that don't will see performance erode until hub planning is quietly abandoned.

Configuration governs cost. Cost governs the decision. The decision governs the network.

Benefit Dimension	Metric	Reported Impact Range	Conditions for Achievement
Unit Transportation Cost	Reduction vs. direct routing on eligible lanes	15 - 35%	Inbound FTL utilization above 80%; hub handling cost below 12% of total lane cost
Vehicle Utilization (Outbound)	Improvement in load factor on last-mile legs	20 - 40%	Hub serves zone with more than 15 delivery stops; outbound frequency matched to inbound volume.
Network Lane Reduction	Reduction in active lane-carrier combinations to maintain	30 - 60%	Zone-based transshipment assignment replaces direct location-to-location lanes.
Mode Flexibility	Share of shipments using intermodal routing (previously unavailable)	Up to 25%	Inbound rail/ocean lanes plus outbound road lanes configured at hub; schedule connections maintained
Planner Productivity	Reduction in manual routing decisions per planner per shift	35 - 50%	Transportation proposal automated; planner reviews exceptions rather than building all routes
Carbon Reduction	Emission reduction from improved vehicle utilization and modal shift	10 - 20%	Intermodal capability active; CO_2 planning costs configured in planning profile

Figure 6. Reported benefits range from hub-based planning implementations across six dimensions, with the operating conditions required to achieve each benefit.

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