

NEO: Comprehensive Design Document

Maternal-Neonatal Emergency Care Access Coordination System

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1. Executive Summary

The Core Insight

During observership at Lurie's Children's Hospital (Level III NICU), we observed that **coordination, not clinical knowledge, is the bottleneck** in maternal-neonatal emergency transport. A constellation of 12+ specialists surrounds every complex case, each contributing domain expertise that must be synthesized into actionable decisions.

This multidisciplinary coordination exists at Level III academic medical centers but is **absent in rural/Level II facilities** where most babies are born. The knowledge gap contributes directly to maternal mortality disparities.

The Solution

NeoCommand is a multi-agent AI system that:

1. **Learns** from Level III multidisciplinary coordination patterns
2. **Simulates** specialist consultation in real-time (12+ agents debating like real specialists)
3. **Synthesizes** complex input into clear recommendations
4. **Transfers knowledge** from academic centers to rural providers who need it most

The Innovation: Simulation Observatory

Before deploying to real clinical scenarios, we're building a **Simulation Observatory** where:

- Real specialists observe AI agents debating anonymized cases
- Specialists validate whether AI reasoning matches clinical reality
- Specialists maintain authority - they approve/override every decision
- The system learns from specialist feedback in a controlled research environment

This is not automation. This is knowledge democratization with human oversight.

2. The Clinical Reality: Lurie's Observership Insights

2.1 The Specialist Constellation at Level III

![Specialist Constellation](reference to 1770435192408_image.png)

What We Observed

Central Care Nucleus:

- Mother
- Father
- Newborn Infant
- Kristen (Head Nurse/Charge Coordinator)
- Hospital Director
- Assigned Nurses

Surrounding Specialist Ring (15+ disciplines):

- **Surgical:** Surgeon, Obstetrician Surgeon
- **Cardiac/Pulmonary:** Cardiology, Pulmonology
- **Neurological:** Neurology
- **Metabolic/Endocrine:** Nephrology, Endocrinology
- **Hematology/Oncology:** Hematology, Oncology
- **Immunology/Rheumatology:** Immunology, Rheumatology
- **Other Specialists:** Urology, Dermatology, Ophthalmology

External Stakeholders:

- Transport Coordinators
- Flight Nurses & Physicians
- Aeromedical Physicians
- Neonatal Transport Technicians
- Critical Care Nurses
- NICU Medical Directors
- Department of Defense (for military transfers)
- Emergency Response Coordinators
- Air Ambulance Operators
- Dispatch Centers
- Insurance & Reimbursement Agencies
- Hospital Legal & Compliance
- Local & Federal Health Authorities

The Coordination Pattern

"I tried to map the conversations but couldn't - because everyone was talking to everyone simultaneously. It was already multi-agent coordination, just happening with human specialists."

Key Observations:

1. **No linear hierarchy** - specialists coordinate peer-to-peer with overlapping conversations
2. **Head nurse/coordinator role** - someone (like Kristen) listens to all input, takes notes, synthesizes
3. **Domain expertise clusters** - specialists defer to each other in specialized areas
4. **Real-time debate** - conflicts are surfaced and resolved through discussion, not authority
5. **Clinical continuity** - same team manages prenatal → delivery → postpartum → NICU
6. **Team scaling** - complexity drives team size: 7-14 people depending on severity

2.2 The Rural Reality: The Gap

Level II/Rural Hospitals:

- X No specialist constellation
- X Generalist OB + Pediatrician at best
- X Nurse often makes decisions alone
- X No clinical continuity across care phases
- X "Transfer if complex" is only option

When Transfer Needed:

- Weather may prevent air transport
- Helicopter may be down for maintenance
- Distance creates time pressure
- Coordination happens via phone tag (20-40 minutes vs. 4 seconds)

Result:

- Higher maternal mortality in rural areas
- Delayed access to specialty care
- Suboptimal decision-making under uncertainty
- Fragmented care coordination

2.3 The Coordination Bottleneck

From transport professional interviews:

"The challenge here is learning the logistics... The medicine becomes easy after a while."

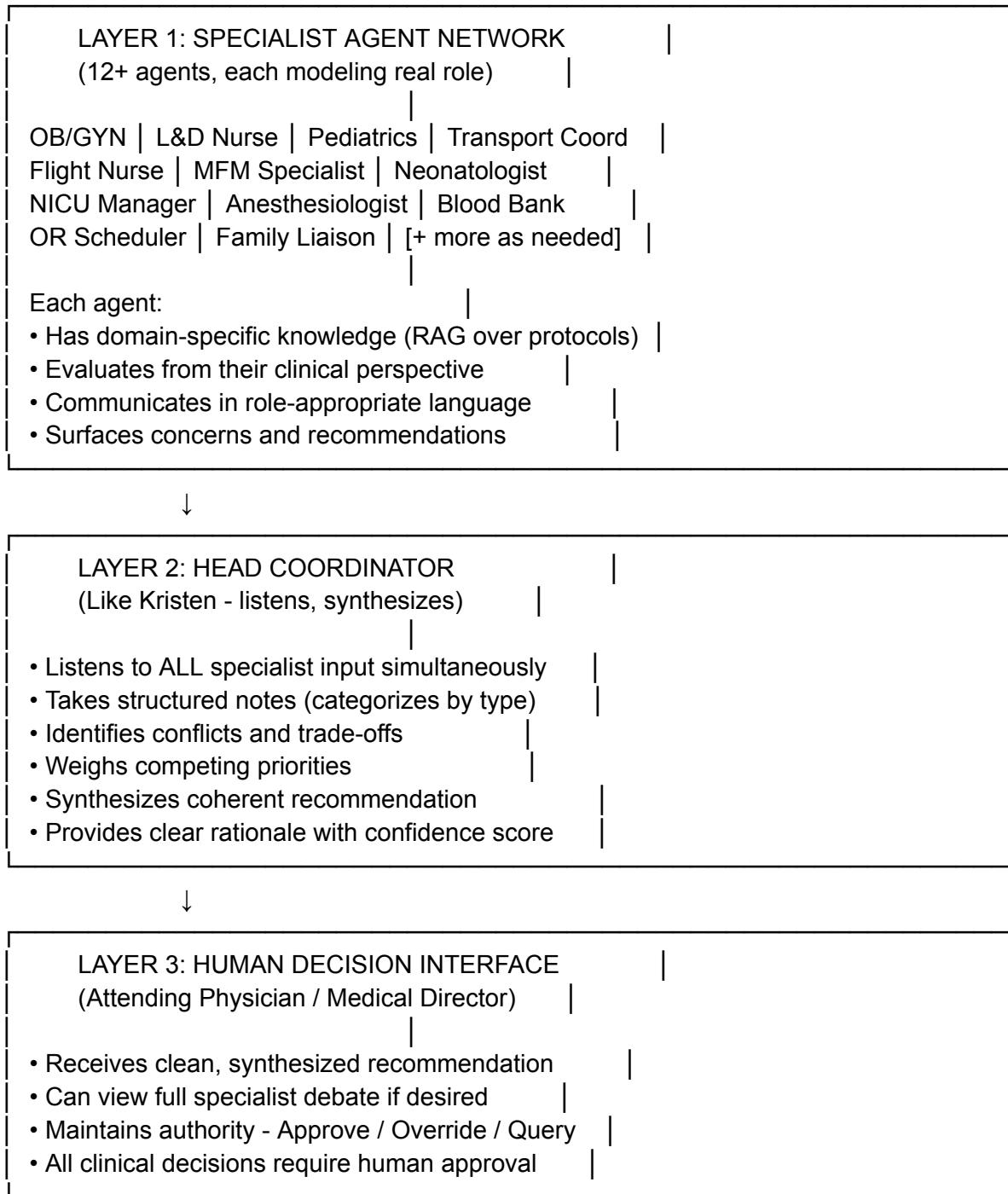
The hard problem is NOT clinical knowledge. It's:

- Knowing who to call
- What buttons to push
- Which facility has what capability
- How to coordinate across 7-14 people
- How to synthesize conflicting input
- How to make decisions under incomplete information

This is the white space NeoCommand enters.

3. System Architecture

3.1 Three-Layer Architecture



3.2 Design Principles

Principle 1: Model Reality, Don't Replace It

- Agent roles map 1:1 with real clinical roles
- Agents debate like real specialists debate
- Head coordinator functions like real charge nurse
- Human maintains final authority (not automation)

Principle 2: Transparency Over Black Box

- Full specialist conversation is always accessible
- Reasoning is explainable at every step
- Confidence scores show certainty levels
- Conflicts are surfaced, not hidden

Principle 3: Learn from the Best, Serve the Rest

- Train on Level III coordination patterns
- Deploy to Level II/rural facilities
- Knowledge flows from academic centers to where it's needed
- Creates equity without requiring specialist presence

Principle 4: Specialists Retain Authority

- System recommends, humans decide
- Specialists can override any recommendation
- System learns from overrides
- Creates human-AI collaboration, not replacement

4. The Simulation Observatory

4.1 Concept: Research Before Deployment

Before deploying NeoCommand in live clinical scenarios, we build a **Simulation Observatory** where:

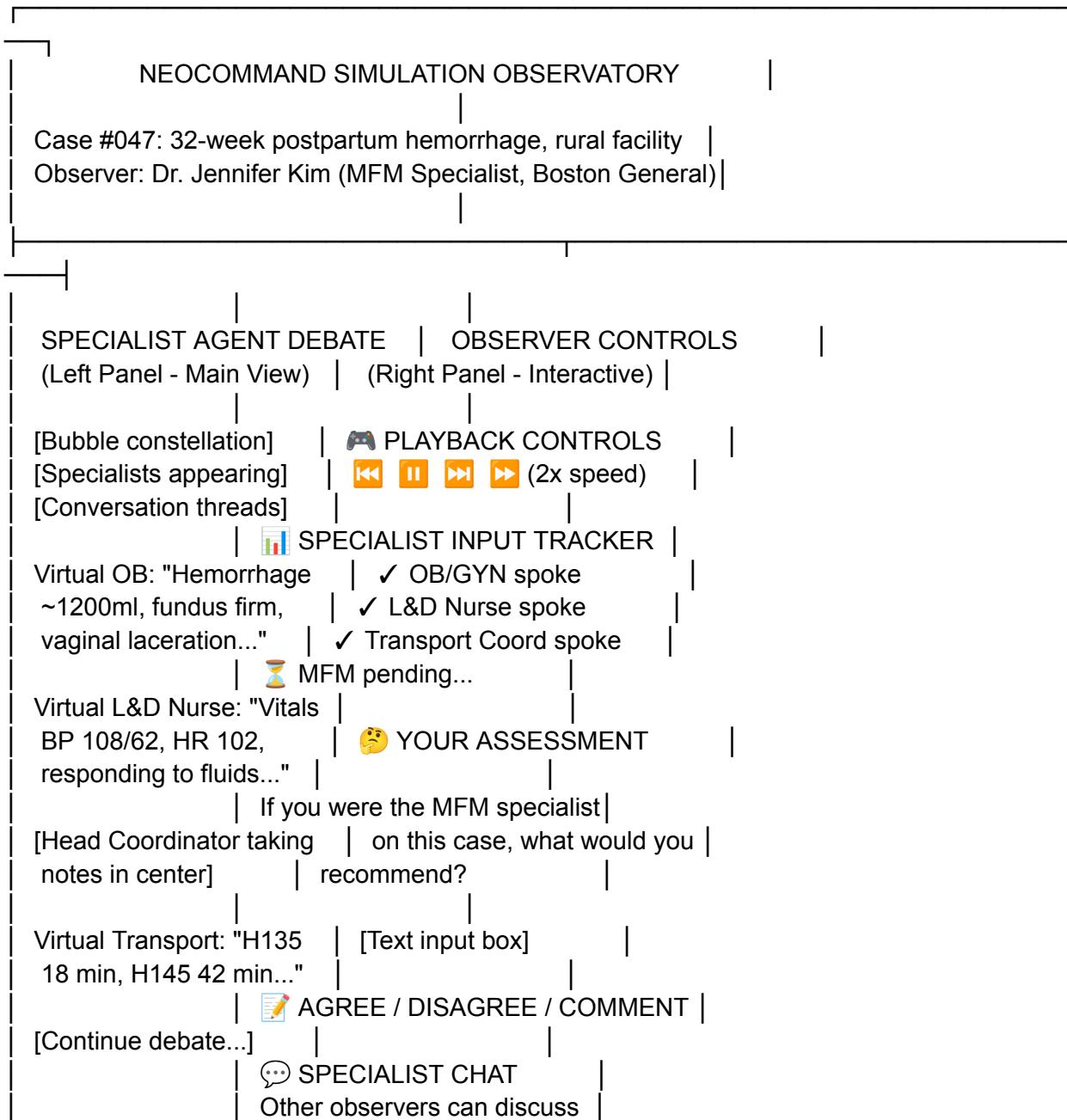
Real specialists observe AI agents debating real (anonymized) cases

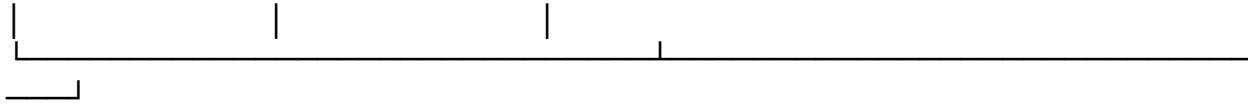
Think of it as:

- **Netflix for clinical decision-making** - specialists watch episodes at their own pace
- **Research validation tool** - does AI reasoning match how specialists would coordinate?
- **Training dataset generator** - specialist feedback improves the system
- **Trust-building mechanism** - specialists see the reasoning before trusting recommendations

4.2 The Observatory Interface

Visual Design: Split-Screen Observation





Key Features

1. Playback Controls

- Watch at own pace (pause, rewind, fast-forward)
- Speed up/slow down debate
- Jump to specific specialist input
- Replay controversial decision points

2. Specialist Input Tracker

- Shows which specialists have contributed
- Highlights missing perspectives
- Indicates when consensus is forming

3. Interactive Assessment

- Specialists input their own recommendation
- Compare with AI agents' conclusion
- Identify agreement/disagreement patterns
- Surface cases where AI reasoning differs from human

4. Annotation & Feedback

- Specialists can comment on any agent's input
- "This is how I would actually think about it"
- "Missing consideration: X"
- "Agree/Disagree with this trade-off"

5. Peer Discussion

- Other specialists observing can discuss
- Creates community of practice
- Identifies controversial cases
- Builds consensus on best practices

4.3 Research Protocol

Phase 1: Case Collection (Months 1-2)

Collect anonymized cases from partner institutions:

- 50 maternal-neonatal emergency transport cases
- Range of complexity (simple → highly complex)
- Mix of outcomes (successful, suboptimal, poor)
- Include edge cases and rare scenarios

Case data includes:

- Clinical presentation (maternal + neonatal)
- Available resources (facilities, transport assets, weather)
- Actual coordination that occurred (who was consulted, how long, what was decided)
- Outcome data (what happened, what worked, what didn't)

Phase 2: AI Agent Training (Months 2-3)

Build specialist agent knowledge bases:

- RAG over clinical protocols (maternal-fetal medicine, neonatology, etc.)
- Transport logistics data (aircraft specs, facility capabilities, weather impacts)
- Historical case outcomes
- Interview transcripts from domain research

Train head coordinator:

- Pattern recognition from Level III coordination observations
- Conflict resolution heuristics
- Synthesis algorithms
- Confidence scoring based on agreement levels

Phase 3: Simulation Observatory Deployment (Months 3-6)

Recruit specialist observers:

- 20-30 specialists across disciplines
- Mix of Level III (academic) and Level II (community) hospitals
- Include transport professionals (flight nurses, coordinators)
- Geographic diversity

Observation protocol:

- Each specialist watches 10-20 cases
- Records their own recommendation before seeing AI conclusion
- Provides structured feedback on AI reasoning
- Discusses controversial cases with peers

Data collected:

- Agreement rate (AI vs. human specialist)
- Disagreement patterns (when and why divergence occurs)
- Missing considerations (what AI didn't think of)
- Novel insights (what AI surfaced that humans missed)

Phase 4: Iterative Refinement (Months 6-12)**Based on specialist feedback:**

- Adjust agent reasoning patterns
- Add missing clinical considerations
- Improve synthesis logic
- Refine confidence scoring

Success criteria:

- 80% agreement with specialist consensus
- <5% critical misses (AI fails to identify major risk)
- Specialists report "I would trust this recommendation"
- System identifies novel insights in >10% of cases

4.4 The "Watch Party" Model

Monthly Live Sessions

Host synchronous "watch parties" where:

- 10-15 specialists join video call
- Watch AI agents debate a complex case together
- Pause to discuss at key decision points
- Specialists debate among themselves
- Compare human vs. AI reasoning
- Build community and shared understanding

Example format:

6:00 PM ET - Specialists log in

6:05 PM - Case presentation (clinical scenario)

6:10 PM - AI simulation begins (specialists watch)

6:25 PM - Pause at first major decision point

"The agents are debating H135 vs H145. What do you think?"

6:35 PM - Resume simulation
6:45 PM - Final AI recommendation revealed
6:50 PM - Specialist discussion: Would you approve this?
7:00 PM - Debrief and feedback collection

Benefits:

- Creates engaged specialist community
 - Rapid feedback cycles
 - Identifies edge cases
 - Builds trust through transparency
-

5. Specialist Agent Design

5.1 Agent Architecture

Each specialist agent has:

```
class SpecialistAgent:  
    def __init__(self):  
        self.profile = {  
            'name': "Dr. Sarah Chen",  
            'role': "OB/GYN Attending",  
            'institution': "Rural Vermont Community Hospital",  
            'specialty': "Obstetrics",  
            'years_experience': 12  
        }  
  
        self.knowledge_base = {  
            'protocols': RAG_over_OB_protocols(),  
            'experience': HistoricalCaseData(),  
            'constraints': LocalCapabilities(),  
            'preferences': ClinicalPhilosophy()  
        }  
  
        self.communication_style = {  
            'tone': "Direct, clinical, patient-focused",  
            'typical_concerns': [  
                'Pregnancy complications',  
                'Delivery outcomes',  
                'Postpartum care',  
                'Infant health',  
                'Maternal health',  
                'Obstetric emergencies'  
            ]  
        }  
    }
```

```
"Maternal safety immediate",
"What can we do locally vs transfer",
"Time sensitivity of intervention"
],
'decision_framework': "Risk vs benefit for mother"
}
```

5.2 The 12+ Core Specialist Agents

Sending Facility Agents (Rural/Level II)

1. Dr. Sarah Chen - OB/GYN Attending

- **Role:** Immediate care provider for mother
- **Knowledge:** Obstetric emergencies, local capabilities, when to transfer
- **Concerns:** Maternal hemorrhage control, blood loss rate, fundal assessment
- **Communication:** "Patient is bleeding 200ml/hr, fundus firm, appears to be vaginal laceration beyond our repair capability..."

2. Sarah Williams, RN - Labor & Delivery Nurse

- **Role:** Bedside monitoring, vital signs, immediate interventions
- **Knowledge:** Maternal vitals, response to interventions, patient status
- **Concerns:** Hemodynamic stability, IV access, fluid resuscitation response
- **Communication:** "Current vitals: BP 108/62, HR 102, two large-bore IVs running, patient alert and anxious..."

3. Dr. Michael Patel - Pediatrician on Call

- **Role:** Initial newborn assessment, stabilization
- **Knowledge:** Neonatal resuscitation, when baby needs higher level care
- **Concerns:** Gestational age appropriateness, respiratory status, need for NICU
- **Communication:** "32-week infant, Apgars 8/9, currently stable on room air but this is borderline viability for our facility..."

Transport Coordination Agents

4. Maria Torres - Transport Coordinator

- **Role:** Dispatch planning, asset allocation
- **Knowledge:** Aircraft availability, maintenance schedules, crew status, weather
- **Concerns:** Which asset available when, timing constraints, weather windows
- **Communication:** "H135 available Burlington in 18 minutes, H145 available Lebanon in 42 minutes. Weather: snow moving in, 30-minute safe window..."

5. James Mitchell, RN, FP-C - Flight Nurse

- **Role:** In-flight clinical care, equipment configuration
- **Knowledge:** Weight limits, equipment needs, in-flight monitoring capabilities
- **Concerns:** Safe patient transport, equipment configuration, monitoring during flight
- **Communication:** "Weight calculation: mother 240, baby 4, maternal equipment 85, isolette 120, crew 350, fuel 65. Total 864 pounds. H135 capacity is 750. We're over..."

6. Captain Martinez - Pilot

- **Role:** Flight safety, weather assessment
- **Knowledge:** Weather patterns, aircraft performance, safety margins
- **Concerns:** Flying conditions, safety windows, aircraft limitations
- **Communication:** "Snow increasing, ceiling dropping. H135 can make it now. H145 in 42 minutes is marginal - right at edge of safe conditions..."

Receiving Facility Agents (Level III)

7. Dr. Jennifer Kim, MD - Maternal-Fetal Medicine Specialist

- **Role:** Advanced obstetric care, surgical intervention if needed
- **Knowledge:** Complex hemorrhage management, surgical repair techniques
- **Concerns:** Optimal maternal outcomes, family-centered care, psychological impact
- **Communication:** "We can handle laceration repair in OR. Blood bank has products ready. My concern is separating mother and baby - psychological impact during bonding period..."

8. Dr. David Washington, MD - Neonatologist

- **Role:** Specialized newborn intensive care
- **Knowledge:** Premature infant care, respiratory support, 32-week protocols
- **Concerns:** NICU bed availability, appropriate care level, long-term outcomes
- **Communication:** "32-weeker needs Level III minimum. We're ready. I agree with Dr. Kim - keeping dyad together is ideal if possible..."

9. Lisa Chen, RN, MSN - NICU Nurse Manager

- **Role:** Unit coordination, bed allocation, staff readiness
- **Knowledge:** Current census, staff availability, equipment status
- **Concerns:** Bed availability, appropriate staffing, protocol readiness
- **Communication:** "We have bed availability in Level III pod. Staff ratio appropriate. 32-week protocols ready to implement..."

10. Dr. Rodriguez - Anesthesiologist/OR

- **Role:** Surgical support if maternal OR needed

- **Knowledge:** Anesthetic management for postpartum patients, OR availability
- **Concerns:** OR readiness, anesthetic risk, timing
- **Communication:** "OR #3 available, team can be ready in 15 minutes if needed for surgical hemorrhage control..."

11. Tom Anderson - Blood Bank Coordinator

- **Role:** Blood product availability
- **Knowledge:** Current inventory, cross-match time, massive transfusion protocols
- **Concerns:** Product availability, timing, special needs
- **Communication:** "We have 4 units O-negative ready, can have more if massive transfusion needed. Cross-match will be complete by arrival..."

12. Jennifer Park - OR Scheduler/Coordinator

- **Role:** Surgical suite coordination
- **Knowledge:** OR availability, equipment, team readiness
- **Concerns:** Room preparation, equipment sterilization, team assembly
- **Communication:** "OR #3 can be prepped and staffed. Need 15-minute notice for full team assembly..."

Support/Contextual Agents (As Needed)

13. Rachel Martinez - Family Liaison/Social Work

- **Role:** Family support, communication, logistical coordination
- **Knowledge:** Family preferences, support needs, communication protocols
- **Concerns:** Family presence, psychological support, communication clarity
- **Communication:** "Partner wants to be with both patients. Can we accommodate family member in transport or coordinate separate arrival?"

14. Hospital Administrator/Legal (for complex cases) 15. Neonatal Surgery (for surgical anomalies) 16. Maternal ICU (for severe maternal conditions)

5.3 Agent Reasoning Framework

Each agent follows this evaluation pattern:

```
def evaluate_situation(self, case_data, context):
    """
    Each specialist evaluates from their domain expertise
    """

    # 1. ASSESS from domain perspective
    assessment = self.analyze_clinical_data(case_data)
```

```

# 2. IDENTIFY concerns from specialty lens
concerns = self.identify_risks_and_issues(assessment)

# 3. FORMULATE recommendation
recommendation = self.generate_recommendation(
    assessment,
    concerns,
    context # What other specialists have said
)

# 4. SURFACE trade-offs
tradeoffs = self.identify_tradeoffs(recommendation)

# 5. EXPRESS in role-appropriate language
return {
    'speaker': self.profile['name'],
    'role': self.profile['role'],
    'assessment': assessment,
    'concerns': concerns,
    'recommendation': recommendation,
    'tradeoffs': tradeoffs,
    'confidence': self.calculate_confidence(),
    'defer_to': self.identify_dependencies() # Other specialists whose input affects mine
}

```

6. Head Coordinator Logic

6.1 The "Kristen" Agent

The Head Coordinator is modeled after the charge nurse/head coordinator role observed at Lurie's. This agent:

- Listens to ALL specialist input
- Takes structured notes
- Identifies conflicts
- Synthesizes coherent recommendations
- Maintains human-in-loop authority

6.2 Note-Taking Structure

```
class HeadCoordinator:  
    def __init__(self):  
        self.notes = {  
            'clinical_requirements': {  
                'maternal': [],  
                'neonatal': [],  
                'dyad': []  
            },  
            'transport_constraints': {  
                'assets': [],  
                'timing': [],  
                'weather': [],  
                'equipment': []  
            },  
            'risk_factors': {  
                'maternal': [],  
                'neonatal': [],  
                'transport': [],  
                'coordination': []  
            },  
            'stakeholder_preferences': {  
                'clinical_optimal': [],  
                'family_centered': [],  
                'safety_first': [],  
                'time_critical': []  
            },  
            'conflicts_identified': []  
        }
```

Example: Note-Taking During Debate

Agent speaks: Dr. Chen (OB)

Input: "Hemorrhage ~1200ml, fundus firm, vaginal laceration,
needs MFM surgical expertise we don't have here"

Head Coordinator categorizes:

```
→ clinical_requirements['maternal'].append({  
    'need': 'MFM surgical capability',  
    'urgency': 'high',  
    'local_capability': 'no',  
    'speaker': 'Dr. Chen (OB)'  
})
```

Agent speaks: James (Flight Nurse)
Input: "Weight 864 lbs, H135 capacity 750 lbs, we're over by 114"

Head Coordinator categorizes:

```
→ transport_constraints['equipment'].append({  
    'constraint': 'H135 weight exceeded',  
    'impact': 'Cannot transport both patients on H135',  
    'magnitude': '114 lbs over',  
    'speaker': 'James (Flight Nurse)'  
})  
  
→ conflicts_identified.append({  
    'conflict': 'Speed vs Capacity',  
    'option_a': 'H135 fast but weight problem',  
    'option_b': 'H145 capable but delayed',  
    'speakers': ['Maria (Transport)', 'James (Flight Nurse)']  
})
```

6.3 Synthesis Algorithm

```
def synthesize_recommendation(self, all_specialist_input):
```

```
    """
```

After hearing from all specialists, create coherent plan

```
    """
```

```
# 1. CATEGORIZE all input
```

```
self.categorize_specialist_input(all_specialist_input)
```

```
# 2. IDENTIFY conflicts and trade-offs
```

```
conflicts = self.identify_conflicts()
```

```
# 3. WEIGH competing priorities
```

```
priority_weights = self.calculate_priority_weights(  
    clinical_urgency=self.assess_clinical_urgency(),  
    safety_margins=self.assess_safety_margins(),  
    family_impact=self.assess_family_impact(),  
    resource_constraints=self.assess_constraints()  
)
```

```
# 4. RESOLVE conflicts using clinical judgment heuristics
```

```

resolution = self.resolve_conflicts(conflicts, priority_weights)

# 5. BUILD recommendation
recommendation = self.construct_recommendation(resolution)

# 6. CALCULATE confidence
confidence = self.calculate_confidence_score(
    specialist_agreement=self.measure_agreement(),
    data_completeness=self.assess_data_quality(),
    historical_similarity=self.find_similar_cases()
)

# 7. GENERATE rationale
rationale = self.generate_rationale(
    recommendation,
    conflicts,
    resolution,
    specialist_input
)

return {
    'recommendation': recommendation,
    'confidence': confidence,
    'rationale': rationale,
    'risk_mitigation': self.identify_contingencies(),
    'specialist_consensus': self.summarize_agreement(),
    'dissenting_views': self.highlight_disagreements()
}

```

Conflict Resolution Heuristics

When specialists disagree, Head Coordinator applies:

1. Clinical Safety First

IF any specialist raises critical safety concern
 THEN that concern overrides efficiency/speed considerations
 UNLESS another specialist provides evidence that safety concern is mitigated

2. Specialty Deference

WHEN conflict is within a specialist's primary domain
 THEN weight that specialist's input more heavily

EXAMPLE: MFM opinion on maternal hemorrhage > generalist OB opinion

3. Consensus Building

WHEN >70% of relevant specialists agree

THEN high confidence in that direction

WHEN 50-70% agreement

THEN moderate confidence, surface trade-offs clearly

WHEN <50% agreement

THEN flag as requiring human judgment, present multiple viable options

4. Time-Critical Tiebreaking

WHEN time is critical (maternal/neonatal deterioration)

AND conflict exists between "optimal" and "fast enough"

THEN favor "fast enough with acceptable safety margins"

BECAUSE perfect can be enemy of good in emergency medicine

5. Family-Centered Care Preference

WHEN clinical outcomes are similar between options

AND one option better preserves mother-child dyad

THEN favor keeping dyad together

UNLESS safety margins are unacceptable

7. Research & Validation Protocol

7.1 The Research Question

Can AI agents, trained on Level III coordination patterns, provide clinically valid multidisciplinary input that specialists would trust and approve?

Sub-questions:

1. Do AI agents reason about cases like real specialists do?
2. When AI and human specialists disagree, why?

3. What does AI miss that humans catch?
4. What does AI surface that humans might miss?
5. Would specialists approve AI recommendations in real scenarios?

7.2 Validation Metrics

Agreement Metrics

Primary:

- **Recommendation Agreement Rate:** % of cases where AI final recommendation matches specialist consensus
 - Target: >80%

Secondary:

- **Specialist-Level Agreement:** For each specialist agent, % agreement with real specialist in that role
 - Example: Virtual MFM agrees with real MFM specialist 85% of time
- **Trade-off Identification:** Does AI identify the same conflicts real specialists would?
 - Measured by specialist annotation: "Yes, this is the key trade-off" vs "AI missed the real issue"

Quality Metrics

Critical Miss Rate:

- % of cases where AI fails to identify a major risk that specialists catch
- Target: <5%

False Alarm Rate:

- % of cases where AI raises concern that specialists deem irrelevant
- Target: <15%

Novel Insight Rate:

- % of cases where AI surfaces a consideration that specialists find valuable but hadn't initially considered
- Target: >10%

Trust Metrics

Approval Rate:

- If this were real: % of specialists who would approve AI recommendation
- Target: >75%

Override Rate:

- % of cases where specialist would override AI recommendation
- Track reasons for override (builds training data)

Explanation Quality:

- Likert scale: "The AI's rationale was clear and clinically sound"
- Target: >4.0/5.0

7.3 Data Collection Protocol

For Each Simulation:

Specialist provides:

1. Pre-simulation assessment:

- "Given this clinical scenario, what would you recommend?"
- Captured before seeing AI debate

2. During simulation:

- Annotations at key decision points
- "Agree/Disagree" markers on specific agent statements
- Comments on missing considerations

3. Post-simulation:

- Final approval/override decision
- Rationale if overriding
- Confidence in AI recommendation (1-5 scale)
- Open-ended feedback

System captures:

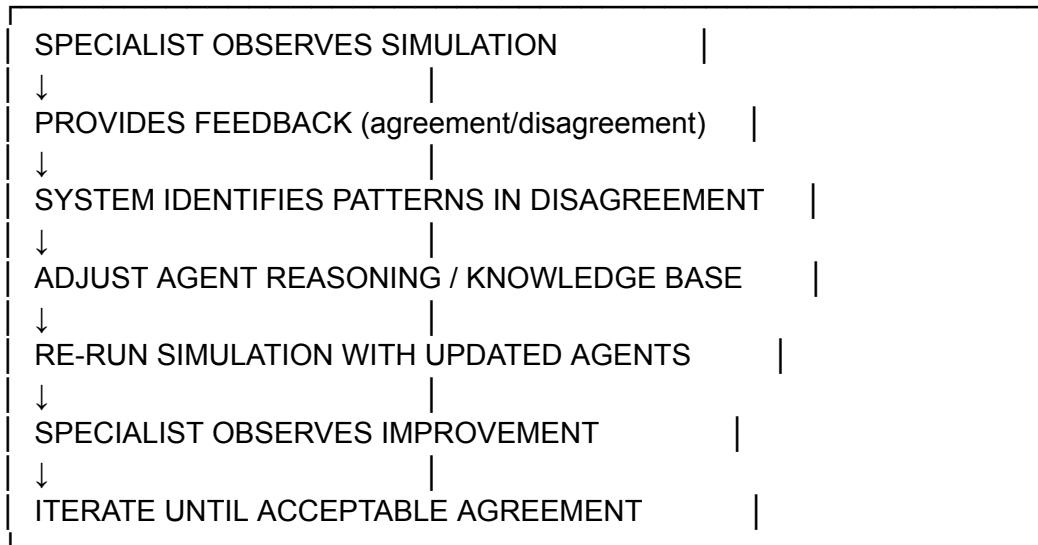
- All specialist annotations
- Timestamp of when specialists pause/replay sections
- Which agents' input specialists re-watch
- Discussion threads in peer chat

Qualitative Feedback:

Monthly interviews with 5-10 specialist observers:

- "What cases made you most uncomfortable with AI reasoning?"
- "Where did AI surprise you positively?"
- "What's missing from the specialist agents?"
- "Would you use this in your practice?"

7.4 Learning Loops



Example Learning Loop:

Case #023: Specialists consistently override AI recommendation

Analysis reveals:

- AI recommended H145 (slower but capable)
- Specialists preferred H135 with separation
- Reason: "Mother's bleeding rate suggests we have less time than AI calculated"

Learning:

- AI's hemorrhage rate calculation was conservative
- Update clinical knowledge base with more nuanced bleeding assessment
- Adjust time-critical heuristics to be more aggressive when bleeding active

Re-run:

- Updated AI now recommends H135 with separation
- Specialists agree: "Now AI is thinking like I would"

8. Technical Implementation

8.1 Technology Stack

Frontend: Simulation Observatory Interface

React + TypeScript

- Three.js (3D bubble visualization)
- Framer Motion (cinematic transitions)
- Recharts (data visualization)
- shadcn/ui (component library)

Why this stack:

- React for component-based UI
- TypeScript for type safety in complex agent interactions
- Three.js for spatial visualization of specialist constellation
- Framer Motion for smooth, professional animations

Backend: Multi-Agent Coordination

Python FastAPI

- LangChain/LangGraph (agent orchestration)
- Anthropic Claude API (agent reasoning)
- Vector Database (Pinecone/Weaviate for RAG)
- PostgreSQL (case data, feedback, simulation results)
- Redis (real-time coordination state)

Why this stack:

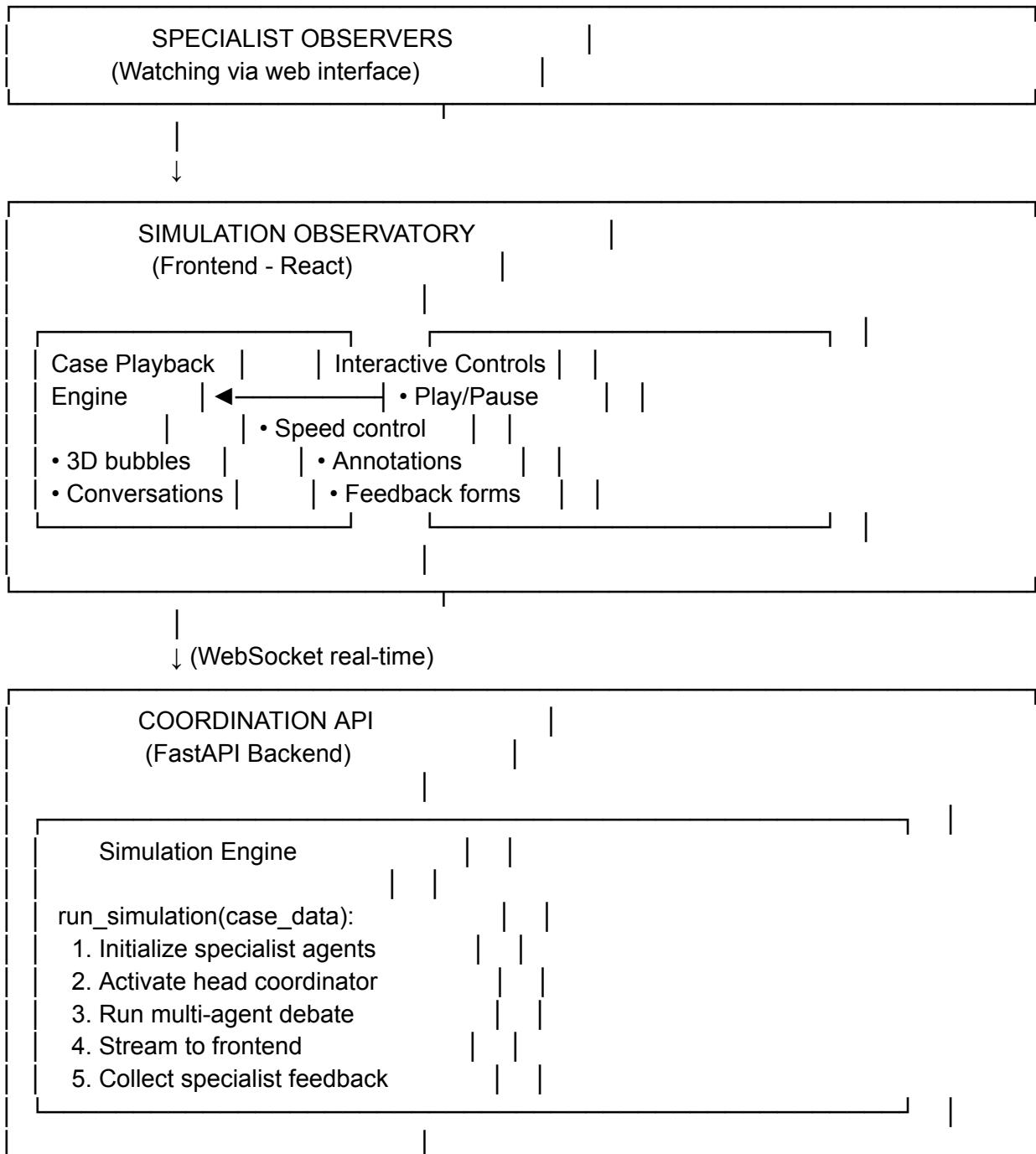
- FastAPI for high-performance async API
- LangChain for proven multi-agent patterns
- Claude Sonnet 4 for specialist reasoning (best in class for nuanced clinical thinking)
- Vector DB for efficient protocol/knowledge retrieval

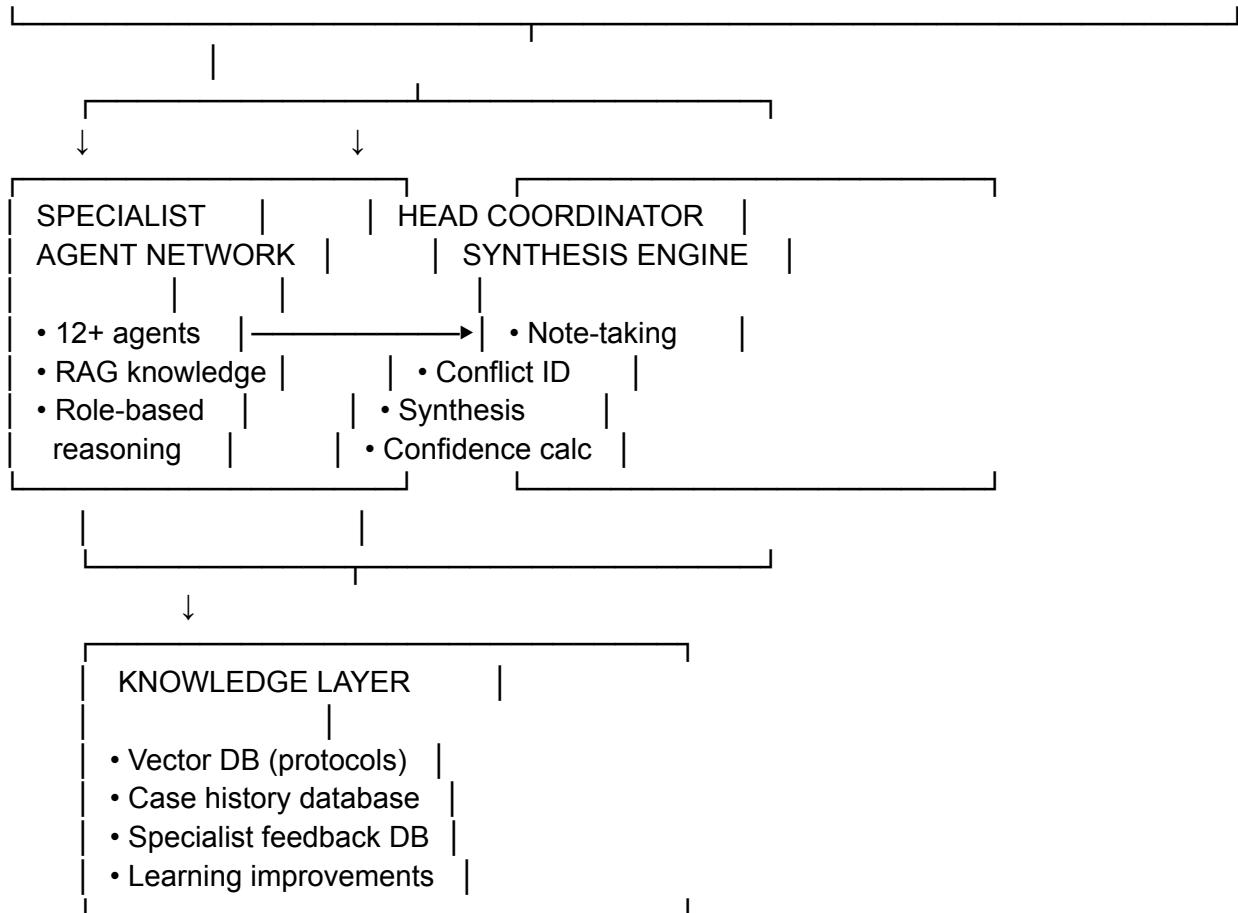
Infrastructure

AWS/GCP

- ECS/Cloud Run (containerized services)
- S3/Cloud Storage (anonymized case data)
- CloudWatch/Cloud Logging (observability)
- CloudFront/CDN (global specialist access)

8.2 System Architecture Diagram





8.3 Data Flow: One Simulation

1. Specialist selects Case #047 in Observatory
2. Frontend requests simulation via WebSocket
 → POST /api/simulation/run
 → { case_id: "047", observer_id: "dr_kim_mfm" }
3. Backend loads case data
 → Clinical scenario (maternal + neonatal status)
 → Available resources (facilities, transport, weather)
 → Outcome data (for post-simulation reveal)
4. Simulation Engine initializes agents
 → Create 12 specialist agent instances
 → Load relevant knowledge for each
 → Initialize head coordinator

5. Multi-agent debate begins
 - Each agent evaluates case independently
 - Head coordinator aggregates input
 - Agents respond to each other
 - Conflicts surface
 - Synthesis emerges

6. Real-time streaming to frontend
 - Each agent statement sent as it's generated
 - Frontend visualizes bubbles speaking
 - Specialist observer sees debate unfold

7. Head coordinator synthesis
 - Final recommendation generated
 - Confidence score calculated
 - Rationale constructed

8. Frontend presents to specialist
 - "Would you approve this recommendation?"
 - Specialist provides feedback

9. Feedback stored
 - Agreement/disagreement logged
 - Comments captured
 - Used for next learning iteration

8.4 Agent Implementation Example

```
# specialist_agent.py

class SpecialistAgent:
    def __init__(self, profile, knowledge_base):
        self.profile = profile
        self.knowledge_base = knowledge_base
        self.anthropic_client = Anthropic(api_key=os.environ["ANTHROPIC_API_KEY"])

    async def evaluate_case(self, case_data, context):
        """
        Generate this specialist's assessment of the case
        """

        # Build prompt with role context
        system_prompt = f"""You are {self.profile['name']}, a {self.profile['role']}"""


```

at {self.profile['institution']} with {self.profile['years_experience']} years experience.

You are participating in a multidisciplinary case conference about a maternal-neonatal emergency transport.

Your communication style is: {self.profile['communication_style']['tone']}

Your typical concerns are:

{chr(10).join('- ' + c for c in self.profile['communication_style']['typical_concerns'])}

Other specialists have already provided input:

{self._format_context(context)}

Provide your assessment from your specialty perspective."""

Retrieve relevant knowledge

```
relevant_protocols = await self.knowledge_base.search(  
    query=case_data['clinical_summary'],  
    filter={'specialty': self.profile['specialty']}  
)
```

Build user prompt with case details

user_prompt = f"""

CASE PRESENTATION:

Maternal Status:

{case_data['maternal']['summary']}

Vitals: {case_data['maternal']['vitals']}

Neonatal Status:

{case_data['neonatal']['summary']}

Assessment: {case_data['neonatal']['assessment']}

Available Resources:

- Sending facility: {case_data['sending_facility']['capabilities']}
- Transport options: {case_data['transport']['options']}
- Weather: {case_data['environment']['weather']}
- Receiving facilities: {case_data['receiving_facilities']}

Relevant Protocols:

{self._format_protocols(relevant_protocols)}

Please provide:

1. Your clinical assessment from your specialty perspective

2. Key concerns you identify
 3. Your recommendation
 4. Trade-offs you see
 5. What other specialists' input you need to finalize your thinking
-

```
# Call Claude API
response = await self.anthropic_client.messages.create(
    model="claude-sonnet-4-20250514",
    max_tokens=2000,
    system=system_prompt,
    messages=[{
        "role": "user",
        "content": user_prompt
    }]
)

# Parse and structure response
assessment = self._parse_assessment(response.content[0].text)

return {
    'speaker': self.profile['name'],
    'role': self.profile['role'],
    'assessment': assessment['clinical_assessment'],
    'concerns': assessment['concerns'],
    'recommendation': assessment['recommendation'],
    'tradeoffs': assessment['tradeoffs'],
    'defer_to': assessment['needs_input_from'],
    'confidence': assessment.get('confidence', 0.7),
    'full_text': response.content[0].text
}
```

8.5 Head Coordinator Implementation

```
# head_coordinator.py

class HeadCoordinator:
    def __init__(self):
        self.notes = self._initialize_note_structure()
        self.anthropic_client = Anthropic(api_key=os.environ["ANTHROPIC_API_KEY"])

    async def listen_and_categorize(self, specialist_input):
        .....
```

Take notes as each specialist provides input

"""

```
# Use Claude to categorize specialist input into note structure  
categorization = await self._categorize_input(specialist_input)
```

```
# Add to appropriate note categories  
self._update_notes(categorization)
```

```
# Identify any conflicts with previous input  
conflicts = self._detect_conflicts(specialist_input)  
if conflicts:  
    self.notes['conflicts_identified'].extend(conflicts)
```

```
async def synthesize_recommendation(self, all_specialist_input, case_data):
```

"""

After all specialists have spoken, create coherent recommendation

"""

```
system_prompt = """You are an expert clinical coordinator, like a charge nurse  
or medical director who synthesizes multidisciplinary input into clear,  
actionable recommendations.
```

You have listened to 12+ specialists provide input on a maternal-neonatal
emergency transport case.

Your job is to:

1. Identify the key trade-offs and conflicts
2. Weigh competing priorities using sound clinical judgment
3. Synthesize a clear recommendation
4. Provide transparent rationale
5. Calculate a confidence score
6. Identify risk mitigation strategies

You maintain human-in-loop authority - your recommendation will be presented
to an attending physician who will approve or override."""

```
user_prompt = f"""
```

SPECIALIST INPUT SUMMARY:

```
{self._format_notes()}
```

CONFLICTS IDENTIFIED:

```
{self._format_conflicts()}
```

CASE CONTEXT:
{case_data['summary']}

Please synthesize this into:

1. RECOMMENDED ACTION:

- Clear, specific recommendation
- Expected timeline
- Key decision points

2. CONFIDENCE SCORE (0-100):

- Based on specialist agreement
- Data completeness
- Similarity to historical cases

3. RATIONALE:

- Why this recommendation over alternatives
- How conflicts were resolved
- Which specialist input was most influential

4. RISK MITIGATION:

- Contingency plans
- Warning signs to watch for
- Backup options if primary plan fails

5. SPECIALIST CONSENSUS:

- How many specialists support this
- Any significant dissenting views

Format your response as JSON for structured parsing.

=====

```
response = await self.anthropic_client.messages.create(  
    model="claude-sonnet-4-20250514",  
    max_tokens=3000,  
    system=system_prompt,  
    messages=[  
        {"role": "user",  
         "content": user_prompt  
     }  
    ]  
)  
  
# Parse JSON response  
synthesis = self._parse_synthesis(response.content[0].text)
```

```

return {
    'recommendation': synthesis['recommended_action'],
    'confidence': synthesis['confidence_score'],
    'rationale': synthesis['rationale'],
    'risk_mitigation': synthesis['risk_mitigation'],
    'specialist_consensus': synthesis['specialist_consensus'],
    'full_synthesis': synthesis
}

```

8.6 Real-Time Streaming to Frontend

```

# simulation_engine.py

class SimulationEngine:
    async def run_simulation(self, case_id, websocket):
        """
        Run full multi-agent simulation with real-time streaming
        """

        # Load case
        case_data = await self.load_case(case_id)

        # Initialize agents
        specialists = self.initialize_specialist_agents()
        coordinator = HeadCoordinator()

        # Stream initial setup to frontend
        await websocket.send_json({
            'type': 'simulation_start',
            'case_id': case_id,
            'specialists': [s.profile for s in specialists]
        })

        # Each specialist evaluates independently
        context = []
        for specialist in specialists:
            # Stream "specialist thinking" indicator
            await websocket.send_json({
                'type': 'specialist_thinking',
                'specialist': specialist.profile['name']
            })

```

```
# Get specialist assessment
assessment = await specialist.evaluate_case(case_data, context)

# Stream specialist's input to frontend
await websocket.send_json({
    'type': 'specialist_input',
    'data': assessment
})

# Coordinator takes notes
await coordinator.listen_and_categorize(assessment)

# Add to context for next specialist
context.append(assessment)

# Small delay for readability (can skip in fast-forward mode)
await asyncio.sleep(1)

# Stream coordinator synthesis phase
await websocket.send_json({
    'type': 'coordinator_synthesizing',
    'notes': coordinator.notes
})

# Generate final recommendation
recommendation = await coordinator.synthesize_recommendation(
    context,
    case_data
)

# Stream final recommendation
await websocket.send_json({
    'type': 'recommendation_ready',
    'recommendation': recommendation
})

# Wait for specialist feedback
feedback = await self.collect_specialist_feedback(websocket)

# Store results
await self.store_simulation_results(
    case_id,
    context,
    recommendation,
```

```
        feedback  
    )  
  
    return {  
        'specialist_inputs': context,  
        'recommendation': recommendation,  
        'specialist_feedback': feedback  
    }  
  
-----  
</a>
```

9. Deployment Roadmap

9.1 Phase 1: Research & Validation (Months 1-12)

Months 1-3: Observatory Build

- Frontend simulation interface
- Multi-agent backend
- 50 anonymized cases collected
- 12 specialist agents implemented
- Head coordinator logic
- First 10 specialists recruited

Milestone: First live observation session with 5 specialists

Months 4-6: Iteration Based on Feedback

- 100+ simulation observations completed
- Agent reasoning refined based on specialist feedback
- Agreement rate tracked, target >70% initially
- Critical miss rate < 10%

Milestone: Specialists report "I would trust this in 50% of cases"

Months 7-9: Scaling Observatory

- 30 specialist observers recruited
- 100 total cases in library
- Monthly "watch party" sessions

-  Agreement rate target >80%

Milestone: Published research paper on validation results

Months 10-12: Pre-Deployment Validation

-  Agreement rate sustained >80%
-  Critical miss rate <5%
-  Specialists report "I would use this clinically" >75%
-  IRB approval for pilot deployment

Milestone: Ready for controlled clinical pilot

9.2 Phase 2: Pilot Deployment (Months 13-18)

Partner Hospital Selection

- 1 Level III academic center (Lurie's or similar)
- 2-3 Level II community hospitals
- 1-2 rural hospitals in transport network

Pilot Protocol

- NeoCommand provides recommendations on real cases
- Attending physician ALWAYS reviews and approves
- All decisions logged (approve vs override)
- Cases compared to historical outcomes

Success Criteria

- 85% approval rate from attending physicians
- Zero adverse outcomes attributable to NeoCommand
- Transport coordination time reduced by >50%
- Specialist satisfaction >4.0/5.0

Milestone: FDA breakthrough device designation (if applicable)

9.3 Phase 3: Scaled Deployment (Months 19-24)

Regional Rollout

- Expand to 10-15 hospitals in network
- Include full spectrum: Level IV → rural
- Integration with existing EMR systems
- Real-time coordination across facilities

Business Model

- SaaS subscription per hospital
- Tiered pricing: rural discounted, Level III pays premium
- "Knowledge contribution" revenue share for Level III hospitals

Milestone: 1000+ coordinated transports

9.4 Phase 4: National Scale (Year 3+)

Expansion

- 100+ hospital networks
 - All maternal-neonatal transports in region
 - Expand to all critical care transport
 - Platform for other specialties
-

Appendix A: Case Example

Case #047: Rural Postpartum Hemorrhage with Premature Infant

Initial Presentation

Patient: Sarah Morrison, 28 years old

Location: Rural Vermont Community Hospital (Level II)

Time: 11:47 PM, Friday

Weather: Snow, deteriorating conditions

MATERNAL STATUS:

- Postpartum hemorrhage, ~1200ml estimated blood loss
- Delivered 32-week infant 45 minutes ago
- Fundus firm, active vaginal bleeding
- Appears to be deep vaginal laceration beyond local repair capability

- Vitals: BP 108/62, HR 102, RR 18, O2 sat 98% on RA
- Alert and anxious
- Two large-bore IVs, LR running
- Local capabilities: Can provide basic resuscitation, blood products limited

NEONATAL STATUS:

- Baby Emma, 32 weeks gestational age, 1850g (4 lbs)
- Apgars 8/9
- Currently on room air, respiratory rate 55, no distress
- Skin-to-skin with mother currently
- Local capabilities: Can provide basic stabilization, no NICU

RESOURCES:

- Sending facility: Level II, no MFM, no Level III NICU
- Transport options:
 - H135 helicopter: Burlington, 18-minute flight
 - H145 helicopter: Lebanon, 42-minute flight
 - Ground ambulance: 90 minutes to Boston General
- Weather: Snow increasing, 30-minute safe flying window
- Receiving facility: Boston General (Level IV maternal, Level III NICU)
All teams available

Specialist Agent Debate (Abbreviated)

Dr. Sarah Chen (OB/GYN, Sending): "28-year-old with approximately 1200ml blood loss postpartum. Fundus is firm, so this isn't uterine atony. I can visualize what appears to be a deep vaginal sidewall laceration - it's actively bleeding and beyond what I'm comfortable repairing here. She needs MFM surgical expertise. We've got two large-bore IVs, she's responding to fluid resuscitation, vitals are holding for now, but this bleeding isn't going to stop without surgical repair. She needs to get to a facility with MFM capability."

Sarah Williams (L&D Nurse, Sending): "Current vitals: BP 108/62, HR 102. She's maintaining blood pressure with fluid resuscitation. We've run through about 1500ml of LR. She's alert, anxious about the baby. Baby is currently skin-to-skin which she really wants. Patient is asking to stay with the baby. We have limited blood products here - maybe 4 units total in our blood bank."

Dr. Michael Patel (Pediatrician, Sending): "This is a 32-week infant - technically viable but really at the edge for our facility. Apgars are good, currently stable on room air, but we need to remember this is a 32-weeker. If she develops respiratory distress, we don't have the capability to manage it properly. She needs Level III NICU observation at minimum. The fact that she's stable right now is good, but 32-weekers can decompensate."

Maria Torres (Transport Coordinator): "Okay, assets available: H135 out of Burlington can be there in 18 minutes flight time. H145 out of Lebanon would be 42 minutes. Ground ambulance would be 90 minutes to Boston General. Weather update: we've got snow moving in, I'm being told we have maybe a 30-minute window where flying conditions are good, after that it's going to be marginal at best."

James Mitchell (Flight Nurse): "Let me run the numbers on the H135 - mother at 240 pounds, baby at 4 pounds, we need full maternal monitoring equipment that's about 85 pounds, neonatal isolette and support is 120 pounds, crew is 350 pounds, fuel for the trip is 65 pounds. That puts us at 864 pounds. H135 capacity is 750 pounds. We're 114 pounds over capacity. We cannot safely put both patients on the H135. The H145 has capacity for 1100 pounds so we'd be fine on that aircraft, but that's the 42-minute timeline."

Captain Martinez (Pilot): "Weather update - snow is increasing, ceiling is dropping. I can make the H135 flight right now, no problem. The H145 in 42 minutes though, we're going to be right at the edge of safe flying conditions. I can do it, but it's not comfortable. If we're going to do the H145, we need to commit right now because that weather window is closing."

Dr. Jennifer Kim (MFM Specialist, Receiving): "From the MFM perspective, we can absolutely handle this laceration repair. It sounds like a vaginal sidewall - we do these all the time. We'll have OR ready, blood bank has products standing by. My main concern here is the mother-baby dyad. Separating them right after delivery, especially with a premature infant, creates significant psychological stress. There's good evidence that keeping mother and baby together, especially for breastfeeding initiation and maternal-infant bonding, is important. If we can keep them together, that would be optimal from a family-centered care perspective."

Dr. David Washington (Neonatologist, Receiving): "We're ready for a 32-weeker in our Level III NICU. Standard 32-week protocols. I agree with Dr. Kim - keeping mom and baby together is ideal if we can do it safely. But if the baby needs to come separately, we can handle it. The clinical urgency for the baby is lower than for the mother - she's stable right now. The time-to-care issue is more critical for the maternal bleeding."

Lisa Chen (NICU Manager, Receiving): "We have bed availability in the Level III pod. Staffing is appropriate - we've got a 2:1 nurse-to-patient ratio available. We're ready to receive. 32-week protocols are standard for us."

Dr. Rodriguez (Anesthesiologist, Receiving): "OR #3 can be ready. If she needs to go straight to OR for the repair, we can have the team assembled in 15 minutes. Anesthetic risk is acceptable - she's young, healthy, responsive to resuscitation."

Tom Anderson (Blood Bank, Receiving): "We have 4 units O-negative ready to go, cross-match will be done by the time they arrive. If we need massive transfusion protocol, we can escalate, but it doesn't sound like that's where we're at right now."

Jennifer Park (OR Scheduler, Receiving): "OR #3 is available, can be prepped and staffed. Just need a 15-minute heads-up for the full team to assemble."

Head Coordinator Synthesis

Notes Taken:

Clinical Requirements:

- Maternal: MFM surgical capability needed (vaginal laceration repair)
- Neonatal: Level III NICU minimum (32-week protocols)
- Preference: Keep mother-baby dyad together if safely possible

Transport Constraints:

- H135: Fast (18 min) but weight capacity exceeded by 114 lbs
- H145: Capable (1100 lb capacity) but delayed (42 min)
- Weather: 30-minute safe window, deteriorating
- Ground: 90 min, less affected by weather

Risk Factors:

- Maternal hemorrhage ongoing (though currently stable)
- Weather window closing
- Separation trauma if split transport
- Neonatal decompensation possible (though stable now)

Conflicts Identified:

- Speed (H135, 18 min) vs. Capacity (H145, 42 min)
- Keeping dyad together vs. getting mother to care fastest
- Weather safety vs. optimal aircraft selection

Final Recommendation:

RECOMMENDED ACTION:

Deploy H145 from Lebanon immediately

Transport mother + baby together

Expected arrival: 42 minutes

Weather window: Sufficient if dispatch NOW

CONFIDENCE: 78%

RATIONALE:

1. Maternal stability supports 24-minute delay
 - Vitals stable with fluid resuscitation (BP 108/62, HR 102)
 - Bleeding active but not catastrophic
 - Dr. Chen reports patient hemodynamically stable

2. Family-centered care priority
 - Strong preference from Dr. Kim (MFM) to keep dyad together
 - Psychological benefit of maternal-infant bonding
 - Supports breastfeeding initiation
 - Reduces family stress during crisis
3. H145 provides full capability
 - Both patients accommodated safely
 - Complete equipment configuration
 - No compromises on monitoring or care
4. Weather window acceptable
 - Capt. Martinez confirms doable if we commit now
 - Marginal but within safety parameters

RISK MITIGATION:

- If maternal condition worsens en route:
Ground ambulance staged at midpoint for emergency landing/transfer
- If weather deteriorates faster than predicted:
Alternate landing sites identified
Ground backup coordinated
- Receiving facility preparation:
OR #3 prepped and staffed
Blood products ready (4 units O-neg, more available)
MFM and NICU teams coordinated for simultaneous arrival

SPECIALIST CONSENSUS:

12/12 specialists consulted
Strong support from MFM (Dr. Kim) and NICU (Dr. Washington) for keeping dyad together
Transport coordinator (Maria) and pilot (Capt. Martinez) confirm feasibility
No strong dissenting views

ALTERNATIVE CONSIDERED:

- H135 with mother-baby separation
- Faster for baby (18 min vs 42 min)
 - Mother via ground (90 min)
 - Rejected due to: family impact, coordination complexity, mother's time-critical need

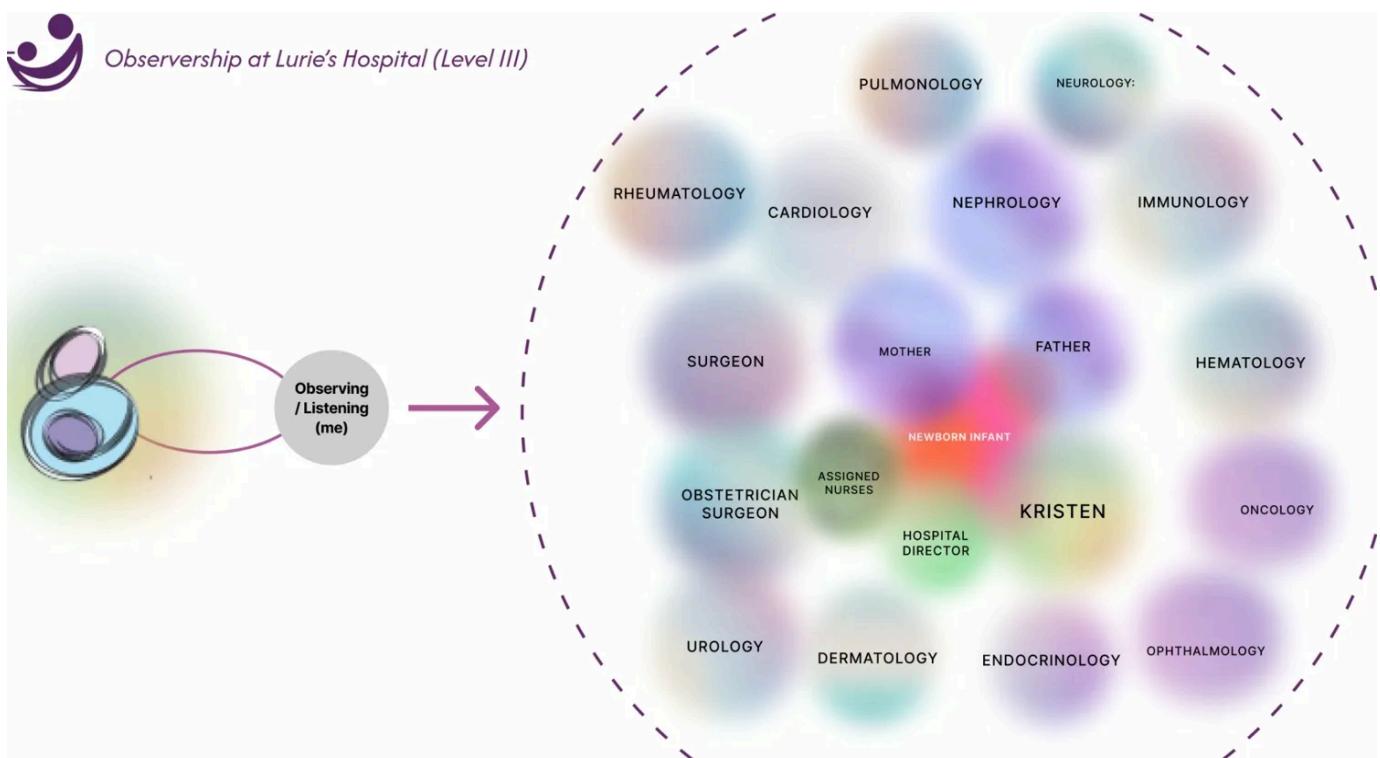
Specialist Observer Feedback (Example)

Dr. Kim (Real MFM Specialist watching simulation):  APPROVE recommendation

"I completely agree with this reasoning. The 24-minute delay is acceptable given her current stability, and keeping the dyad together is really important here. The AI correctly weighted the family-centered care consideration, which I appreciate. The risk mitigation around weather and having ground backup staged shows good contingency planning. I would make this exact same recommendation."

Confidence: 5/5 Comments: "The virtual MFM agent reasoned very similarly to how I would. Good job identifying the key trade-off and resolving it appropriately."

Original research : solution is not the same so you don't need to take the pics too seriously





The Original Motivation

Symposium on Respiratory Disorders in the Newborn

Stabilization and Transport of Severely Ill Infants

M. Douglas Cunningham, M.D.,^a and Franklin R. Smith, M.D.^{a,b}

During the past 10 years there has been great interest in planning and building medical facilities for the care of the newborn. Many medical centers, community as well as university, now are developing and maintaining specialized intensive care nurseries. In smaller hospitals that lack space, personnel, and equipment to care for sick infants are helped greatly when it is possible for them to transport these infants to larger medical centers. In the United States and throughout the country, specialized intensive care transport of sick infants is becoming a necessary community and regional medical resource.

The first step in providing medical service to the sick infant is stabilization. For two decades medical centers in metropolitan areas have transferred sick infants by air. However, these efforts have proved handicapped because of limited means for temperature stabilization, monitoring vital signs, and maintaining an adequate airway. Also, poor and erratic flight schedules have caused many problems and delays encountered en route.

Recent technological advances have made available portable self-powered incubators with temperature control and oxygen supply, portable cardiac monitors, portable mechanical ventilators, and small infusion pumps for administration of parenteral fluids.

Improved modes of travel have expanded medical transport. Larger ambulances accommodate several transport team members and their equipment. Improved aircraft have increased range and altitude, thus increased team mobility and range of travel. And the increasing use of air conveyances for medical purposes has made sick infant transport available to more areas.

Presently, a medical transport system can take neonatal intensive care techniques to the sick infant. In this way specific therapy can be started before departure and continued throughout the transport procedure.

In this report an attempt is made to distinguish between the simple

^aAssociate Clinical Professor of Pediatrics, University of California, San Diego, La Jolla, California.

^bPresently, U.S. Army, Tripler General Hospital, Honolulu, Hawaii.

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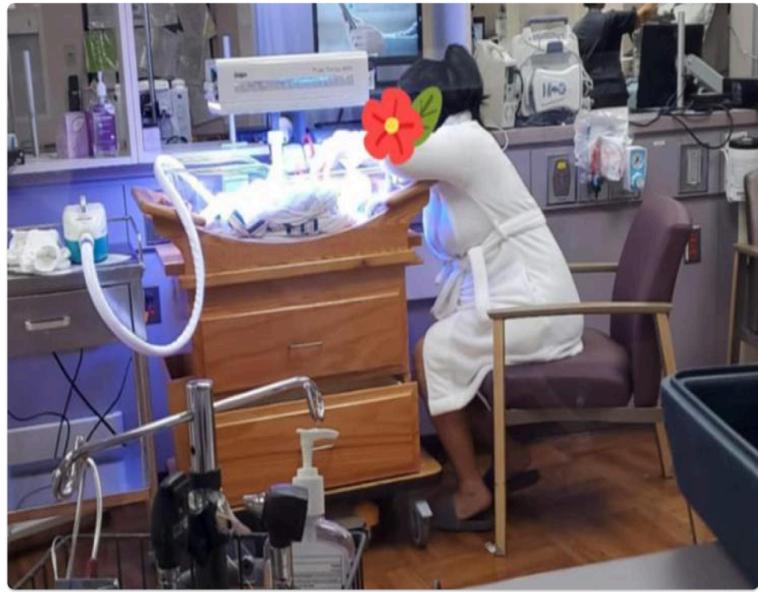
FRANKLIN R. SMITH
y to another, and
ill infants to

at by the infant
ad an inhalation
ordinates the ef-
ficient and safe
stabilizes therapy
mission for trans-
The system conse-
e assembles and
physicians during
of the infant. An
constant oxygen
e designed and
y, and storage for
resuscitation equip-
specifications and
stable units, this
sight. The system
includes a battery-
out. Respiratory
filled Mapleson
T (M-T) (see Fig. 1
P) as previously
jonal equipment
n wheels. It con-
taining the patient
and establishing
ntravenous fluid
the infant along
various sizes of
regional, and re-
separate

drawings are listed in Table 1.

Conventional ambulances are used, with preference for van-type ambulances for short distances because of their ample interior space. For distances over 50 miles an airplane must be used on account of automobile speed.

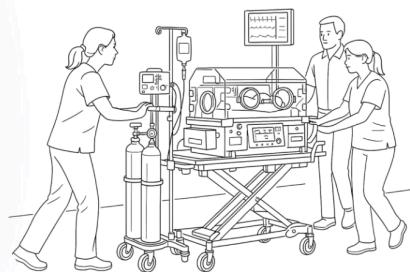
For distances greater than 100 miles a helicopter or fixed wing aircraft may be used. This reduces travel time, but vibration and noise interfere with patient monitoring and interteam communication.



<https://www.sciencedirect.com/science/article/pii/S0031395516328486>

Research Objective

Nestara as a modular, standalone platform initiative to deliver shock stabilization and thermal solutions, eliminating the need for bulky charging stations and transport shuttles.



General standards for vibration (i.e. ISO -2631) and thermo-regulation exists primarily for adults, but are not specifically **tuned to the needs of neonates** during exposure within transportation and heavy machinery. This highlights a critical gap in ensuring the safety and well-being of infants during transit.

Equipment Complexity

1

Vibration & Heat Instability

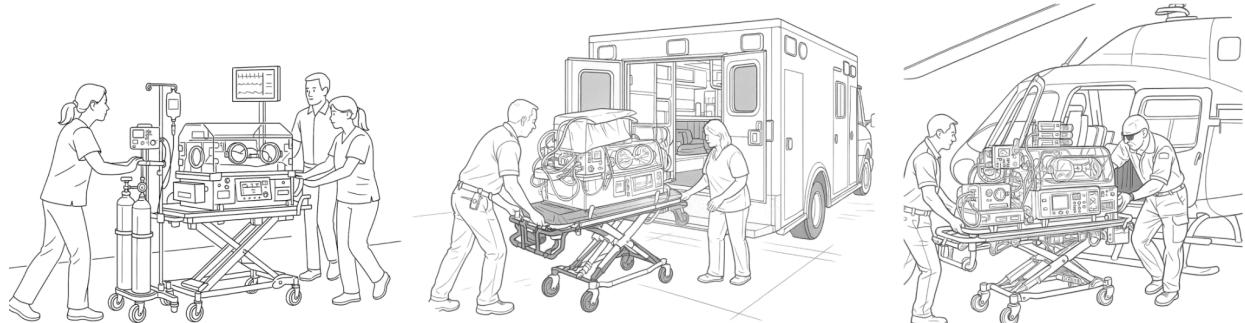
2

Power Limitations

3



Transportation Modes



Intra-hospital



Ground

Photo credit: Boston Med Flight

Illustrations: Boston Med Flight



Air

Photo credit: Boston Med Flight

Illustrations: Boston Med Flight



Site Visit at Boston MedFlight



“ ... But vibration and noise interfere with patient monitoring and inter-team communication ”

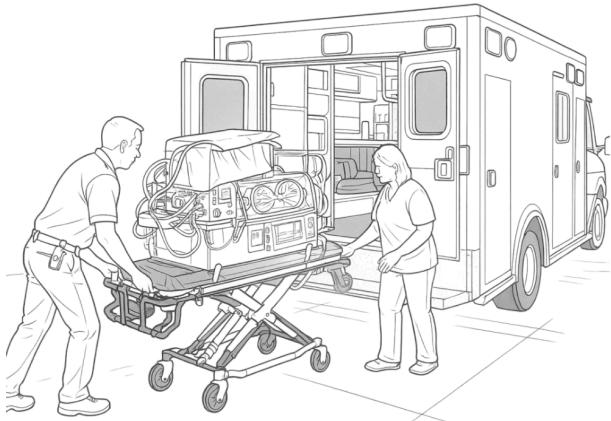


Air

<https://www.sciencedirect.com/science/article/pii/S0031395516328486>



Site Visit at Boston MedFlight



Ground



Video: Nestara 2
Play Time 2:04

“ It can be really costly to redesign the entire system for it to then go through an entire certification process ”



"All to go, one to say no"



Observing / Listening
(me)



Listening
(me)



INTERNATIONAL
MEDICAL
EVACUATION
TEAMS

AIR AMBULANCE
OPERATORS
(PUBLIC & PRIVATE)

DISPATCH
COORDINATION
CENTERS

DEPARTMENT OF
DEFENSE (FOR
MILITARY
TRANSFERS)

EMERGENCY
RESPONSE
COORDINATORS

NEONATAL TRANSPORT
TECHNICIANS

NICU MEDICAL
DIRECTORS

INSURANCE &
REIMBURSEMENT
AGENCIES

LOGISTICS
COORDINATION
CENTERS

CRITICAL CARE
NURSES

FLIGHT
PHYSICIANS (IF
ROTOR/WHEEL-
BASED)

AEROMEDICAL
PHYSICIANS

FLIGHT
NURSES

LOCAL & FEDERAL
HEALTH AUTHORITIES
(E.G., FEMA, WHO, CDC)

HOSPITAL CASE
MANAGERS

HOSPITAL LEGAL &
COMPLIANCE
TEAMS

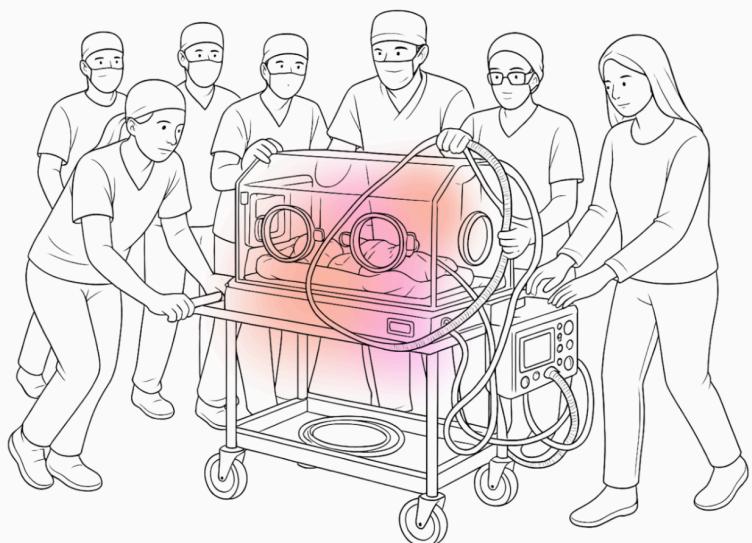
PRIVATE OR PUBLIC
AMBULANCE
OPERATORS

TRANSPORT
COORDINATORS

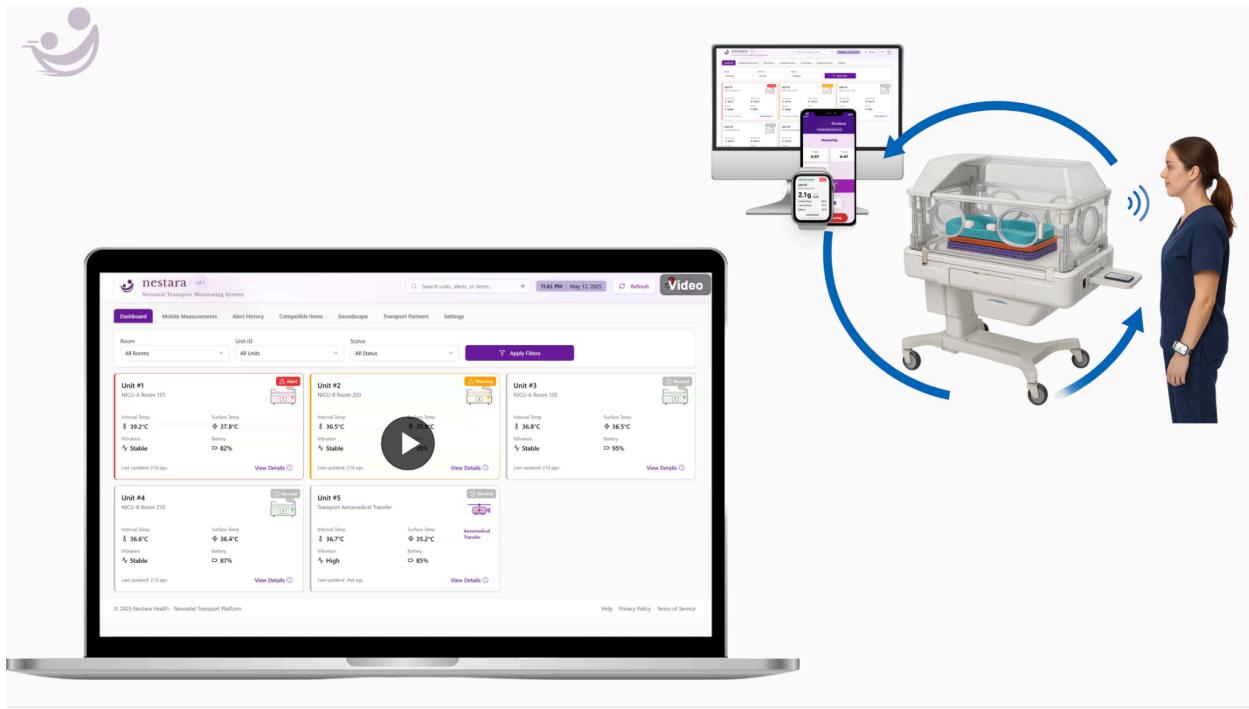
NEWBORN INFANT



"All to go, one to say no"



Depending on severity of the needs of patient, teams can increase anywhere from 7 - 14 people



PUGH CHART

A	B	C	D	E	F	G	H	I	J
Concepts	Effectiveness in Transport Stability	Integration with Existing Hospital Systems	Manufacturing Feasibility	Cost per Use	Disruption to Hospital Workflow	Deployability Across Transport Modes	Innovation	Reason for Selection/Rejection	
Heated Bed	Negative (Director: Hospitals already use these but they does not solve transport issues.)	Positive (Director: Hospitals already use these but they does not solve transport issues.)	Positive (Director: Simple to produce but does not solve root transport issue.)	Negative (Director: Costs add up without addressing transport safety.)	Negative (Director: Adds unnecessary equipment to an already crowded NICU.)	Negative (Director: Not useful for ambulances or air transport.)	Negative (Director: No real innovation here.)	Existing solutions does not work well for transport and provide inconsistent heating.	
Hand Warmers & Heat Covers	Negative (Nurse: Only keeps baby warm, but does not help with handling bumps.)	Strong Positive (Nurse: Common and easy to use but only good for static warming.)	Strong Positive (Nurse: Easiest to procure but limited effectiveness.)	Positive (Nurse: Inexpensive, but limited impact on transport.)	Strong Positive (Nurse: Easy to use, no extra training required.)	Positive (Nurse: Better than nothing, but limited for hospital use only.)	Negative (Nurse: Nothing new, just existing methods.)	Already available but does not address transport vibration issues.	
Modular Incubator with Built-in Heating	Negative (Aeromedical: Unreliable at high-altitude transport where air pressure fluctuates.)	Negative (Aeromedical: Bulky, hard to integrate into flight systems.)	Negative (Aeromedical: Complex build, custom requirements make it expensive.)	Negative (Aeromedical: Too expensive for hospitals to maintain.)	Negative (Aeromedical: Would require retraining of transport teams.)	Strong Positive (Director: Designed for seamless transition between locations.)	Strong Positive (Director: Tackles a problem that has been overlooked.)	Too costly and complex; difficult to integrate with current NICU setups.	
Vibration-Dampening Base (Selected)	Strong Positive (Director: Directly improves transport safety by reducing shock.)	Strong Positive (Director: Easy to attach without modifying hospital workflow.)	Strong Positive (Director: Relies on off-the-shelf materials, no major R&D needed.)	Positive (Director: Affordable and justifies investment in technology.)	Positive (Nurse: Potentially good but installation could slow transport down.)	Positive (Nurse: Works for hospitals but harder to implement in ambulances.)	Strong Positive (Director: Reduces transport times are needed, so this is critical.)	Selected due to its ability to improve transport stability with minimal disruption.	
Suspension System for Incubator Transport	Positive (Nurse: Good idea but tricky to implement with existing carts.)	Positive (Nurse: Might require retrofitting some existing transport carts.)	Positive (Aeromedical: Specialized engineering, hard to mass produce.)	Negative (Nurse: Expensive because of custom parts and maintenance.)	Negative (Aeromedical: Battery changes and maintenance could disrupt workflow.)	Strong Positive (Director: Better transport autonomy, good for longer transfers.)	Strong Positive (Director: Could reduce reliance on external battery power.)	Promising, but difficult to manufacture and deploy effectively.	
Innovative Battery System for Transport	Positive (Aeromedical: Would improve power supply but doesn't fully address physical movement issues.)	Negative (Aeromedical: New battery systems would require power infrastructure changes.)	Negative (Aeromedical: Battery production is expensive and requires FDA approval.)	Negative (Aeromedical: High initial investment but long-term benefits.)	Negative (Aeromedical: Hospitals are not designed for this kind of power storage.)	Strong Positive (Director: Better transport times are needed, so this is critical.)	Strong Positive (Director: Cutting-edge battery design could change ground transport.)	New battery systems could extend transport duration, but development and approval timelines are long.	
3D-Printed Solid-State Batteries	Positive (Director: Could allow for better heating and power but does not stabilize the infant.)	Negative (Director: Hospitals don't currently support solid-state battery tech.)	Negative (Director: 3D printing solid-state batteries is too experimental.)	Negative (Director: Never technology is not yet affordable at scale.)	Negative (Nurse: Extreme cost makes it impractical for clinical use.)	Negative (Nurse: Handling nuclear materials in a NICU? No way.)	Strong Positive (Nurse: Would revolutionize transport, but would it be safe?)	3D-printed solid-state batteries could improve efficiency, but manufacturing and regulatory barriers exist.	
Nuclear Batteries (Pacemaker-Inspired)	Strong Positive (Nurse: Long-lasting power is great but raises safety concerns.)	Negative (Nurse: Radiation concerns make this non-viable in hospital settings.)	Negative (Aeromedical: Nuclear energy sounds great, but patient safety is a nightmare.)	Negative (Aeromedical: Short battery life means repeated purchases.)	Negative (Aeromedical: Recharge cycles interrupt emergency readiness.)	Positive (Aeromedical: Usable but constrained by limited battery life.)	Strong Positive (Nurse: Game-changing if safe, but barriers are high.)	Nuclear batteries offer long-lasting power but face safety concerns and stringent regulations.	
Existing Battery-Powered Transport Incubators	Positive (Aeromedical: Current solutions work but need more reliability.)	Positive (Aeromedical: Commonly used but recharge time is a major issue.)	Positive (Aeromedical: Available but needs better power management.)				Positive (Aeromedical: Incremental improvement rather than true innovation.)	Existing solutions have short battery life and require frequent recharging, limiting usability.	

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Function	Requirements	Design Parameters	Analysis	References	Risks	Countermeasures
Reduce incubator vibrations during transport	Minimize vibration intensity without adding excess weight	Vibration-dampening system using viscoelastic and lightweight materials	Compare vibration exposure levels in neonatal transport [PubMed](https://pubmed.ncbi.nlm.nih.gov/25429381/)	[University of Wisconsin-Madison Study on Neonatal Transport] [PubMed](https://pubmed.ncbi.nlm.nih.gov/25429381/)	System must not interfere with NICU procedures or emergency interventions	[Study on Neonatal Transport Mattress Efficiency](https://pubmed.ncbi.nlm.nih.gov/25429381/)
Ensure adaptability of dampening system across all transport environments	Allow for modular design compatible with hospital, ground, and air transport setups	Adaptive suspension to accommodate different transport surfaces (e.g., elevator gaps, ambulance turbulence, rotor vibrations)	Assess neonatal stress factors during transport [PMC](https://pmc.ncbi.nlm.nih.gov/articles/PMC8557728/)	[Ambulance Transport Vibration Mitigation Research] [https://www.aeromedsocaustralia.sia.org/img.ashx?f=f&p=melbourne_2013%2FTAMASSY_Ann-Marie.pdf]	Weight constraints must be met to avoid affecting transport maneuverability	[Study on Neonatal Transport Mattress Efficiency](https://pubmed.ncbi.nlm.nih.gov/25429381/)
Enhance safety while maintaining seamless NICU workflow integration	Ensure sterility, easy handling, and regulatory compliance	Quick-release and non-disruptive attachment mechanisms for incubators and stretchers	Analyze existing isolation systems for neonatal transport [Xi Engineering](https://xiengineering.com/isolation-system-for-neonatal-transport/)	[Study on Neonatal Transport Mattress Efficiency](https://pubmed.ncbi.nlm.nih.gov/25429381/)	Material durability and performance must be tested under different transport conditions	[Study on Neonatal Transport Mattress Efficiency](https://pubmed.ncbi.nlm.nih.gov/25429381/)