



R&S Consulting

Innovation in Systems Engineering for ITS Design, Management and Operations

August 14, 2006

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Joe McCarthy,
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Key Take-Aways

- Systems Engineering Approach
- Consensus Building
- Concept of Operations
- Virtual TMC
- Best Practices for Rural TMCs
- Organizational Issues
- Adaptability

ITS Can Save Lives



TIM O'HESNUT, Laramie Daily Boomerang/AP

Several tractor-trailers burn on Interstate 80 between Laramie and Cheyenne on Thursday. One person was killed and 15 others hospitalized in a fiery chain reaction of crashes involving 33 vehicles on a wet and foggy Interstate 80.

33-vehicle wreck closes part of I-80

One killed, three critically injured between Laramie and Cheyenne

By **JOHN MORGAN**
Star-Tribune staff writer

At least one person was killed and three people were critically injured in a series of crashes and chain-reaction collisions Thursday on Interstate 80 near Buford. As many as 33 vehicles were involved in the fiery crash, which occurred at 10:30 a.m. on eastbound I-80, about 18 miles east of Laramie,

according to Lisa Murphy of the Wyoming Department of Transportation's public affairs office.

Rescue workers were battling the fires and sorting through the wreckage late into the night.

"Excessive speed and wet, foggy conditions contributed to the crash," Murphy said. "Heavy fog in the area made visibility extremely poor."

The first crash occurred about

three miles west of the Buford Interchange, where as many as seven tractor-trailers and a horse trailer quickly became engulfed in flames. A series of smaller vehicle crashes cascaded back up I-80, as drivers began rear-ending others stopped for the initial crash scene.

Eastbound I-80 was to be closed from Cheyenne to Laramie

Please see **WRECK**, A16

'It was horrendous'

Survivors of deadly crash say they're lucky to be alive

By **JARED MILLER**
Star-Tribune staff writer

RAWLINS — Survivors of Sunday's deadly Interstate 80 crash described a nightmarish scene of twisted vehicle bodies, screaming victims the intermittent crunch of more vehicles slamming into the pileup. "It just didn't stop," said Todd Munn, a truck driver from Ontario, Canada, who was recovering from injuries Monday at the Rawlins hospital. "It was horrendous."

Six people died and a dozen others were injured in the wreck that compacted 22 cars and trucks into just a few hundred yards of interstate. The crash is under investigation by the Wyoming Highway Patrol.

Several smaller chain-reaction crashes broke out behind the larger one, said Sgt. Stephen Townsend of the Highway Patrol.

Authorities released the victims' names Monday night, including four members of a single Conifer, Colo., family who perished in the wreck.

Laura Graves, 40, and her sons Kaleb, 18, and Cameron, 14, and her daughter, Kelsey, 16, died when their Mercury Sable crashed into a tractor-trailer and then was hit from behind by another rig, Townsend said.

The remaining victims were identified as Patrick Guinn, 57, of Loveland, Colo., and Christopher Starz, 22, of Eagle River, Wis. Guinn was outside his vehicle when he was struck and killed, Townsend said.

Troopers were still trying to get an exact count of those injured in the wreck Monday, he added.

Ivinson Memorial Hospital in Laramie transferred two victims with head and facial in-



Jared Miller, Star-Tribune

Jean Renken, 72, left, and her husband, Norris Renken, 73, of Bertrand, Neb., say they're lucky to be alive after they were sandwiched by tractor-trailers in Sunday's deadly crash. The Renkens and their 47-year-old daughter, who was also in the Chevy S-10, suffered back injuries. They were hospitalized in Rawlins.

juries to Poudre Valley Hospital in Fort Collins, Colo., and treated "four or five" others, said Sharon Gern, assistant vice president of nursing.

Dana Cramer, nursing supervisor at Poudre Valley, said the hospital admitted two men, one in critical condition and the other in serious condition.

Nine others were taken by ambulance to Memorial Hospital of Carbon County in Rawlins. Seven were admitted, and Monday afternoon, hospital CEO Patsy Carter said.

Authorities closed 150 miles of I-80 overnight while crews

cleared the mangled cars, trucks and cargo. The highway opened by 7:30 a.m. Monday.

The wreck was reported at 4 p.m. Sunday about nine miles east of Elk Mountain between Rawlins and Laramie.

Munn said he was driving his refrigerated truck about 30 mph when the highway suddenly disappeared behind a dense wall of wind-whipped snow.

"I've seen some snow, but never that come in like it did yesterday," Munn, 40, said. "Trucks just disappeared into a wall of snow and hit each other."

Munn was driving behind another tractor-trailer that made a sudden stop.

The median and the barrow ditch were littered with cars and people and Munn had no choice but to slam into the truck in front of him.

"The only thing I could do was hit the truck or kill the people," said Munn, who suffered knee and hand injuries. His company will fly him home to Canada this week, Munn said.

The truck he hit was carrying the driving team of Prescott Hayden, 38, and his nephew

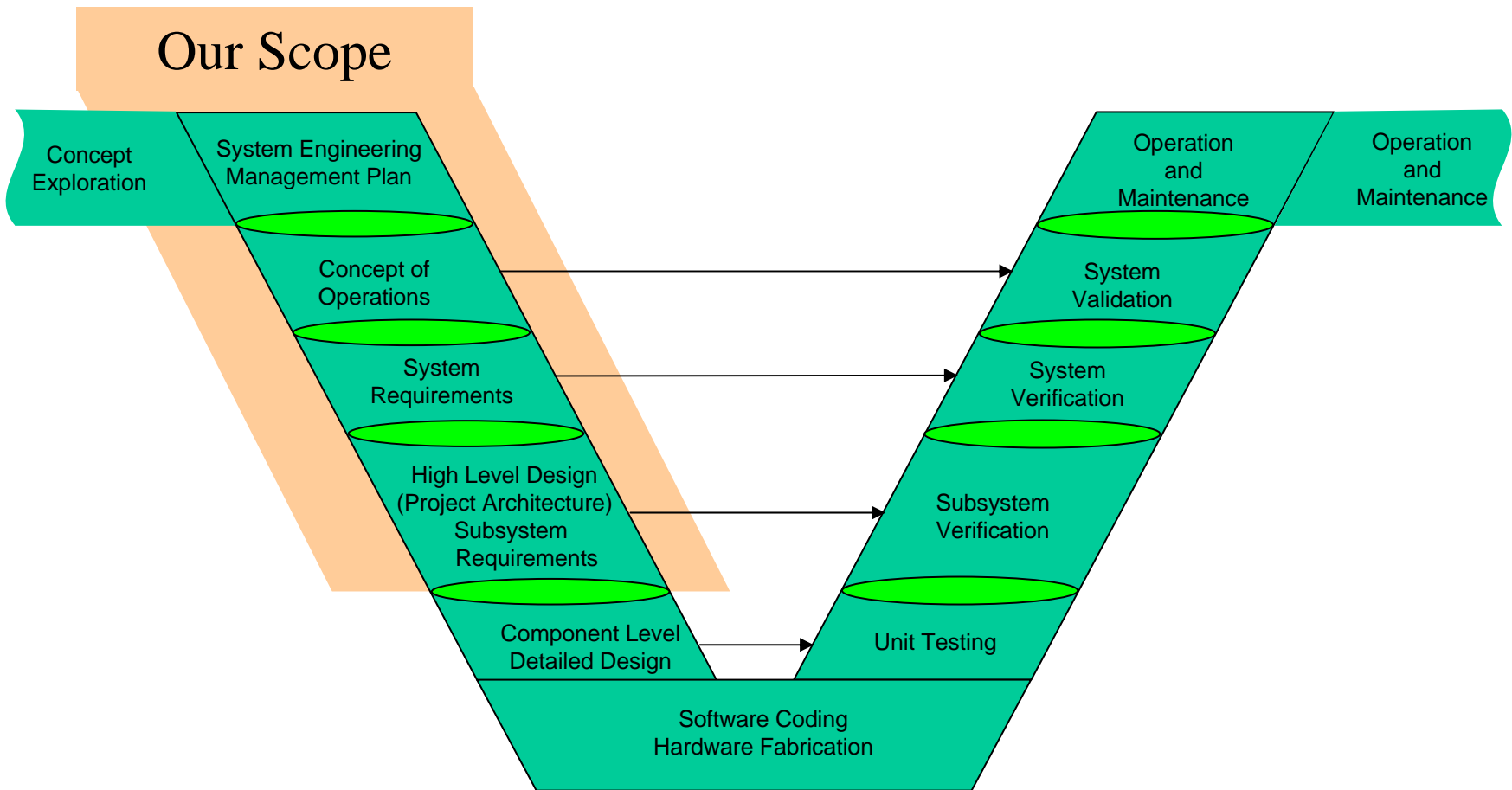
Please see **CRASH**, A12 or 6

TMC Multi-Disciplinary Team

- Executive Sponsor

- Program Managers
 - Traffic
 - ITS
 - Patrol (Dispatch & Enforcement)
 - Districts (DE, Maintenance, Traffic)
 - Telecom
 - Public Affairs
 - IT
 - Asset Management

System Engineering “Vee”



Guiding Principles

- Rigorous System Engineering approach
 - Requirements based on Usage Scenarios
 - Analyze current and optimized future processes
 - Analyze alternatives and tradeoffs
 - High level design based on requirements
- Global optimization to complement program plans
 - Based on WYDOT's strategy
 - Fit in with program strategies
 - Use of metrics to focus attention and to measure results
- Long term vision with specific first phase
 - Realize benefits from step one **and**
 - Build a future-ready foundation

Two Levels of Risk Analysis

- **“Traditional”**

- Design may not meet system requirements
- Process is to identify risks, analyze them (e.g. prob. & impact), and mitigate impacts
- Feedback from the analysis is to the subsystem tradeoffs and design options
- High-level system requirements are usually unchanged

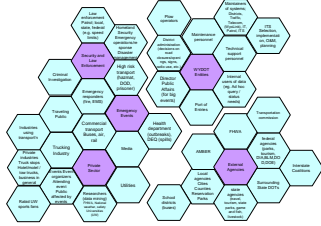
- **“Adaptability” Analysis**

- Concept of Ops and overall Vision may be impacted by unknowns
- Technological, \$, policy, customers, stakeholders, and other design drivers
- Scenario Analysis will be used, to anticipate myriad future paths/options
- Goal is design flexibility and/or robustness
- Feedback is to Vision and Concept of Ops

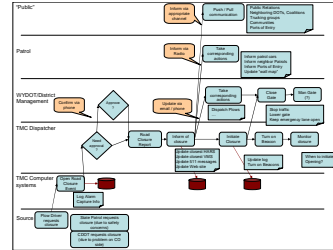
Roadmap to Requirements

Stakeholders

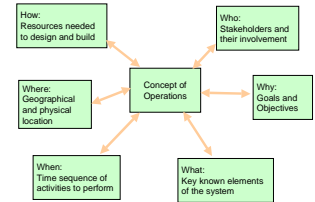
Who are the stakeholders/customers that will benefit from/contribute to be impacted by the TMC



Scenarios -> Process flows

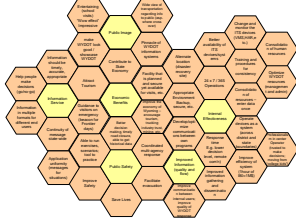


Concept of Ops



Goals & Objectives

What goals / objectives do you see for the TMC



Scenario Characteristics:

- Situation/Context
- Occurrence frequency
- Event vs. on-going
- Causes
- Impacts
- Affected parties
- Expected outcomes

WYDOT Process Mapping

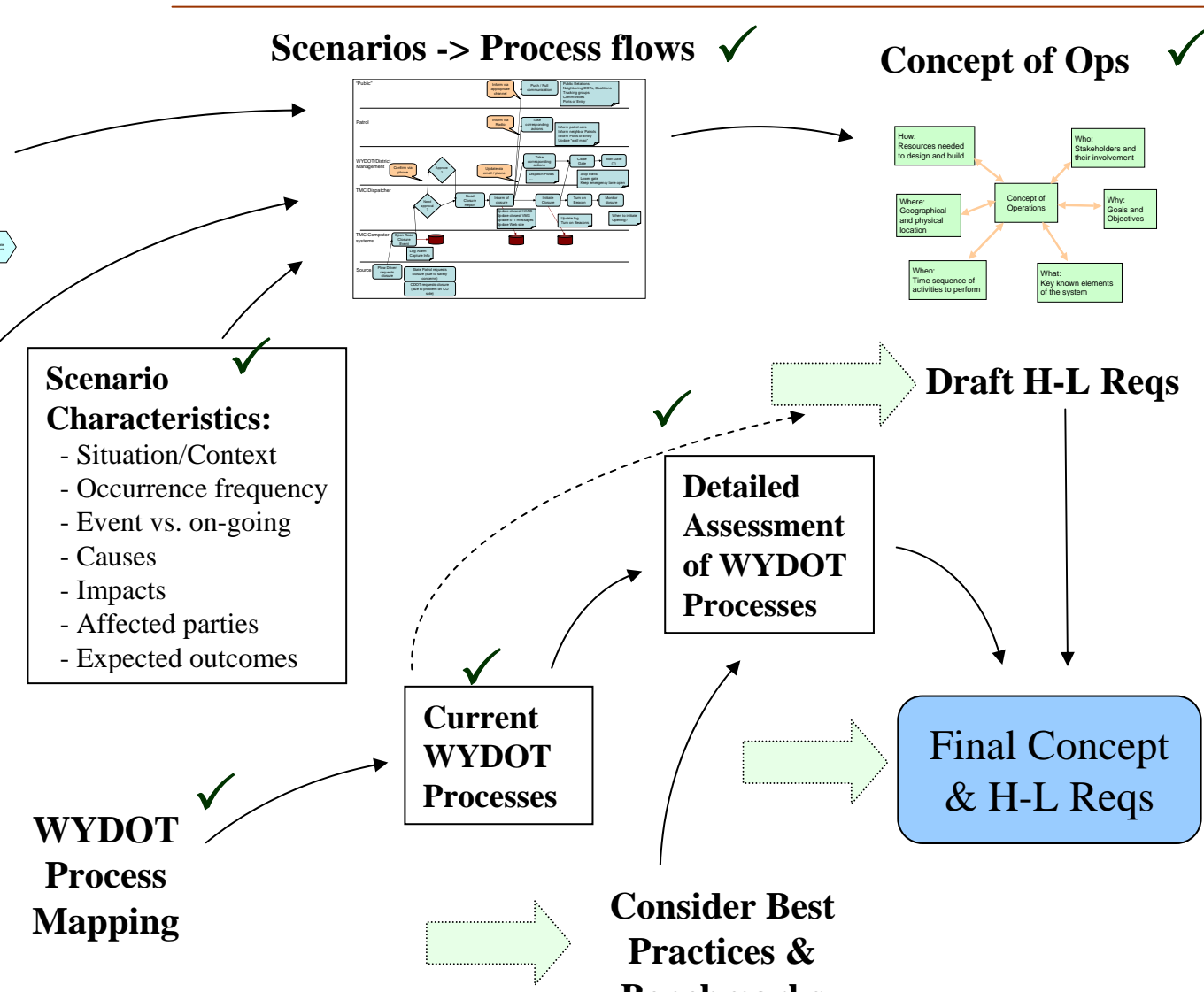
Current WYDOT Processes

Detailed Assessment of WYDOT Processes

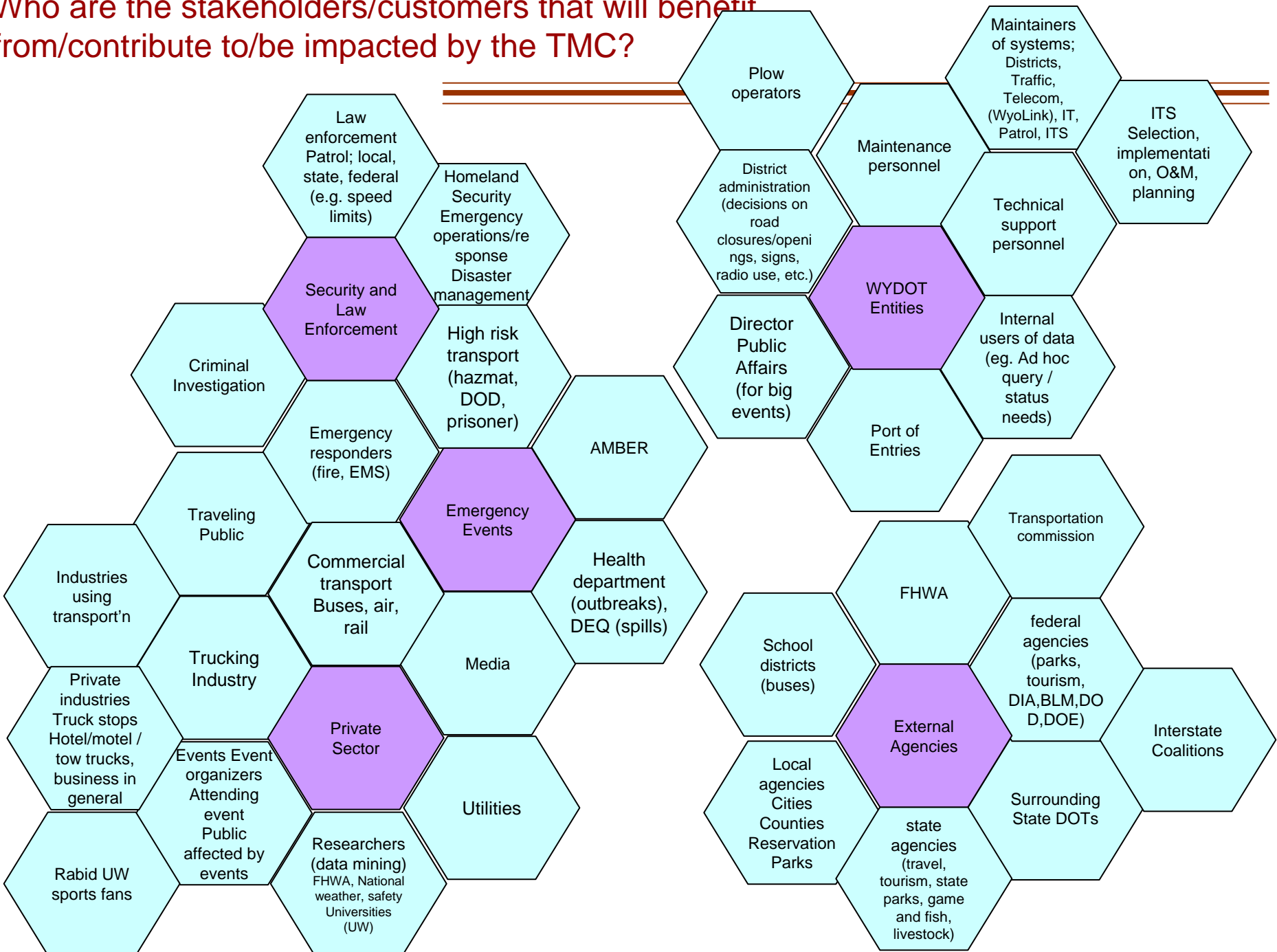
Draft H-L Reqs

Final Concept & H-L Reqs

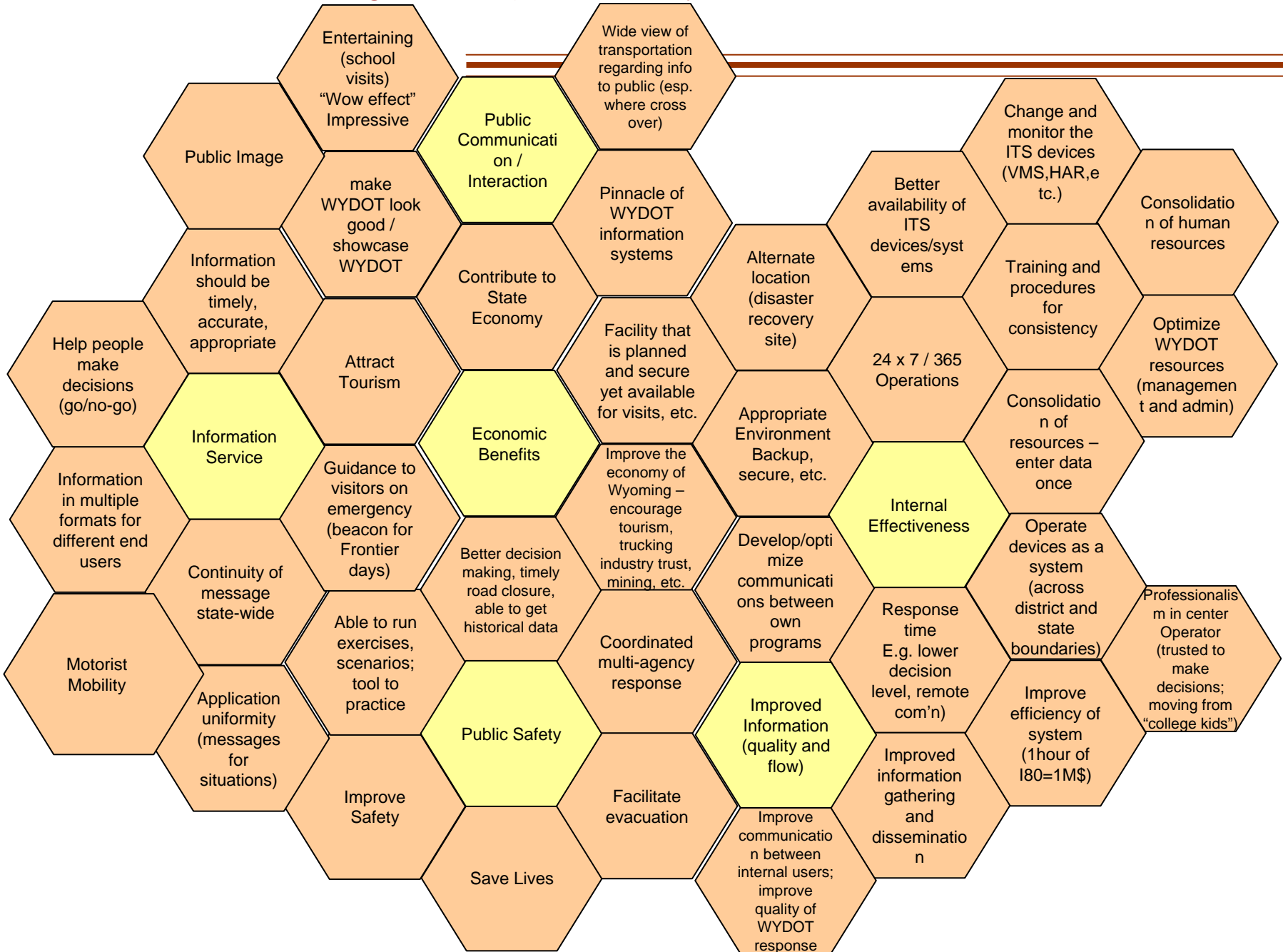
Consider Best Practices & Benchmarks



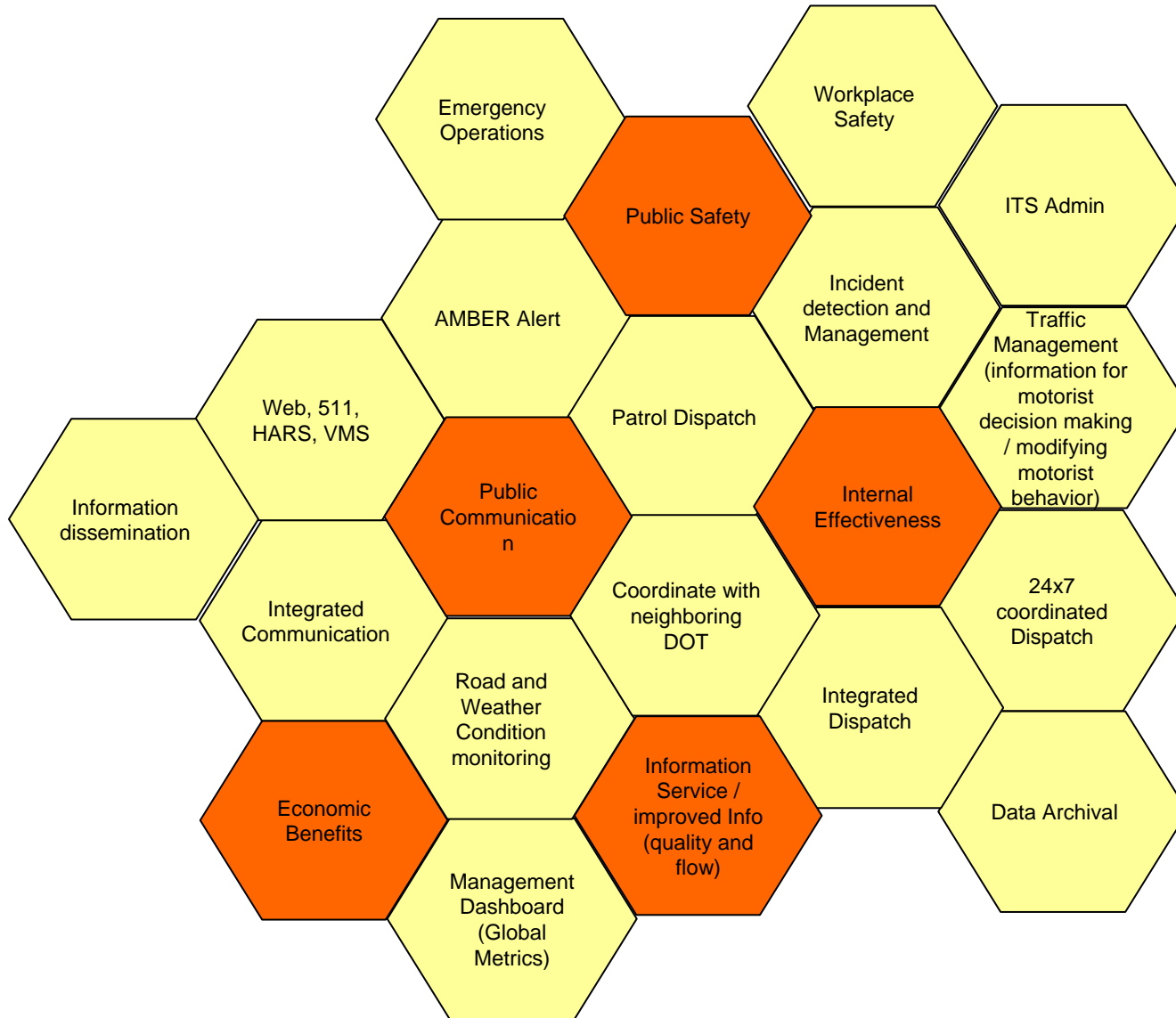
Who are the stakeholders/customers that will benefit from/contribute to/be impacted by the TMC?



What goals / objectives do you see for the TMC?



What functions do you see addressed by the TMC?



Goals, Objectives, & Benefits

WYDOT Goals & Objectives

Benefits to Public

TMC Goals & Objectives

Benefits to WYDOT

Program Goals & Objectives

Benefits to Programs

Maintenance
Traffic Ops
Patrol Dispatch
ITS
Blowing Snow

Scenarios

- Incident Management
- Handling Abnormal conditions
- Roadway status change
- High risk locations factors
- Planned / anticipated activities / events
- Emergency Operations
- Reactive / Preventive Maintenance
- Surveillance of key areas
- Information: meeting needs and expectations
- Data collection and archival
- Enhancing system capabilities
- Disaster recovery

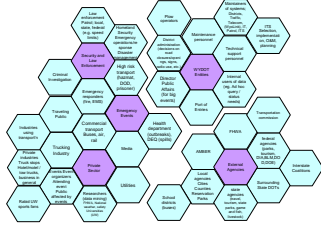
Benefits

- Improved:
- Inter-program coordination/communication
 - Incident response time (lower)
 - More appropriate response
 - Quality Info on current conditions
 - Quality info on evolving conditions
 - Completeness, accessibility of data
 - Time to close / open road (shorter)

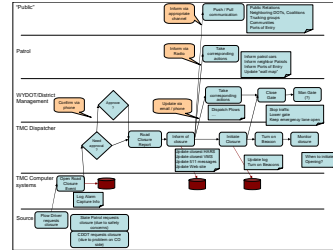
Roadmap to Requirements

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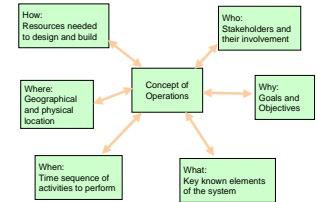
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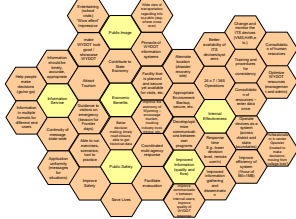


Concept of Ops ✓



Goals & Objectives ✓

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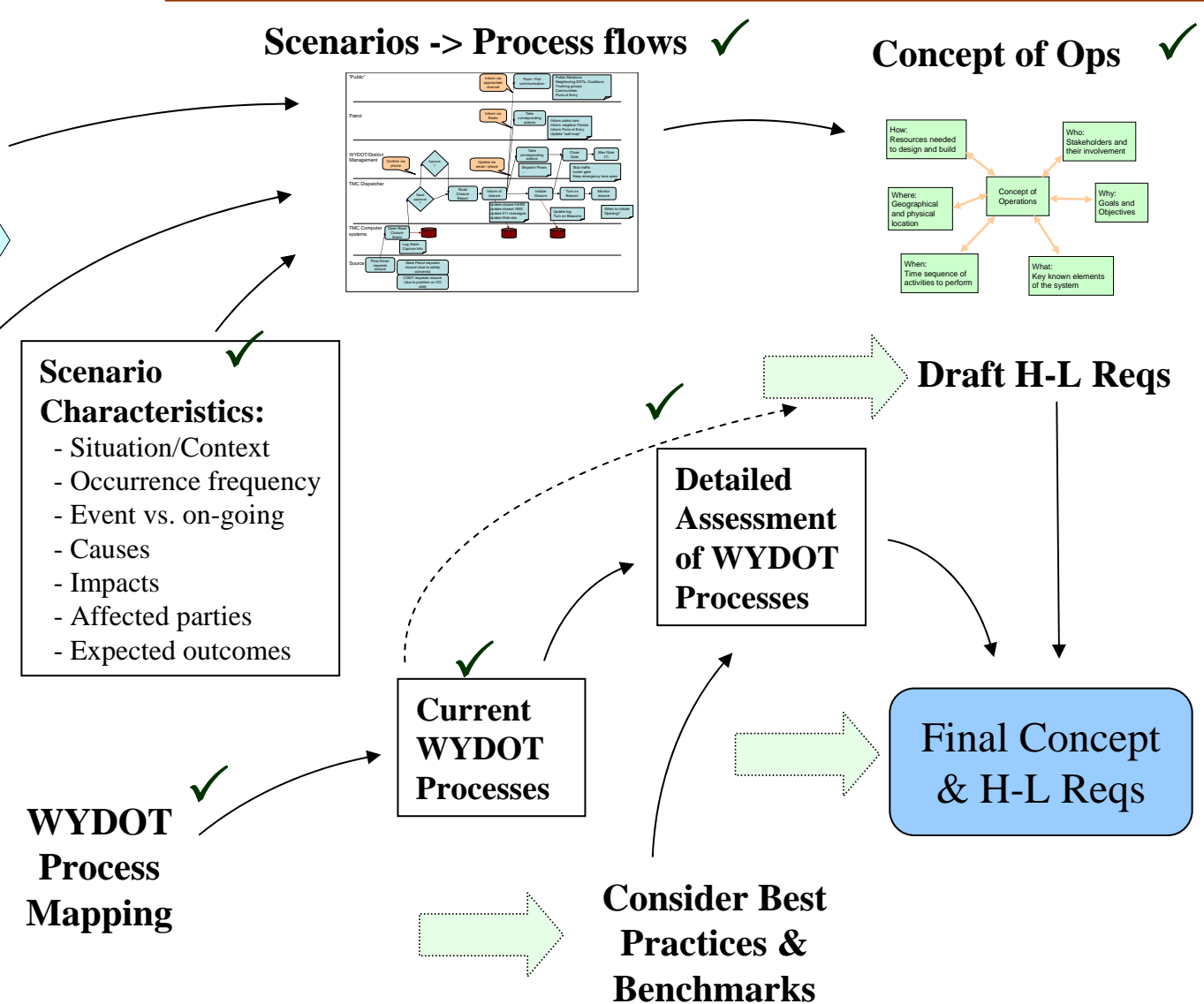
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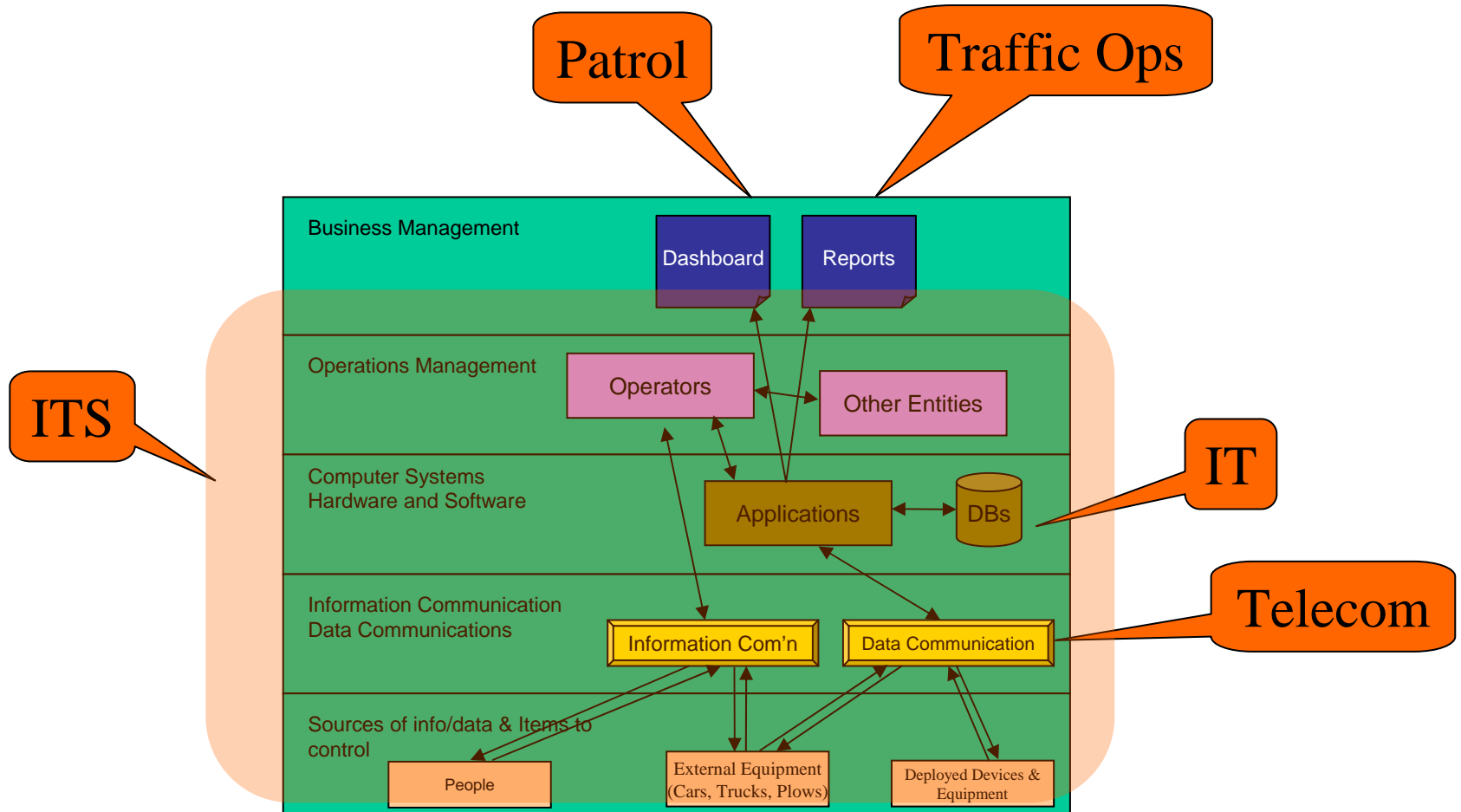
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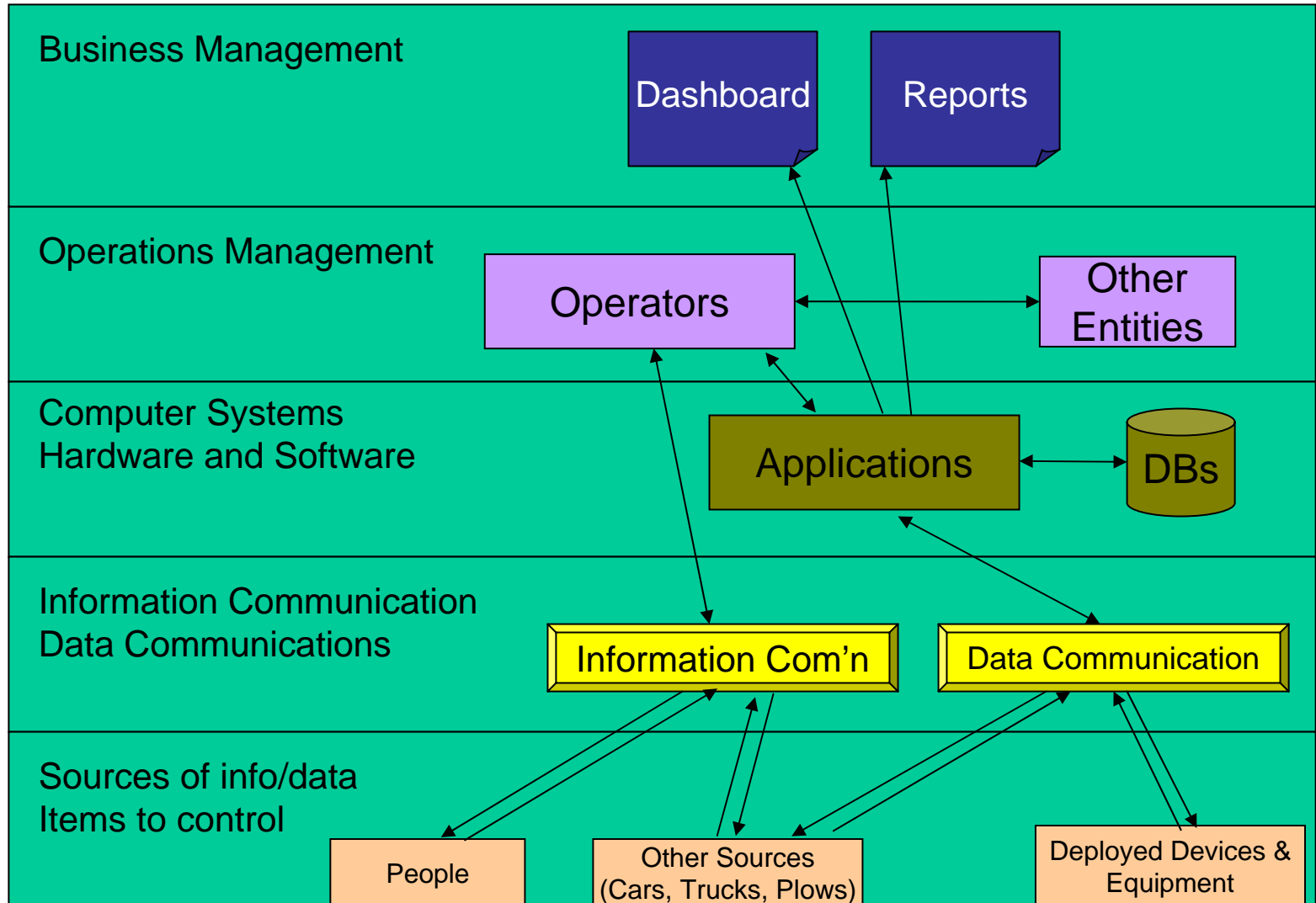
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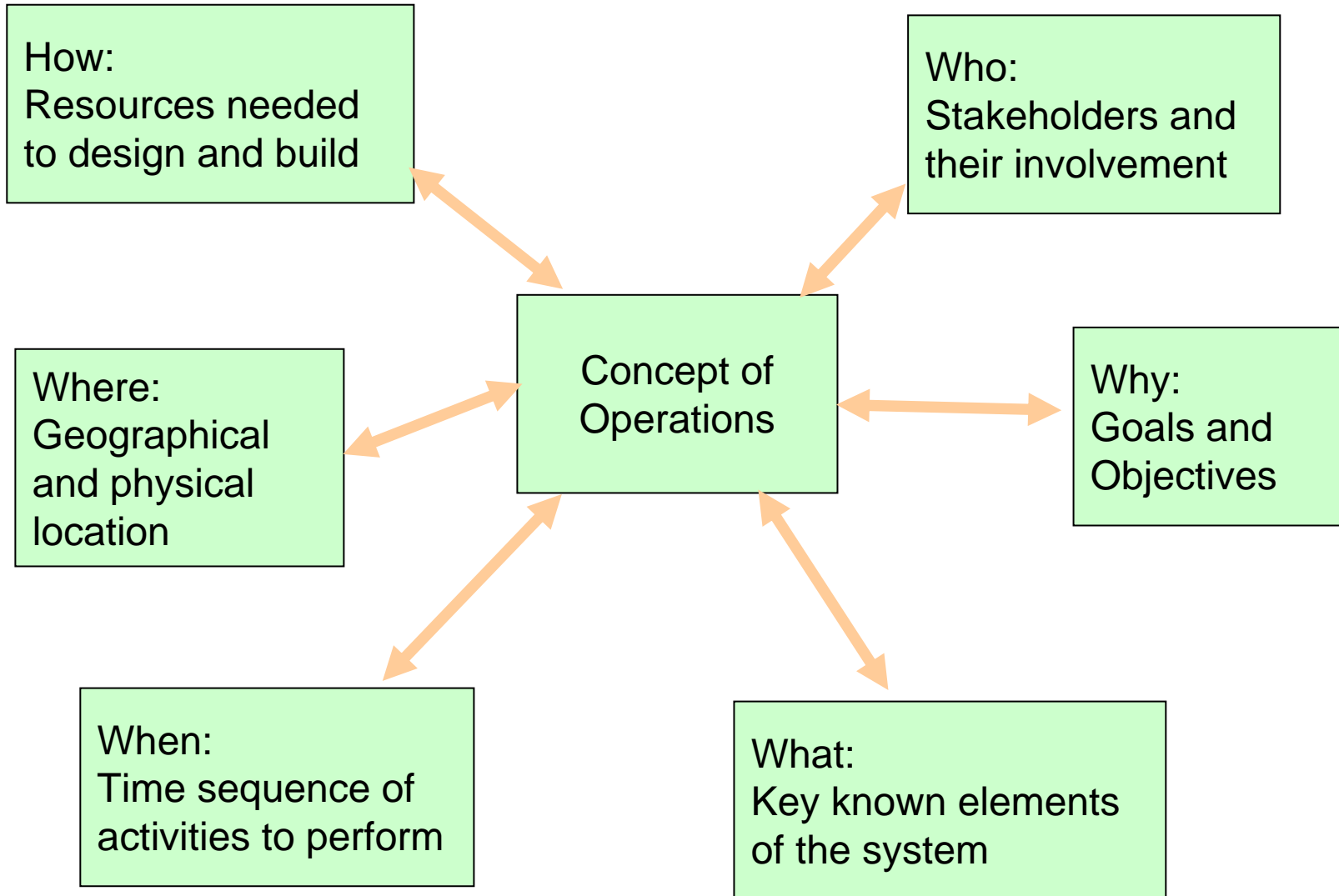
Logical View of Operations



Logical View of TMC



Concept of Operations Overview

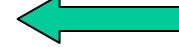


TMC Physical & Virtual Space

TMC Input Requirements



TMC Functional Requirements



TMC Concept of Operations

Inputs into TMC

(what, why, how, who, when, where)

- Data
- Information
- Observations
- Decisions
- Policies

Functions of TMC

Coordination of:

- Org/People (Patrol, ITS, Maintenance, Traffic ops)
- Business Processes / Procedures / Rules / Decision Rights
- Technologies (applications, databases, datacom, networking, hardware, devices)

Outputs of TMC

Providing:

- Actions and Decisions
- Outbound Communication
- Data Archival / Queries

TMC Physical Space

(Interactions and Inter-relations)

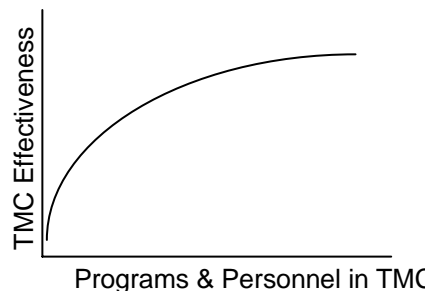


Requirements:

- Organization
- Common areas
- Systems areas
- Security
- Data comm

TMC Virtual Space

(anytime, anywhere, anyone*)



Information & Layers:



- Assets & Resources
- Incidents & Events
- Traffic Conditions
- Weather Conditions
- Road Conditions

Conceptual Prototype

Wyoming

Highway Monitoring

- Event Monitoring Conditions
- Incidents/Events



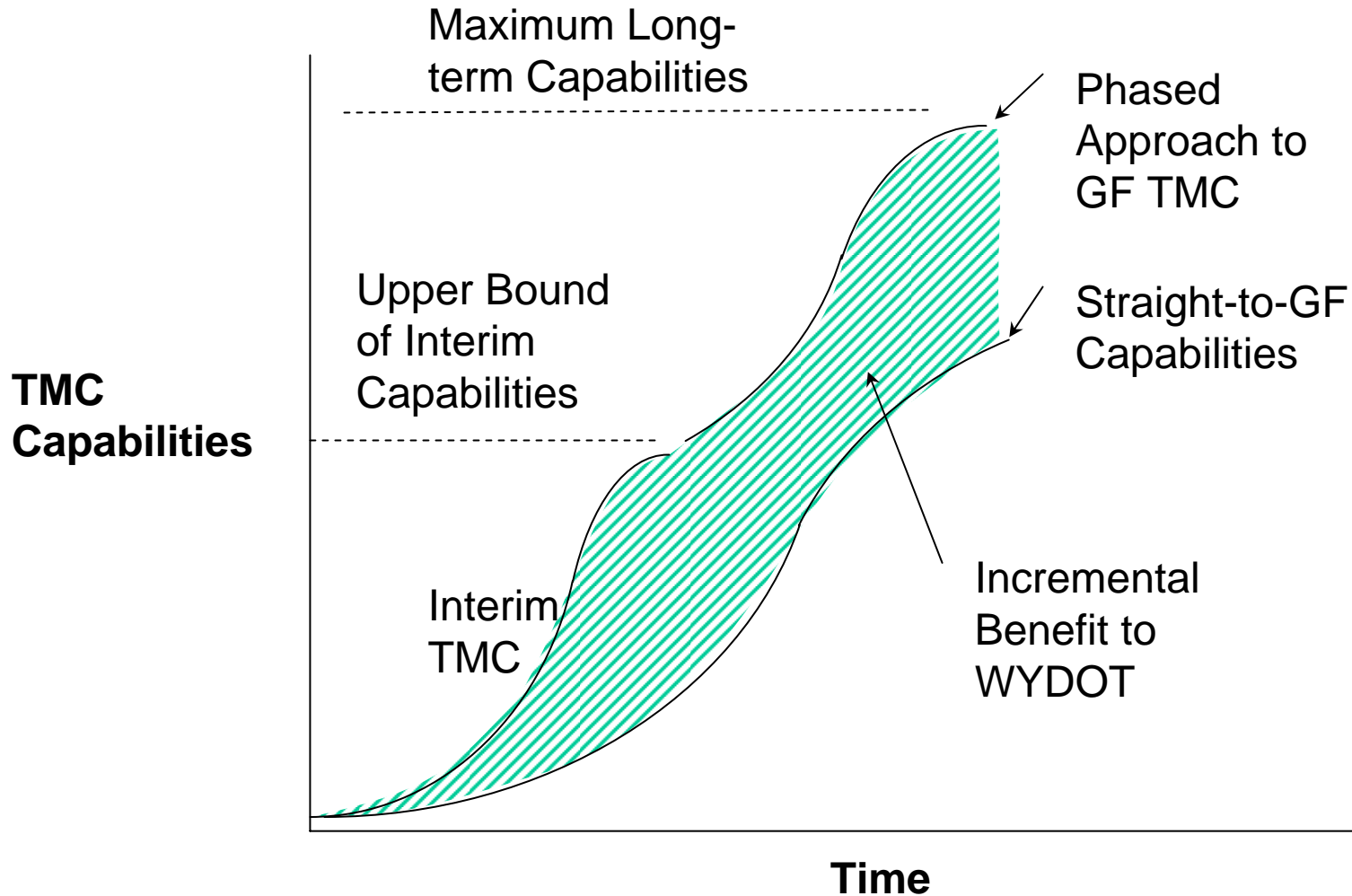
Event Monitoring Overlays

Road Conditions as of 4/28/06 12:00PM

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- Patrol Cars
- VMS Information
- Speed Indicators
- RWIS Information
- Closure Gates

Interim TMC Supports Adaptability

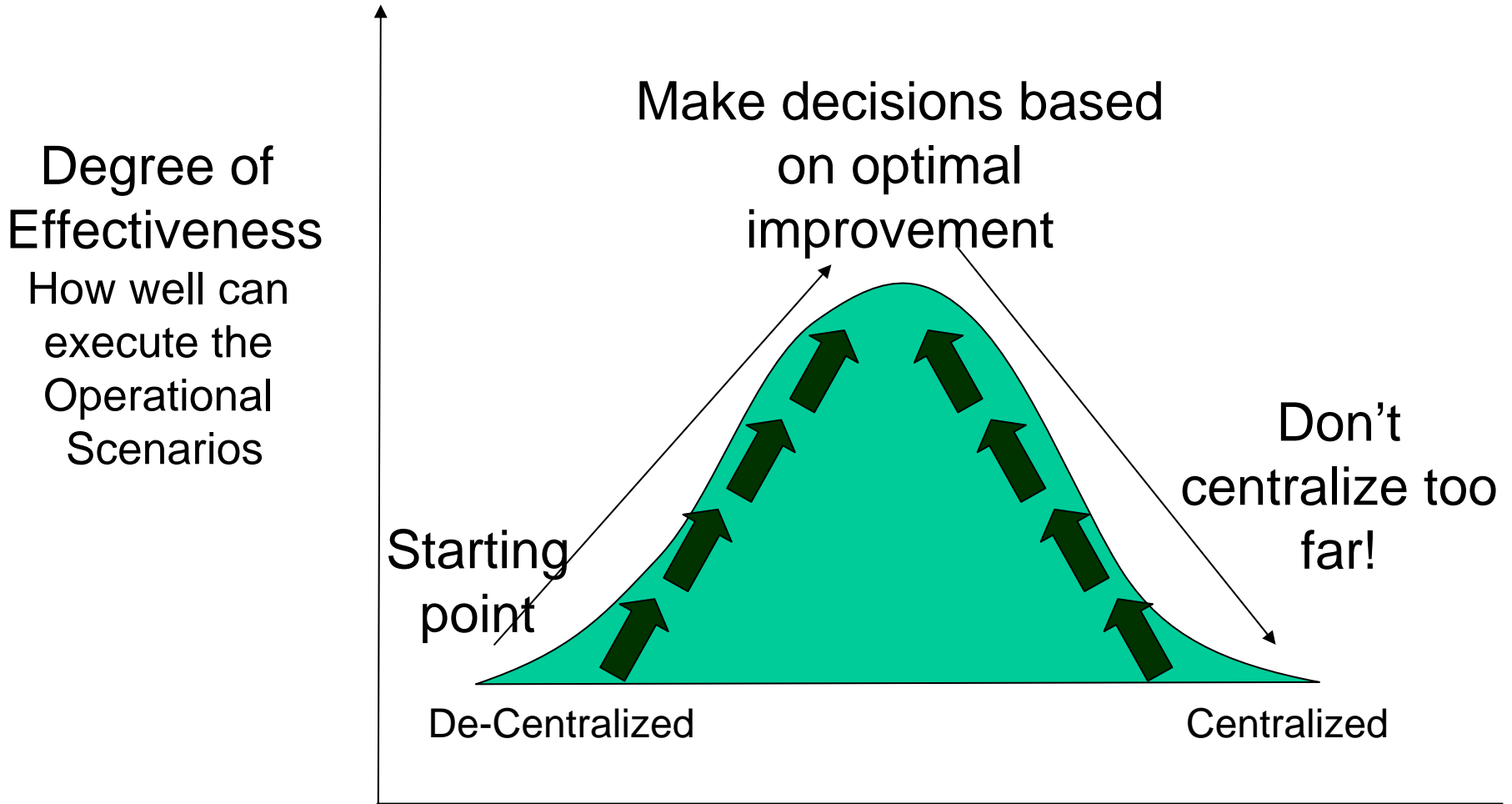


Should Maintenance Dispatch (communication between the operator and the Foreman) be from the TMC?

Criteria	Pros	Cons	Score
Making the right decision(s)	<ul style="list-style-type: none"> • Many decisions don't need "local knowledge" • Foreman can validate view of situation from "on-the-ground" 	<ul style="list-style-type: none"> • Foreman will make decisions on local view (not state-wide) 	
Speed to Action	<ul style="list-style-type: none"> •24-hour operation 	<ul style="list-style-type: none"> •If sequence applied too rigorously can slow things down 	
Certainty / Reliability (implementing action)	<ul style="list-style-type: none"> •Capture data and feed back to DME; will drive improvements •Resilient to system failure •TMC; More disciplined review •TMC as "independent auditor" •TMC consolidates data from multiple sources 	<ul style="list-style-type: none"> •Leaving decision with foreman does not drive to state-wide consistency (e.g. plowing at night) 	
Resource Usage	<ul style="list-style-type: none"> •TMC (with state-wide view) will help improve situation •Helps overcome personal-based local decisions 	<ul style="list-style-type: none"> •Crew pride; doesn't help cross-district coordination 	
Cause Resolved (fix problem)	<ul style="list-style-type: none"> •Better balanced use of resources •TMC has possibilities to apply protocol (escalate/work-around) 		

Sequence of events: A) Issue on road, B) call comes to TMC or TMC observes through ITS, C) TMC calls foreman, D) foreman decides if/who to respond, E) TMC coordinates with drivers

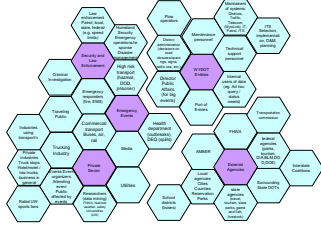
WYDOT Effectiveness – Central or De-Central



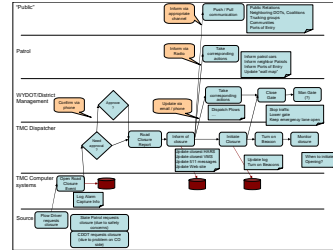
Roadmap to Requirements

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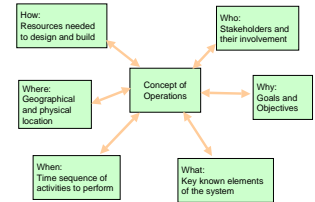
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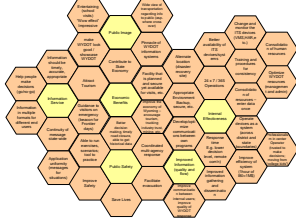


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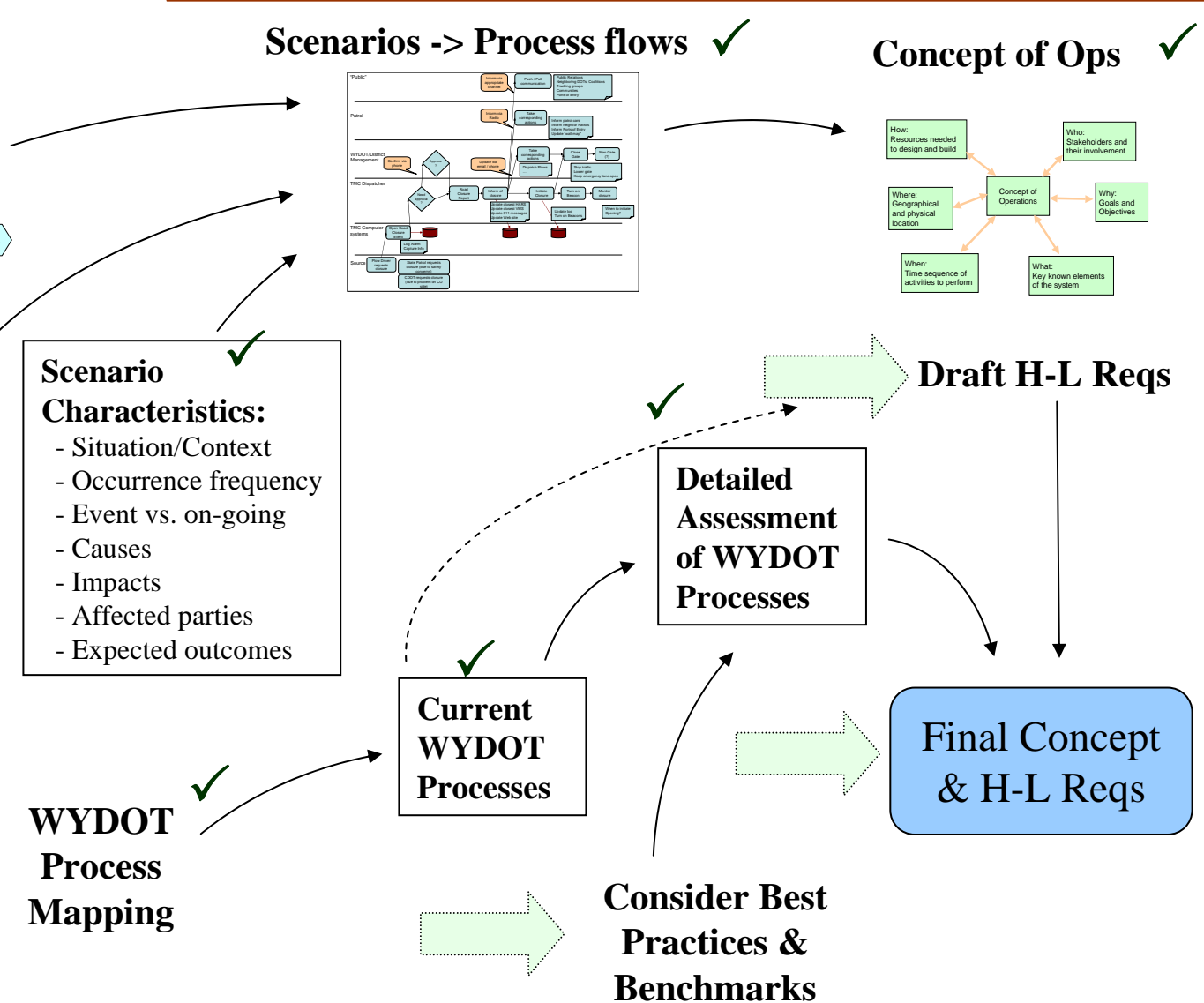
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Detailed Assessment of WYDOT Processes

Consider Best Practices & Benchmarks

Draft H-L Reqs

Final Concept & H-L Reqs



Best Practices

Who

- Arizona – Phoenix and rural (entire state)
- Minnesota – Twin Cities and some rural
- Nevada – Los Vegas; rural in future
- New Mexico – Urban and some rural
- Utah – Salt Lake City; rural (new; entire state)

Best Practices

Observations

- All are in their second (even third) “incarnation”
- Coverage: ITS ops, patrol dispatch, traffic ops, maintenance dispatch
- 24x7 operation
 - Though not all functions; but on call
- Most have an active supervisory (or advisory) body
- Professional level (e.g. traffic technician)
 - Mechanisms to make pay adequate
- Significant investment for integrated software application (no COTS for Rural TMC)
- Weather forecasting (**esp. winter**) is important function
- TMC takes incoming road/traffic reports from public
- Public Affairs is tightly linked, not necessarily “in” the TMC

Best Practices

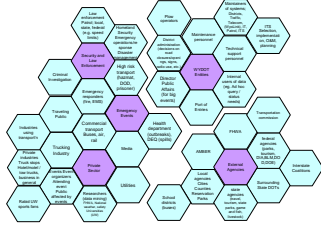
Recommendations

- Make sure have full stakeholder buy-in from start
- Make sure patrol dispatch and others can interact
Organization barriers break down over time
- Leave enough space for growth
 - Both the Operations Floor and overall facility
- Have measures in place from beginning
- Define requirements for software based on real needs (as vendors will push what they have)

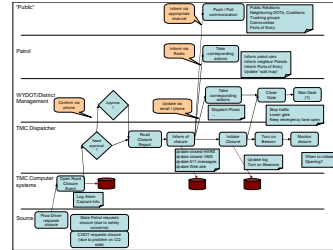
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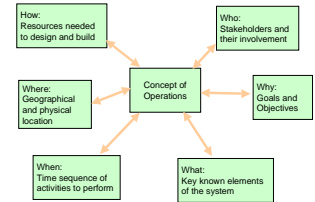
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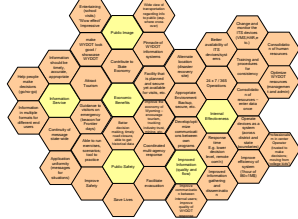


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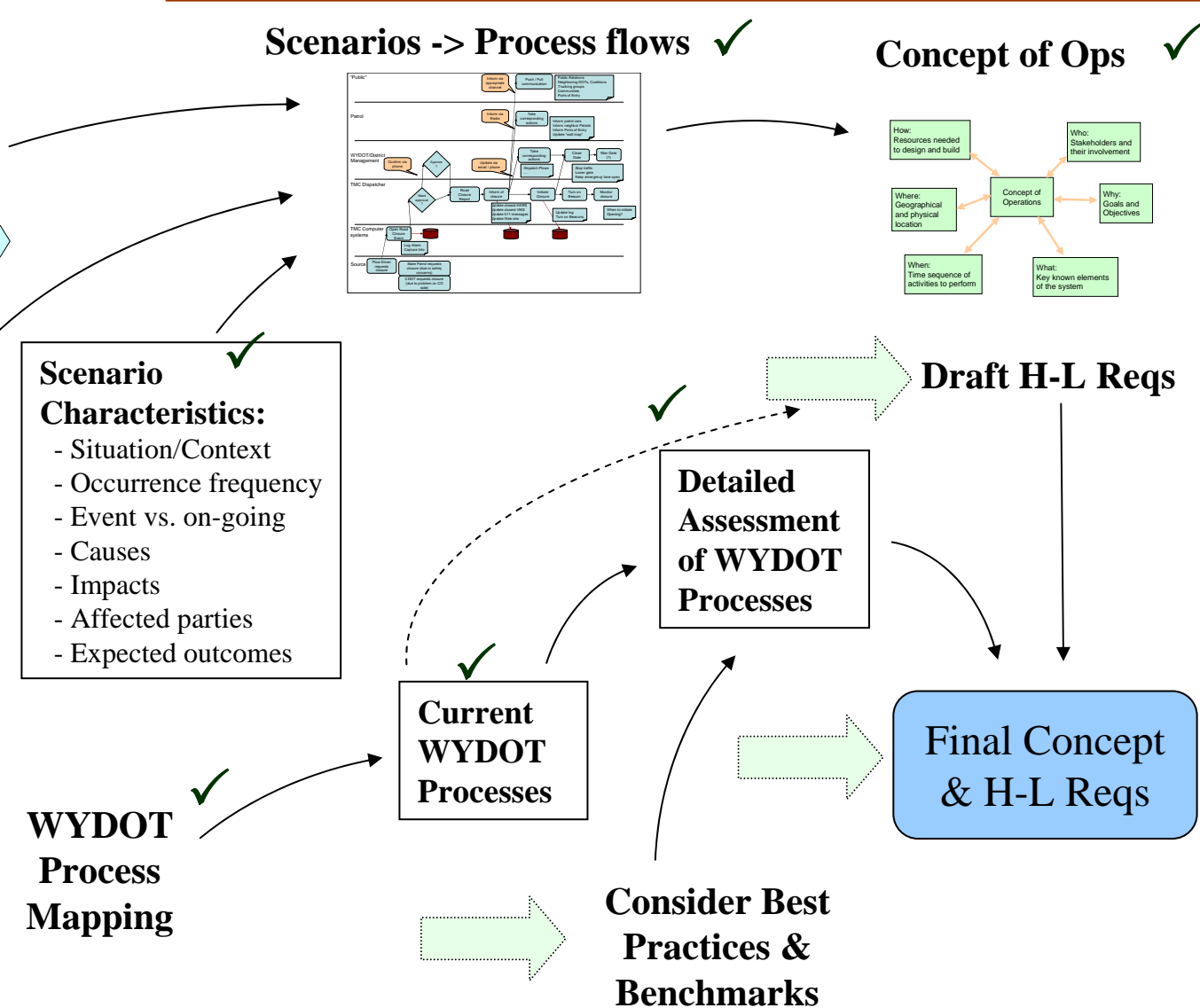
Current WYDOT Processes

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Final Concept & H-L Reqs



Function / Scenario Mapping

TMC Functions	Monitor Devices	Monitor Weather	Control Devices	Info Out	Traffic Ops	Data Logging	Public Affairs	Maintenance Dispatch	Patrol Dispatch
Scenarios									
Incident Management	✓	✓	✓	✓	✓	✓	✓	✓	✓
Abnormal Conditions	✓	✓	✓	✓	✓	✓			
Roadway status change	✓	✓	✓	✓		✓	✓	✓	✓
High Risk locations		✓	✓	✓		✓	✓		
Planned or anticipated activities or conditions	✓	✓	✓	✓	✓	✓	✓	✓	✓
Reactive Maintenance	✓		✓	✓		✓		✓	✓
Ongoing / Preventive Maintenance					✓	✓			
Emergency Operations	✓	✓	✓	✓	✓	✓	✓	✓	✓
Surveillance of key areas	✓		✓	✓		✓			
Disaster Recovery	✓					✓			
Quality Information Dissemination	✓	✓		✓		✓	✓	✓	✓
Data collection and archival	✓	✓	✓	✓	✓	✓		✓	✓
Enhancing system capability					✓	✓	✓	✓	✓

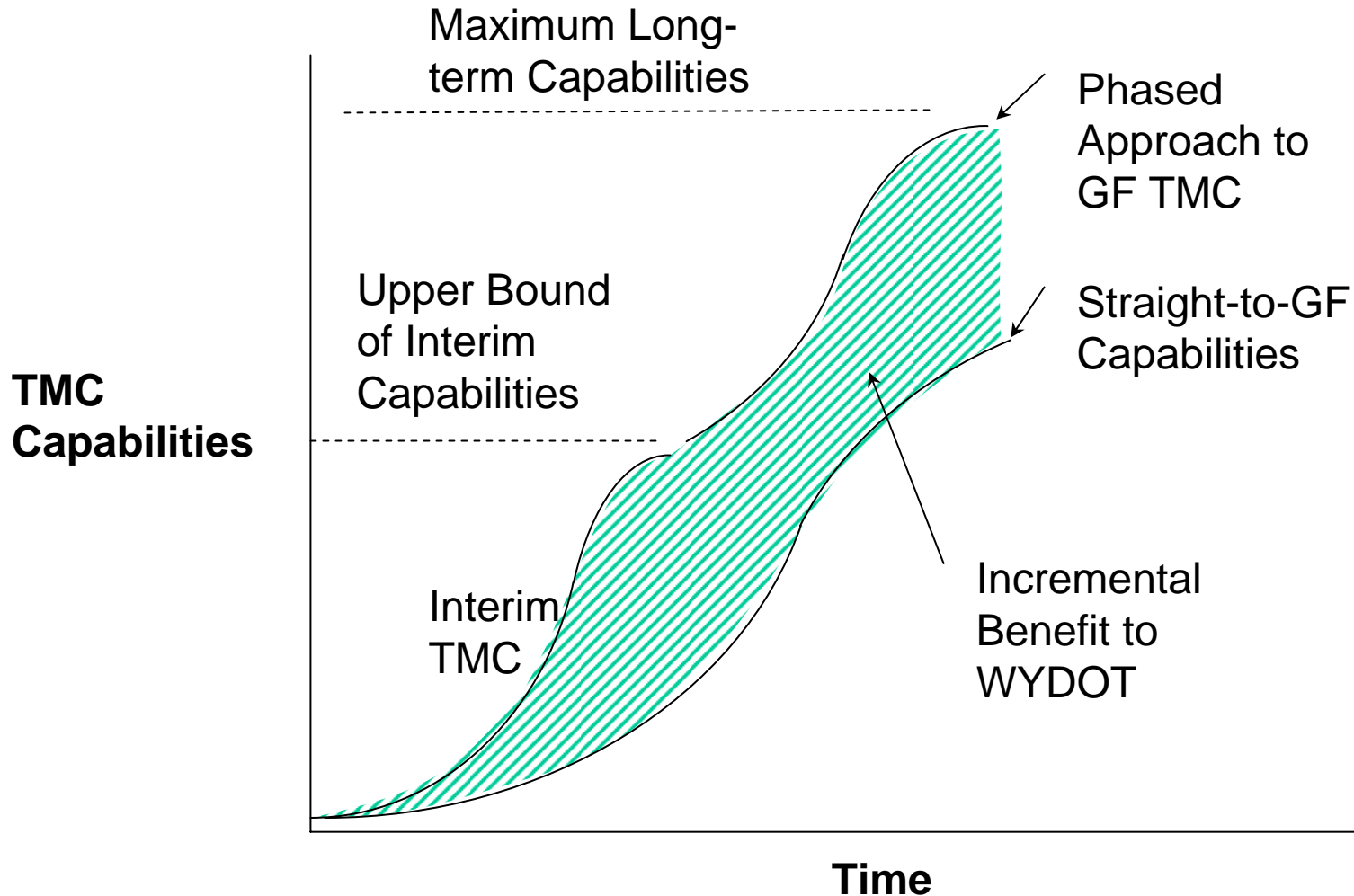
Types of Requirements

- Functional ➤ *Operational Scenarios*
- Integration ➤ *With other (existing) applications*
- Capacity ➤ *Size of state, department*
- Performance ➤ *Load, response time*
- Reliability ➤ *Up-time needs*
- Usability ➤ *Operators, supervisors*
- Adaptability ➤ *Anticipate future needs*
- Scalability ➤ *Hardware/Software review*
- Expandability ➤ *Architecture review*
- Supportability ➤ *Enhancements, maintain*
- Security ➤ *Regulations, department*

Requirements Document

- High Level
- Global Coverage
- Qualified Requirement
- Represents Conceptual Design
- Covering all areas...
- Overall System
- Integration
- Facility
- Organization
- Process
- Communication
- Software
- Hardware
- Documentation
- Training

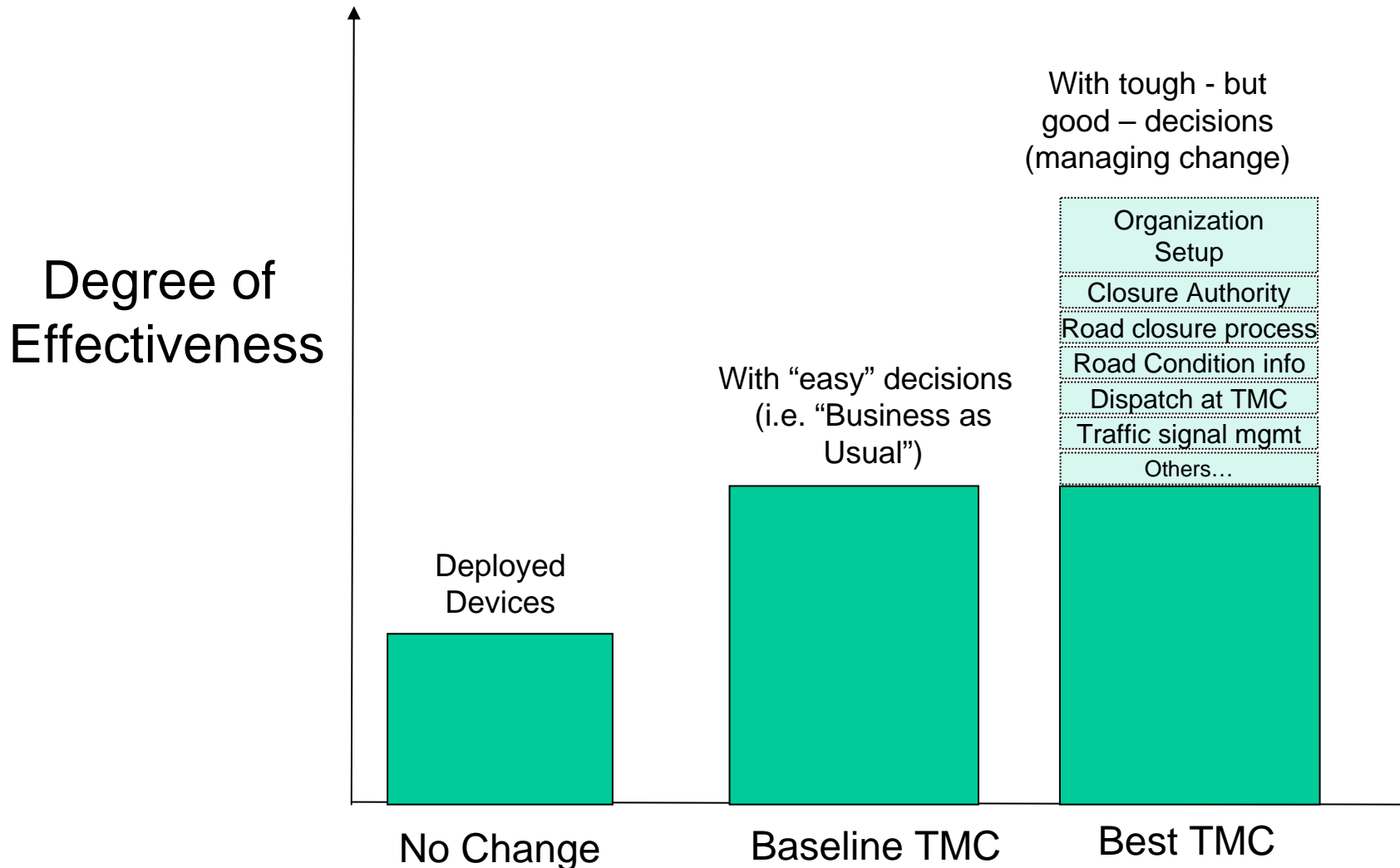
Interim TMC Supports Adaptability



Organizational Evolution

- Based on Assumptions
 - Skills / Professionalism; part-time college to career
 - Travel information; web hit counts to satisfaction measures
 - Focus; road segment to corridor / district-centric to state-wide
 - Info to public; what's available to decision support
 - Protocol; local to global
 - Historical Data; disparate logs (paper) to consolidated database
 - Data access; “sneakernet” to secure on-line queries
- Based on Decision to make
 - Safety improvements; “deploy” to deploy and measure results
 - Efficiency; local to global
 - Authority; nebulous to crystallized
 - Driving Decisions; anecdotes to hard data
 - Connectedness; collection of devices to integrated system
 - Software; disparate components to integrated architecture
 - Driving Improvement; stove-pipes to cross-program processes

WYDOT Effectiveness with TMC



Interim TMC – Transition to Baseline

- Work out TMC 24x7 approach
- Work out TMC Operators / Patrol Dispatch Synergy
- Staff TMC Operators
- Provide “on-call” lists to TMC
 - District maintenance foremen
 - Perhaps even maintenance personnel
- Handle Construction Emergency Call lists
- Transition DMS/HAR/Beacon management to TMC
 - Define System-wide DMS/HAR/Beacon approach
- Transition Wyo Road Report (Web + 511) process to TMC
 - Including 10-13 calls in to TMC
- Transition after-hours dispatch to TMC
- Transition District 4 dispatch to TMC
- Tracking Maintenance Vehicle Location by TMC
 - Pending AVL
- Virtual TMC for District Staff
 - Getting road/weather/traffic information to District Staff desks / fingertips
- Transition to electronic logging
- TMC *overall* ownership of ITS Maintenance

Timeline: ~ Apr 2007

TMC – Transition to Best

- Implement “No Report” discipline; expire *old* reports
- Add Event Manager(s)
- Incident Management Plan
- Deploy Road/Traffic Report “Hotline”
- Transition TMC into Corridor organizations
 - I-80, I-25, I-90
- Corridor-based Closure Plans; cross-district, cross-state
 - Alternate Routes
 - Estimate Duration (at least internally)
- Corridor-based Re-Open Plans
 - Coordinate with neighbor states
- Emergency Operations Plan
- High Quality Information to Stakeholders
- Implement Performance Measures for TMC (and WYDOT)
- Implement *Continuous Improvement* processes

Timeline: ~ Sep 2007

TMC – Transition to Ultimate

- Apply Lessons Learned
 - Software, Facility, Processes
- Better Adapted Facility
 - Fully secure
 - More effective Video Wall
 - More secure Data Center
- Improved facility layout
 - Address additional needs
 - Better use / allocation of space
 - Improved interactions within TMC
 - Improved customer satisfaction
 - Public, Media
 - ITS workbench (repair, deploy)
- Integrate with other initiatives
 - Better leverage of Data / Radio communication (e.g. WyoLink)
 - Full AVL (Patrol & Maintenance)
 - Real-time traffic management (e.g. Variable Speed Limits)
 - Integration with MDSS
- Better Integration with rest of WYDOT
 - Traffic, Planning, Sign Shop, Staff
- Comprehensive automated Data Archival and Query

Timeline: Sep 2010

How the TMC Becomes Vital

- Measurable improvements in information to public
 - Wyoming residents, tourists, commercial transportation
 - Timely, consistent, accurate, at decision points
 - Information in form they need, where/when they need
- More effective communication and coordination
 - Patrol Dispatch, Maintenance, Traffic
 - Inter-district, inter-state agencies
 - Inter agency
- Embraced by District personnel
 - Better information for higher efficiency
 - Reduced time to respond / close / open
 - Reduce demands on radio dispatch folks
 - Allows to focus on core activity; maintaining roads
- Appreciated/demanded by the public
 - Improved satisfaction in WYDOT (improvements realized)
 - TMC is highly visible (tip of iceberg)

Significant Accomplishment in 4 Months

- Created a solid cross-program team with common and compelling vision of TMC
 - Inclusive; districts, FHWA, WTA
 - Team platform that will endure – as a Cross-functional TMC
- Future operational processes developed in detail and agreed
 - Road Closure, event management, incident management, congestion management
 - ITS deployment and Maintenance
- Articulated compelling vision and strategy for TMC
 - Interim TMC as stepping stone
 - Full TMC with both vision & solid experience
- Drove consensus on key points, hard decisions
 - Shift of responsibilities to/from districts
 - From points of disparity to points of agreement (scratched the surface)
 - “No report”, info not only from plow drivers
- Drove clarification of interactions, roles and responsibilities (some still pending)
- Developed compelling conceptual prototype (team and districts)
- Developed SPI Performance Measures for TMC
- Enhanced Customer Satisfaction survey for TMC
- ROI - \$20 million worth of TMC functionality for less than \$2 of investment

Concluding Remarks

Thank You for your Attention
&
Enjoy the Rest of the Conference!



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