Field Service Routing & Scheduling Guidelines

Calibration Services Division | Version 3.2 | October 2025

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1. Daily Capacity Constraints

1.1 Maximum Visits Per Technician Per Day

- **Standard Limit**: 4 clinic visits
- **Rationale**:
  - 2 hours average service time per device
  - 1-2 hours total travel time
  - 8-hour working day
  - Buffer for traffic/delays

Exceptions:

- **3 visits maximum** if any visit > 100km from home base
- **5 visits allowed** only for same-city clusters with < 5km between sites

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1.2 Maximum Daily Travel Distance

- **Standard Limit**: 200 kilometers per day
- **Rationale**:
  - Fuel efficiency
  - Technician fatigue management
  - Environmental impact reduction

Calculation Method:

```
Total Distance = Home Base → Clinic 1 → ... → Clinic N → Home Base
```

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2. Route Optimization Principles

2.1 Primary Optimization Goal

Minimize total travel distance while respecting:

1. SLA deadlines (hard constraint)
2. Technician specialization (hard constraint)
3. Daily capacity limits (hard constraint)
4. Clinic time windows (soft constraint)

2.2 Algorithm Recommendation

Nearest Neighbor with Constraints:

1. Start with highest priority device (OVERDUE > URGENT > SCHEDULED)
2. Select closest unvisited clinic matching technician specialization
3. Check daily capacity (visits & distance)
4. Verify SLA compliance
5. Repeat until all devices assigned

Advanced: Consider using Google Maps Directions API with waypoint optimization (up to 25 waypoints per request)

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3. Geographic Clustering Rules

3.1 City-Based Clustering

Priority Order:

1. **Same City**: Always prioritize visits within technician's home base city
2. **Adjacent Cities**: Group inter-city visits for same day when > 2 devices
3. **Regional Clusters**: Create regional routes for rural areas

Example - Technician in Warszawa:

- Day 1: All Warszawa clinics (4 visits)
- Day 2: Poznań cluster (3 visits)
- Day 3: Wrocław cluster (3 visits)
- Day 4: Szczecin cluster (2 visits)

3.2 Distance Thresholds

Cities	Distance	Same-Day Feasible?	Notes
Warszawa-Poznań	310km	❌ No	Separate day required
Poznań-Wrocław	170km	✅ Yes (max 2 visits)	Early start needed

Cities	Distance	Same-Day Feasible?	Notes
Warszawa-Wrocław	350km	❌ No	Too far for same day
Szczecin-Poznań	250km	⚠️ Conditional	Only if 2 urgent devices

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4. Time Windows & Scheduling

4.1 Clinic Operating Hours

Hospitals (24h/48h SLA):

- **Preferred Window**: 08:00 - 16:00
- **Flexible**: Can accommodate early (07:00) or late (17:00) if needed
- **Weekend**: Available for emergency OVERDUE devices

Clinics (72h SLA):

- **Strict Window**: 09:00 - 15:00
- **Lunch Break**: 12:00-13:00 (avoid scheduling)
- **Weekend**: Closed (plan accordingly)

4.2 Service Time Buffers

Add these buffers to estimated service times:

- **Setup Time**: +15 minutes (unpacking equipment)
- **Documentation**: +15 minutes (completion paperwork)
- **Clinic Handover**: +10 minutes (discussing results with staff)
- **Parking/Building Access**: +10 minutes (urban clinics)

Total Buffer: ~50 minutes per visit

Example Schedule:

```
08:00 - Depart home base
08:45 - Arrive Clinic 1 (45min travel)
09:00 - Start calibration (15min setup)
11:00 - Complete service (2h work)
11:15 - Paperwork & handover (15min)
11:30 - Depart to Clinic 2
12:15 - Arrive Clinic 2 (45min travel)
13:00 - Lunch break (avoid scheduling during this time)
14:00 - Start calibration
16:00 - Complete service
16:15 - Paperwork
16:30 - Depart to home base
17:15 - Arrive home (45min travel)
```

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5. Technician Assignment Logic

5.1 Specialization Matching

Priority 1: Exact Match

- Audiometer → Technician with "Audiometry" or "All"
- Tympanometer → Technician with "Tympanometry" or "All"

Priority 2: "All" Specialists

- Can handle any device type
- Ideal for mixed-device clinics

Example Scenario:

```
Clinic has: 2 Audiometers + 1 Tympanometer

Option A: Send "All" specialist → 1 visit, 5 hours total
Option B: Send Audiometry + Tympanometry → 2 visits, 3.5h each
      (Only if urgent SLA requires it)

Recommendation: Option A (fewer visits = lower travel cost)
```

5.2 Home Base Proximity

Rationale: Reduce travel time and cost

Assignment Priority:

1. Technician in same city as clinic (0-20km)
2. Technician in adjacent city (50-100km)
3. Technician in regional city (100-200km)
4. Cross-region dispatch (> 200km) - only for OVERDUE emergencies

Example - Clinic in Poznań:

```
Best: TECH002 (Anna Nowak - Home Base: Poznań)
Alt1: TECH005 (Marcin Lewandowski - Warszawa, 310km)
Alt2: TECH003 (Tomasz Wisniewski - Wrocław, 170km)
```

5.3 Workload Balancing

Goal: Distribute work evenly across team

Monthly Target: 15-20 visits per technician

Weekly Check:

- If Technician A has > 5 visits this week
- And Technician B has < 2 visits
- Assign new jobs to Technician B (if specialization matches)

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6. Multi-Device Clinic Optimization

6.1 Batching Same-Clinic Devices

ALWAYS batch when:

- Multiple devices at same clinic
- Within same scheduling window (SCHEDULED or URGENT)
- Single technician can handle all device types

Example:

```
Clinic CLI005 has:
- EQP010: Audiometer (SCHEDULED, due in 23 days)
- EQP045: Tympanometer (URGENT, due in 8 days)

Decision: Send "All" specialist on Day 5
      → Service both devices in single 3.5-hour visit
      → Save 1 trip = €75 travel cost
```

6.2 Sequential Routing

For multi-clinic days, order visits by:

1. **Priority**: OVERDUE first, then URGENT, then SCHEDULED
2. **Geography**: Nearest neighbor from current location
3. **Time Windows**: Respect clinic operating hours

Example Route (Warszawa Technician):

```
Priority Sort:
1. CLI003 (OVERDUE, Priority 1)
2. CLI007 (URGENT, Priority 2)
3. CLI011 (SCHEDULED, Priority 3)
4. CLI015 (SCHEDULED, Priority 3)

Geographic Optimization (using CLI003 as start):
CLI003 (Warszawa Center)
  → CLI015 (5km, 15min)
  → CLI007 (8km, 20min)
  → CLI011 (12km, 25min)

Total: 25km intra-city travel vs 45km if unoptimized
```

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7. Traffic & Seasonal Considerations

7.1 Peak Traffic Periods

Avoid scheduling during:

- **Morning Rush**: 07:00-09:00 (Warszawa, Poznań, Wrocław)
- **Evening Rush**: 16:00-18:00 (all major cities)
- **Friday Afternoons**: 14:00+ (weekend exodus)

Add Traffic Buffer:

- Normal conditions: Use Google Maps estimated time
- Peak hours: Add +30% to travel time
- Winter (Nov-Feb): Add +20% (weather delays)

7.2 Seasonal Adjustments

Winter (December-February):

- **Max Distance**: Reduce to 150km/day
- **Max Visits**: Reduce to 3/day
- **Start Time**: Delay to 09:00 (ice/snow)
- **Emergency Kit**: Required (shovel, blankets, phone charger)

Summer (June-August):

- **Holiday Coverage**: 20% reduced clinic availability
- **Technician Vacation**: Stagger schedules, maintain 3 active techs minimum

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8. Route Planning Workflow

8.1 Automated Agent Process

Step 1: Device Collection

```
Query Data Fabric:
  - Status = OVERDUE, URGENT, or SCHEDULED
  - Group by: clinic_id, priority, device_type
```

Step 2: Priority Ranking

```
Sort devices by:
  1. Status (OVERDUE > URGENT > SCHEDULED)
  2. SLA hours (24h > 48h > 72h)
  3. Priority number (1 > 2 > 3 > 4 > 5)
```

Step 3: Technician Matching

```
For each device:
  - Filter technicians by specialization
  - Calculate distance from home_base to clinic
  - Check daily capacity (visits & km)
  - Assign to closest available technician
```

Step 4: Route Optimization

```
For each technician's daily assignments:
  - Use Google Maps Directions API
  - Optimize waypoint order
  - Validate: total_distance <= 200km
  - Validate: total_visits <= 4
```

Step 5: Schedule Generation

```
Create ServiceOrder records:
  - scheduled_date: Next available date
  - route_sequence: 1, 2, 3, 4 (optimal order)
  - estimated_start_time: Calculated with buffers
```

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9. Google Maps API Integration

9.1 API Endpoints

Directions API:

```
Endpoint: https://maps.googleapis.com/maps/api/directions/json
Parameters:
  - origin: Technician home_base coordinates
  - destination: Last clinic coordinates
  - waypoints: optimize:true|lat1,lng1|lat2,lng2|...
  - mode: driving
  - departure_time: now (for traffic data)
```

Distance Matrix API (for quick distance checks):

```
Endpoint: https://maps.googleapis.com/maps/api/distancematrix/json
Parameters:
  - origins: Multiple technician locations
  - destinations: Multiple clinic locations
  - mode: driving
```

9.2 Response Parsing

Extract from Directions API response:

- `routes[0].legs[].distance.value` → Total kilometers
- `routes[0].legs[].duration.value` → Travel time in seconds
- `routes[0].waypoint_order[]` → Optimized sequence

Cost Calculation:

```python
total_km = sum(leg['distance']['value'] for leg in legs) / 1000
travel_cost = total_km * 0.50  # €0.50/km
fuel_cost = total_km * 0.15    # €0.15/km (internal accounting)
```

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10. Edge Cases & Exceptions

10.1 Emergency OVERDUE Handling

Scenario: Device is overdue, clinic has 24h SLA

Action:

1. **Immediate Dispatch**: Regardless of daily capacity
2. **Cancel/Reschedule**: Lower priority visits if needed
3. **Overtime Approved**: Technician can work beyond 8 hours
4. **Cross-Region OK**: Send any available specialist

Example:

```
Technician TECH001 has 4 visits scheduled
OVERDUE device appears at CLI050 (critical hospital)

Decision:
  → Reschedule 1 SCHEDULED visit to tomorrow
  → Insert CLI050 as Visit #1 (highest priority)
  → Adjust route dynamically
```

10.2 No Available Technician

Scenario: All technicians at max capacity for urgent timeframe

Escalation Path:

1. **Alert Manager**: Send Action Center task immediately
2. **Options Presented**:
   - Hire temporary contractor (€500/day)
   - Reschedule lower priority visits
   - Request overtime from technicians
3. **Manager Decision**: Approve within 2 hours

10.3 Device Requires Special Equipment

Scenario: Clinic has rare device model requiring special calibration kit

Process:

1. Check `calibration_rules.pdf` for equipment requirements
2. Verify technician has kit (stored in `technician_equipment` table - future)
3. If not: Schedule 2 days later (allow time for kit delivery)

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11. Performance Metrics

11.1 Route Efficiency KPIs

Target Metrics:

- **Average km per visit**: < 50km
- **Visits per technician per day**: 3.5 average
- **On-time arrival rate**: > 95%
- **Route optimization savings**: > 20% vs naive routing

11.2 Cost Tracking

Per Route:

```
Total Cost = (Travel Distance × €0.50) + (Service Time × Tech Hourly Rate)

Example:
  - 120km travel × €0.50 = €60
  - 6 hours work × €45/hour = €270
  - Total: €330 for 3-visit day
```

Monthly Target: < €8,000 travel costs for team of 5

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12. Communication & Coordination

12.1 Pre-Visit Notifications

Send to Clinic (48 hours before):

- Scheduled date & time
- Technician name & photo
- Estimated duration
- Preparation checklist

Send to Technician (24 hours before):

- Optimized route map (Google Maps link)
- Device details for each clinic
- Special instructions
- Emergency contact numbers

12.2 Day-Of Coordination

Technician Check-In:

- SMS/App notification when arriving at each clinic
- Update ServiceOrder status: "In_Progress"
- Upload photos of calibration stickers

Real-Time Adjustments:

- If running > 30min late → Auto-notify next clinic

- If device cannot be calibrated → Manager alert
- If traffic delays route → Recalculate remaining stops

Document Control

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Document Owner: Field Service Operations Manager
Approved By: Director of Service Delivery

Revision History:

- v3.2 (Oct 2025): Added winter seasonal adjustments
- v3.1 (Jul 2025): Updated Google Maps API integration
- v3.0 (Apr 2025): Major rewrite - added automation guidelines
- v2.5 (Jan 2025): Initial structured routing rules
