POTENTIAL FOR AUTOMATION OF ROAD CONDITION REPORTING SERVICES

NATIONAL RURAL ITS CONFERENCE
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POTENTIAL FOR AUTOMATION OF ROAD CONDITION REPORTING SERVICES

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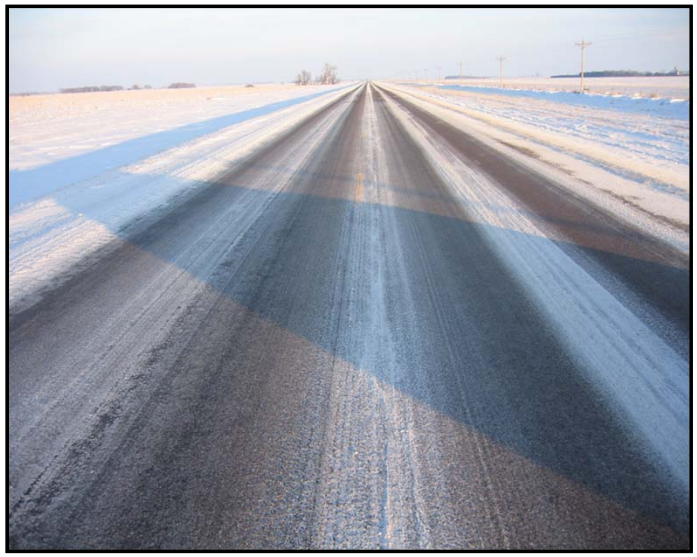
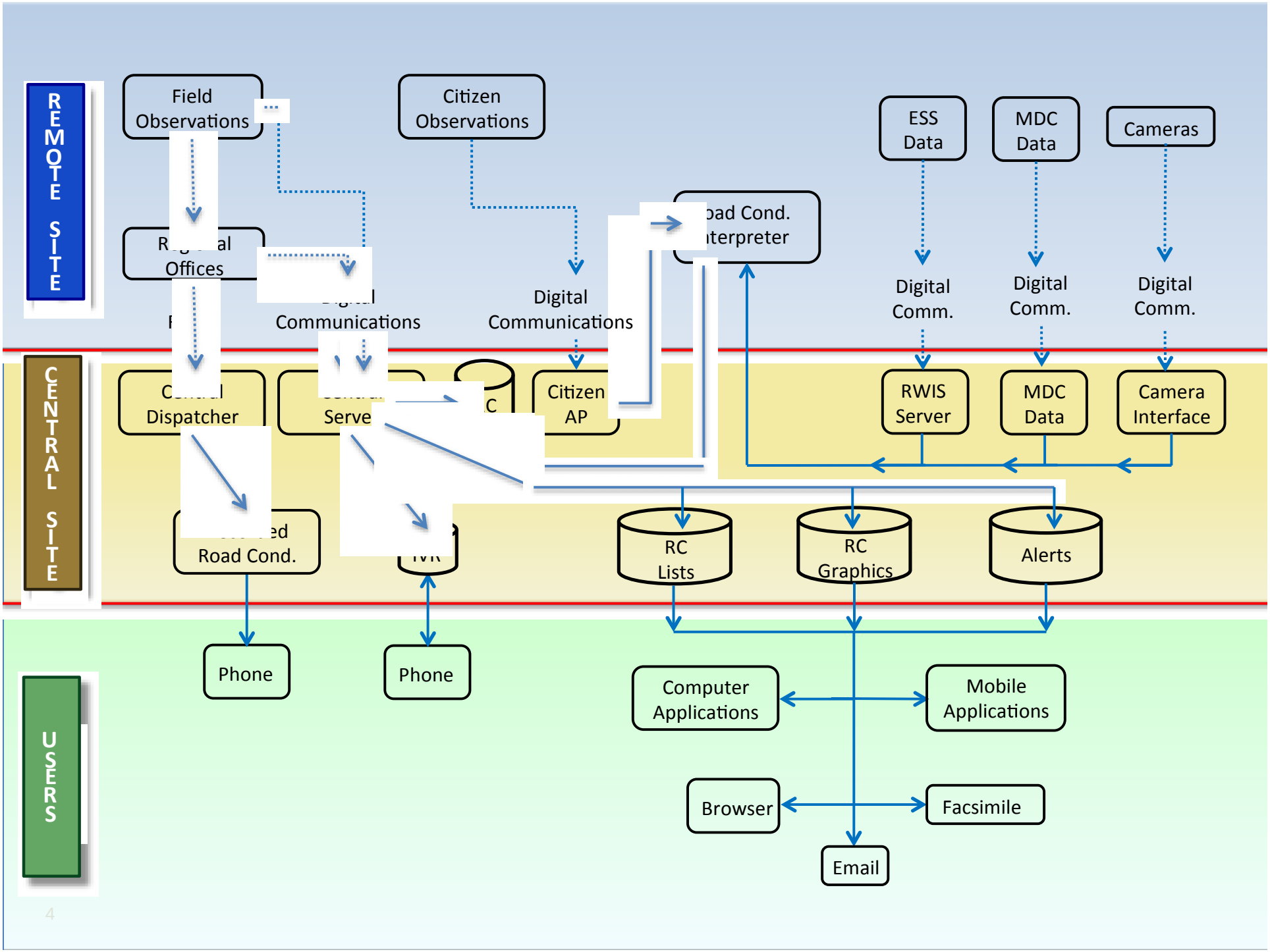
Current Road Condition Reporting Practices

Four basic stages

- Observe field conditions
- Communicate field conditions
- Consolidate observations and transform to digital format
- Generate and disseminate reports




REMOTE SITE
Field Observations
Citizen Observations
ESS Data
MDC Data
Cameras
Offices
Digital Communications
Digital Communications
Digital Comm.
Digital Comm.
Digital Comm.
Dispatcher
Citizen AP
RWIS Server
MDC Data
Camera Interface
CENTRAL SITE
Road Cond.
RC Lists
RC Graphics
Alerts
Phone
Phone
USERS
Computer Applications
Mobile Applications
Browser
Facsimile
Email

Study Objective

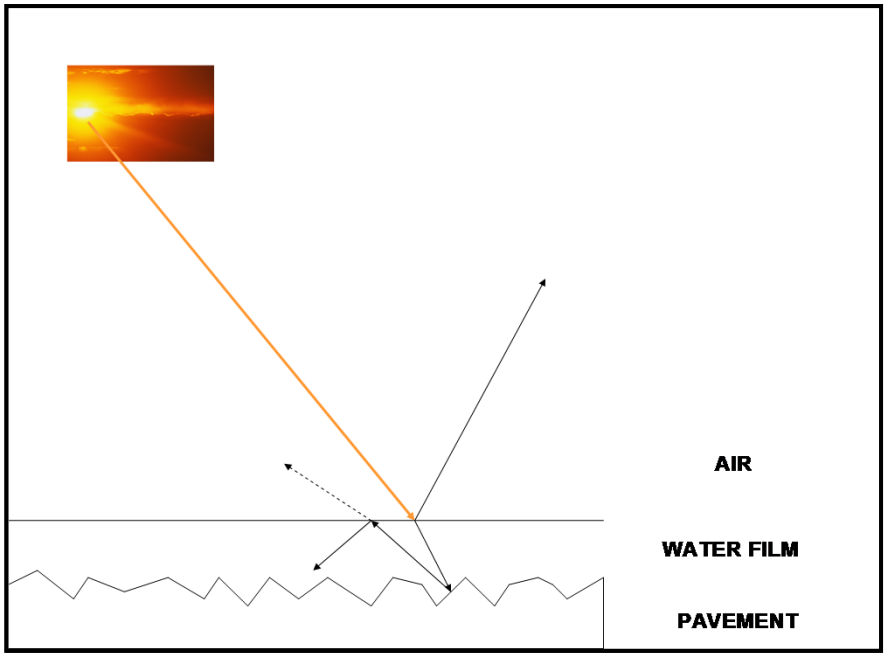
Explore technologies to automate road condition reporting

- Potential approaches
  1. Automate current practices
  2. Use non-contact infrared imagery on mobile platform
  3. Integrate Maintenance Decision Support System techniques
  4. Develop image analysis techniques
  5. Create a decision logic integration of multiple sensors
  6. Develop social networking solutions

Challenge

Duplicate the human ability to integrate multiple sources of information to determine road condition

- Visual appearance
  - Light absorption, reflection, refraction
    - Color changes
    - Spectral reflection patterns
    - Isotropic reflection



Challenge

Duplicate the human ability to integrate multiple sources of information

- Visual appearance
  - Light absorption, reflection, refraction
  - Changes over time
    - Splatter
    - Surface pattern changes
    - Depth irregularities

Challenge

Duplicate the human ability to integrate multiple sources of information

- Visual appearance
  - Light absorption, reflection, refraction
  - Changes over time
- Obstructions to visibility
  - Reductions related to precipitation intensity
  - Fog/mist
  - Blowing snow
  - Smoke/haze

Challenge

Duplicate the human ability to integrate multiple sources of information

- Visual appearance
  - Light absorption, reflection, refraction
  - Changes over time
- Obstructions to visibility
- Sounds
  - Rainfall
  - Sleet/hail

Challenge

Duplicate the human ability to integrate multiple sources of information

- Visual appearance
  - Light absorption, reflection, refraction
  - Changes over time
- Obstructions to visibility
- Sounds
- Sense of feel
  - Impact with body
  - Slipperiness

Challenge

Duplicate the human ability to integrate multiple sources of information

- Visual appearance
  - Light absorption, reflection, refraction
  - Changes over time
- Obstructions to visibility
- Sounds
- Sense of feel
- Odor

Challenge

Duplicate the human ability to integrate multiple sources of information

- Visual appearance
  - Light absorption, reflection, refraction
  - Cha
- Obstru
- Sounds
- Sense of feel
- Odor

IT IS A COMPLEX PROCESS AND A CHALLENGE TO AUTOMATE

Potential/Issues Related to Individual Approaches

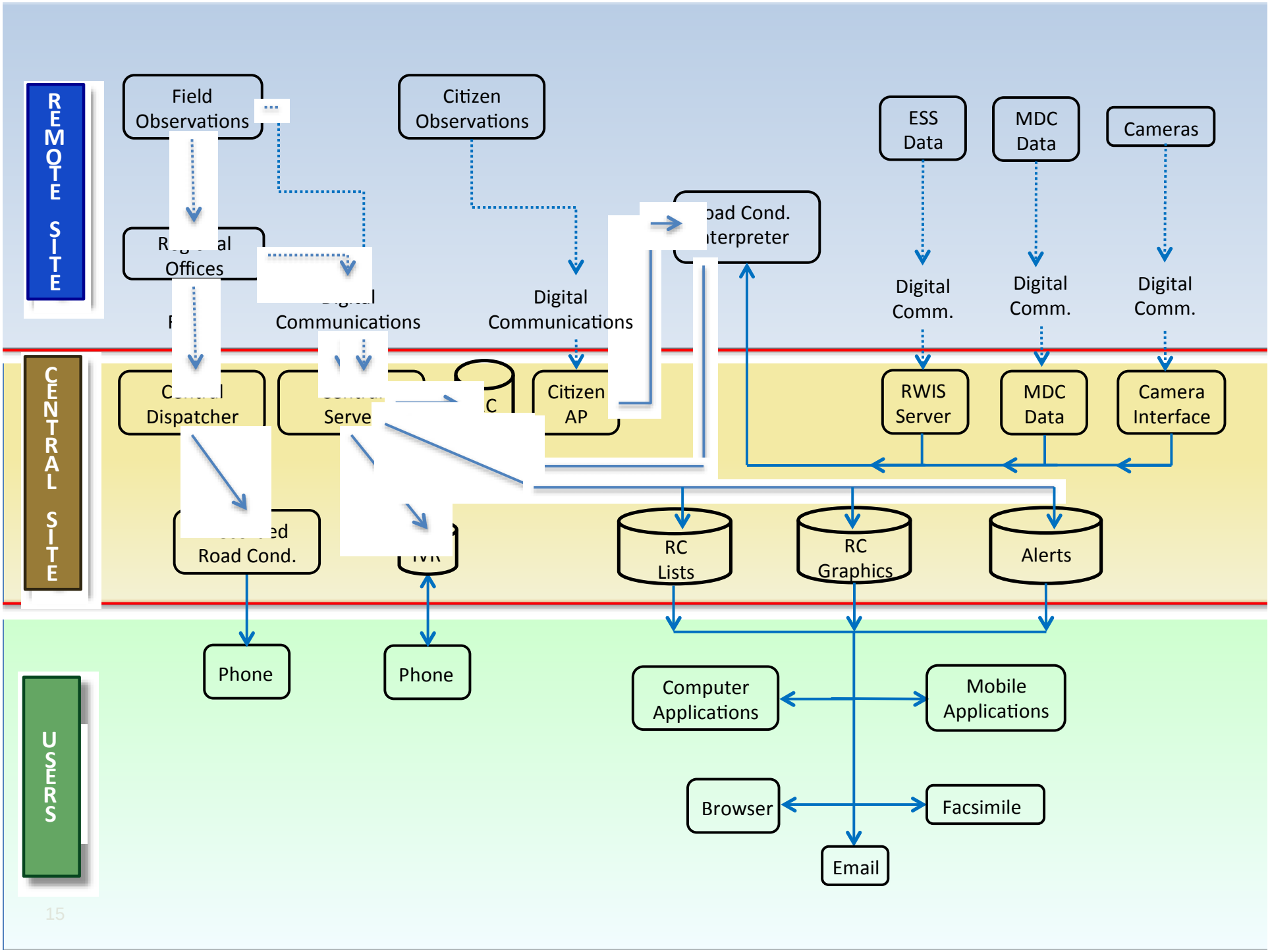
Explore technologies to automate road condition reporting

- **Potential approaches**
  1. **Automate current practices**
  2. **Use non-contact infrared imagery on mobile platform**
  3. **Integrate Maintenance Decision Support System techniques**
  4. **Develop image analysis techniques**
  5. **Create a decision logic integration of multiple sensors**
  6. **Develop social networking solutions**

1. Automate current practices

Possible Enhancements

- In the Field
  - Establish efficient data input technique
    - Preferably a voice recognition system
    - Optionally input via a mobile device ap
  - Utilize improved communications networks
  - Establish direct link to central site
- At the Central site
  - Quality check and confirmation of observation
  - Immediate composition of road condition report for single site
  - Composition of multiple reports into bulletin and dissemination to users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Technology approach 6 -- an option to approach 1

Explore technologies to automate road condition reporting

- **Potential approaches**
  1. Automate current practices
  2. Use non-contact infrared imagery on mobile platform
  3. Integrate Maintenance Decision Support System techniques
  4. Develop image analysis techniques
  5. Create a decision logic integration of multiple sensors
  6. Develop social networking solutions

6. Social networks & Connected Vehicle

Enhancements

- Field
  - Establish efficient data input technique
    - Preferably a voice recognition system (dependent on auto industry)
    - Optionally input via a mobile device ap
  - Connected Vehicle program options
  - Establish direct link to central site
- Central site
  - Quality check and confirmation of observation
  - Integration of non-public sources into automation procedures

2. Mobile non-contact infrared imagery

Technique

- Use mobile platform to measure all or part of these parameters:
  - Thickness of water, snow, and ice components of sfc material
  - Temperature of the road surface or the upper surface of the materials atop the road
  - Air temperature
  - Relative humidity

2. Mobile non-contact infrared imagery

Technique

- Output
  - Road condition
    - Dry
    - Damp
    - Wet
    - Snow
    - Ice
  - Thickness of water, snow, and ice components
  - Grip
  - Air temperature
  - RH
  - Dew point temperature

2. Mobile non-contact infrared imagery

Current capabilities/assets

- Provides mobile assessment of conditions
- Outputs partial set of road conditions
- Correlates components to grip factor
- Provides thickness of water, snow, and ice components for thin film situations
- Outputs pavement temperature and dew point temperature to support guidance on possible frost conditions

2. Mobile non-contact infrared imagery

Limitations

- IR technique cannot discriminate thickness of components
  - When depths exceed a thin film depth
  - When snow layer forms on top of existing materials
- Sensors do not output variable depths common with traffic
- Research indicates:
  - That snow and water depth measurements are marginally accurate
  - The grip values provide irregular levels of accuracy to actual conditions

3. MDSS

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Technique – Estimation or simulation of current conditions

- **Mass flux of materials on and off pavement:**
  - Water, snow, ice, chemicals, abrasives, and water vapor
- **Changes in state of water (water, ice, and vapor)**
- **Movement of snow, water, and slush due to traffic**
- **The effects of applied chemicals on the phase state of the water and ice components**
- **The temperature flux due to:**
  - Weather conditions
  - Latent heat changes
  - Heat flux from sub pavement materials
  - Heat capacity and flow through pavement

3. MDSS

Input to support simulation model (hourly or less)

- Precipitation type, intensity, & amount
- Air & dew point temperature
- Wind direction & speed
- Solar radiation flux & net radiation balance (or cloud cover to compute)
- Time of plowing
- Material application time, type & rate
- Surface character of surrounding snow
- Depth of snow in fields surrounding highway
- Traffic volume, speed, and type of vehicle

Output

- Road condition specified in detailed classes
- Mass (depth) of water, snow, ice
- Percent ice and pavement temperature

3. MDSS

Critical input parameters - typically

- Precipitation type, intensity, & amount
- Solar radiation flux & net radiation balance (or cloud cover to compute)
- Time of plowing
- Material application time, type & rate

Critical input parameters – blowing snow

- Surface character of surrounding snow
- Depth of snow in fields surrounding highway
- Wind direction and speed

3. MDSS

Issues

- Route segment specific precipitation info extremely important but there are limited tools to provide good values
- Solar & net radiation must be estimated
- MDC/AVL is source of maintenance activity and a critical piece of info
  - MDC/AVL is not a mature program and not available in many locations
  - MDC/AVL is unreliable for a number of reasons

Result

- Simulation model has significant input deficiencies and accuracy limitations

Impact

- Considerable improvement is needed in input resources before road conditions can be simulated accurately

4. Image Analysis

Approach

- Create an image processing technique that can analyze fixed images to determine road condition
- Develop algorithms or logic that uses the visual cues discussed earlier to determine road and weather condition classifications
- Perform this analysis continually in time steps and integrate the results from the time steps into an aggregate determination of road conditions for a specified period of time

Status

- Image analysis techniques exist; the logic to determine road conditions does not
- Development cost may be a barrier

5. Multiple Sensor Aggregation

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Issue

- Human assessment of road condition uses many factors
- Current RWIS sensors measure one or or possibly two parameters
- Field or onboard controllers integrate sensor combinations
- No combination has been effective at duplicating the ability of human observation

Approach

- Evaluate procedures to combine existing sensors to provide more exacting assessment of road conditions
- Vendors are evaluating/developing new solutions

Conclusions and Recommendations

- End-to-end automation of current reporting system
  - Add Interactive Voice Recommendation in maintenance vehicles
  - Create a direct communication interface to central system
  - Establish data transfer design to assure data can move efficiently from field to the user
- Develop a camera system and network to automatically evaluate road conditions
  - Develop an image analysis system
  - Establish a network of new or existing cameras as source of road cond info
- Implement a non-contact sensor network to assist road cond reports
  - Network may use stationary or mobile sensing devices
  - Improve the performance of non-contact sensors to work in all conditions
  - Integrate other observations to improve quality of road cond classes

Conclusions and Recommendations

- **MDSS**
  - Will require maturation of MDC/AVL capabilities
  - Will require improvement in ability to determine precipitation accurately at all locations
  - Requires improvement in estimates of key weather parameters at route level
- **Multiple sensor solutions**
  - Partial combinations exist but their output is incomplete for road conditions
  - Research is needed to determine more robust solutions
- **Social networking / Connected Vehicle**
  - Connected vehicle has tremendous promise but needs much development
  - Social networking has potential but will require development of data assimilation process and quality control techniques
  - Legal considerations with non-government sources will need resolution

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