
NWS S&T Roadmap
Fire Weather Team

NWS Science and Technology Roadmap

Fire Weather

Team Composition

- Peter Roohr, NWS/OST - Team Leader
- Doug Hilderbrand, NWS/OST - Contributor
- Sher Schranz, OAR (ESRL) – Contributor (Boulder)
- Heath Hockenberry, NWS/OCWWS - Fire Weather Program Manager (Boise ID, NIFC)
- Eli Jacks, NWS/OCWWS - Contributor
- Geoff DiMego, NWS/EMC/MMB - Contributor
- Jeff McQueen, NWS/EMC/MMB - Contributor
- John Gaynor, OAR - Contributor

Vision/Outputs/Impacts

- **Team Vision:**
  - High-resolution fire weather information and services, in close collaboration with agency partners, focused on providing impact-oriented, integrated improvements of fire danger and behavior predictions that save lives and reduce impact to property
- **Benefits/Outputs:**
  - Improved resolution and accuracy of coupled fire weather/behavior forecasts
  - Improved decision support systems and tools
  - Extended lead time of high threat areas
  - Extension of Red Flag Warning capability to include a Watch/Advisory capability and severity levels
  - Efficient evacuation of threatened communities
  - Reduced risk of escaped prescribed burns
  - Reduced out-of-control acreage burned
  - Improved public safety (evacuations) due to reduced smoke danger in WUI

Vision/Outputs/Impacts

- **Impacts/Outcomes: So what?**
  - Minimize firefighter fatalities due to unpredicted fire behavior. There is a 60:1 benefit on $1M investment for fire weather initiative. NWS can expect to save about 10 to 25 lives per year, taxpayer $140M to $560M based on 10% to 40% improvement in # fires prevented by improved weather data.
  - Cost savings with more efficient use of resources. Just one high-value Wildland-Urban Interface (WUI) subdivision saved because of improved response service and modeling would save nearly 120 million dollars in property loss.
  - Reduced time to detection of fires due to lightning to allow better preparation, resource planning
  - Better understanding of growth of existing fires to prevent loss of life and enhance evacuation process
  - Improvement of intra-seasonal forecasts to ensure fire assets are properly deployed well ahead of time (saving millions of dollars in avoiding day-day crisis action)

Goals/Targets:
Customer Needs

Goal	Outstanding Issues/Dependencies
Increased resolution of data with mobile fire scale observing system	Lack of data assimilation in various formats. OSSE's needed to best utilize emerging obs and existing mobile and remote sensing systems.
Execution of very fine scale, coupled modeling techniques to improve fire weather/behavior, and smoke forecasting	Fire scale model improvement and verification difficult without field observing systems. Resolution of discrepancies between fire/weather models.
Deliver timely and relevant forecast services to our land management partners.	Integrated weather and climate data needed for seasonal fire assessment. Forecast data available via web services, gridded forecast dissemination. Debris flow assistance. Visualization tools.
Provide next generation technology and tools for Incident Meteorologist (IMET) and local Weather Forecast Office (WFO) services	Sustaining field forecast systems, equipment, IT/Web services, improving spot forecasts, trusted verification and responding to all levels of Appropriate Management Response (AMR).

Goals/Targets:
Customer Needs

Goal	Outstanding Issues/Dependencies
Fully develop more accurate, high-resolution and longer range Red Flag information, with more refined severity levels for strategic planning purposes	Improved intra-seasonal forecasting and National Integrated Drought Information System (NIDIS) output with current weather and fuels modeling systems from land management agencies.
On-Demand, local, fully trained forecasters on stand-by in high-risk, Red Flag areas	Overall: Need to expand decision support services to reduce response time Provision of robust training resources. Fully funded equipment refresh. Critical Decision Support Services (DSS) staffing and program support.
Consistent and collaborative social science evaluation program for fire weather support	Limited understanding of public reaction to warnings and outlooks. Lack of process to integrate lessons learned. Determine process to analyze % customer satisfaction
Improve integrated collaboration with International partners to spark transition of technology and information for fire weather services	Lack of developed partnership(s) and processes for international research efforts and exchange of technology/data. Need to support programs like Fire Paradox.

Goals/Targets:

Emerging Science & Technology

Goal/Target	Outstanding Issues
Improved observations and measurements to initialize numerical models	Deployable surface and aerial platforms. Improved use of remote sensing tools. Real-time assimilation of data.
Development and execution of high-resolution forecasts of humidity, wind, and precipitation for fire prediction	Significant challenges with modeling weather over complex terrain and WUI. Validation to confirm adequacy.
Successful coupling of weather and fire models	Bridging disparity between resolution of fire and weather models. Integration of thermodynamics, physics over complex terrain and vegetation/soil conditions
Improved capability of IMETs to provide rapid response to incident commanders and emergency managers with fire-scale information	On demand assimilation of local data. Merging of weather with current fire information. Establishing mobile WFO; GIS-centric, intelligent agent system.

Goals/Targets:
Emerging Science & Technology

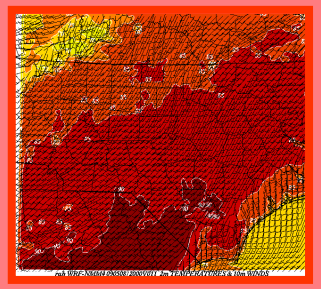
Goal/Target	Outstanding Issues
Improve forecasting of dry lightning and comprehension of atmospheric processes leading to CG lightning (i.e., initiation of convection)	Development of index based on lightning coverage and precipitation chances. Better understanding of ignition potential and what cloud processes lead to CG lightning for high-based thunderstorms.
On demand 90 day Red Flag WWA decision-support system with high resolution Red Flag warning lead times of 24 hours	Incorporation of NCEP models into fire danger reporting modules. Development of GIS-centric platform and training plans.
Reduced time of detection for new and existing fires	Faster detection of fire location and intensity with remote sensing devices. Examination of satellite and high altitude UAS-based technologies.

Key Information Gaps

Larger, Numerous Fires

Large Gaps

Improved Obs/Support



High Res Wx Guidance

Improved DSS Tools and information

Outline

1) Limited observations and measurements near fires
2) Real-time detection of fires
3) Improved high-res model forecast guidance
4) Fine-scale coupled model (sub 1-km, hourly)
5) Improved Red Flad ID, lead time, indexing
6) No coupled smoke behavior prediction less than 4 km res
7) Intra-seasonal prediction of fires
8) IMET capability improvements (training, customer interface)
9) Tool for debris flow prediction
10) Social science evaluation

Key Information Gaps

Gap	Solution Alternative	Impact
1. Limited observations and measurements in vicinity of fires	1.1 Deployable Sfc Remote Automatic Weather Station 1.2 UAS (Unmanned Aerial Sys) 1.3 GPS Met 1.4 Sounders/profilers (ground)	1.1 Fire-scale coverage (sfc) 1.2 3-D coverage of atmosphere in area of fire 1.3 Analysis of water content and winds from dropwinsondes 1.4 3-D coverage of atmospheric winds and temperature near fire
2. Faster detection and tracking of new and existing fires	2.1 Satellite sensors like MODIS and VIIRS 2.2 Geostationary satellite rapid scan observations 2.3 High altitude UAS 2.4 Airborne sensors (e.g., Firemapper) 2.5 Dry lightning forecast capability	2.1 Analyze fire radiative power and determine fire intensity 2.2 Improved, timely detection of fires with combination of various wavelength channels 2.3 Tracking and detection of fires on consistent basis for 1 week or more from > 60 kft 2.4 Tactical location of firelines and spot fires thru smoke, ash 2.5 More exact location of lightning-induced fires

Key Information Gaps

Gap	Solution Alternative	Impact
3. Improved high-resolution model guidance (includes lack of probabilistic skill)	3.1 Assimilation of regional and special fire weather observations with solutions like GSI and RTMA (MADIS: ingest, dissemination) 3.2 Conduct case studies to validate impact to coupled models (ref Gap 4, 6, 9) 3.3 Ensembling approach 3.4 Robust joint probabilistic forecasting	3.1 On demand real-time situational awareness. Validation of model performance. High res input to models 3.2 Validation of model performance 3.3 Decrease effect of biases from single models. Quantify uncertainty. 3.4 Vast improvement in forecasting interaction of fire weather with fire behaviors
4. Fine-scale, coupled model to provide sub 1-km forecast information (High Resolution Fire System, HRFS)	4.1 Development and execution of high-res coupled model for fire behavior 4.2 Conduct case studies to understand fire-atmosphere interaction 4.3 Establish test beds 4.4 Incorporate fire-scale terrain & vegetative parameterization	4.1 On demand real-time situational awareness. Validation of model performance. Communication of uncertainty. 4.2 More precise prediction of weather on fire at small scales. 4.3 Validate performance of models in controlled situations 4.4 Integrates effects of fuel and complex terrain

Key Information Gaps

Gap	Solution Alternative	Impact
5. Improved Red Flag WWA area identification, lead time and fire potential index	5.1 Utilize NCEP forecast output in gridded detail (include ensemble models) 5.2 Develop GIS platform for users to customize maps 5.3 Develop/validate technology to pinpoint areas of fire danger	5.1 Meets different spatial needs of all fire fighters (strategy) 5.2 Suits immediate spatial and temporal needs of customer 5.3 Narrows down the exact area(s) of fire danger within broad region
6. No coupled smoke behavior prediction model with < 4 km res.	6.1 Develop high-resolution model that rapidly predicts smoke propagation and behavior	6.1 Real-time prevention of accidents due to on demand smoke propagation runs. Helps route evacuation efforts.
7. Intra-seasonal prediction of fires	7.1 Develop, via probabilistic and other means, a sophisticated long-range outlook tool (up to 90 days)	7.1 Agencies involved in firefighting will have valuable strategic tool that enables emplacement of resources in most vulnerable areas

Key Information Gaps

Gap	Solution Alternative	Impact
8. Insufficient DSS tools. IMET capabilities must improve to match demands of growing requirement of incident response.	8.1 Develop a system to merge weather and fire behavior information 8.2 Create multi-tiered IMET response capability to ensure incident information needs are met. 8.3 Ensure technology meets deployment (S/W and H/W) 8.4 Develop validation process	8.1 Provides incident commander with accurate picture of weather impacts 8.2 Meets customer timing need 8.3 IMET forecaster has tools needed to support operations, including an "intelligent assistant" 8.4 Refines models based on forecast errors
9. Tool that accurately depicts debris flow for recently burned areas	9.1 Develop thresholds for rainfall rates and totals for public warning of debris flows	9.1 Timely warnings of flash-flood induced debris flow that can damage infrastructure and kill people
10. Social science evaluation	10.1 Develop methods and processes to evaluate customer usage and reaction to fire weather information	10.1 Improved knowledge of customer requirements and where to concentrate influx of new technology/policies

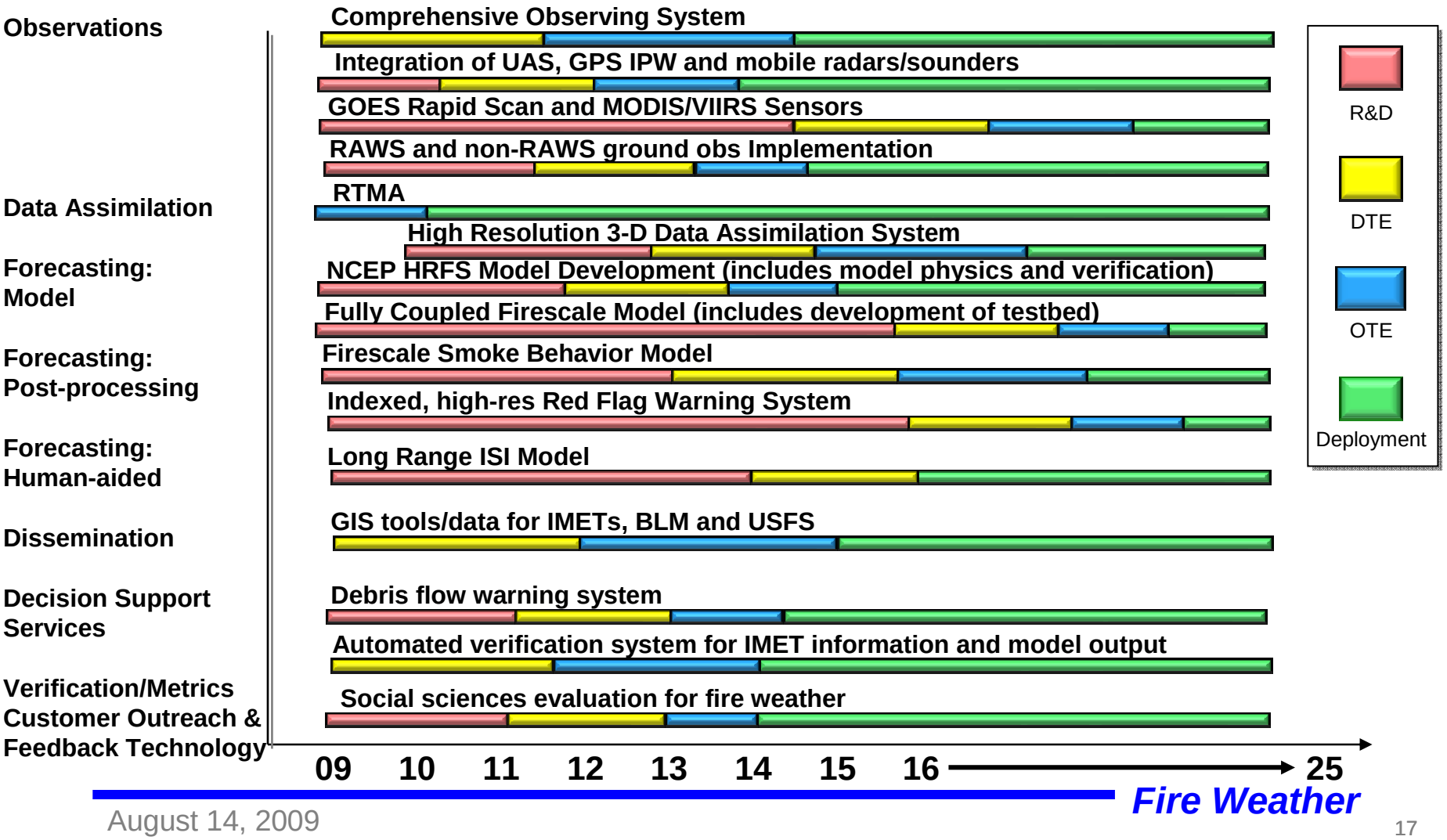
Enabling Capability/Information Linkage Issues

1. Meteorological models performance
2. Integrated observations
3. Data assimilation methods and infrastructure
4. Air quality (critical for long-term fires)
5. Forecasting: Human-aided (intelligent agents)
6. DSS 1-2 and DSS 3-5
7. Verification and Metrics
8. Customer outreach & feedback technology
9. Dissemination
10. Interagency links (USFS, BLM, NIST, USGS, etc.)

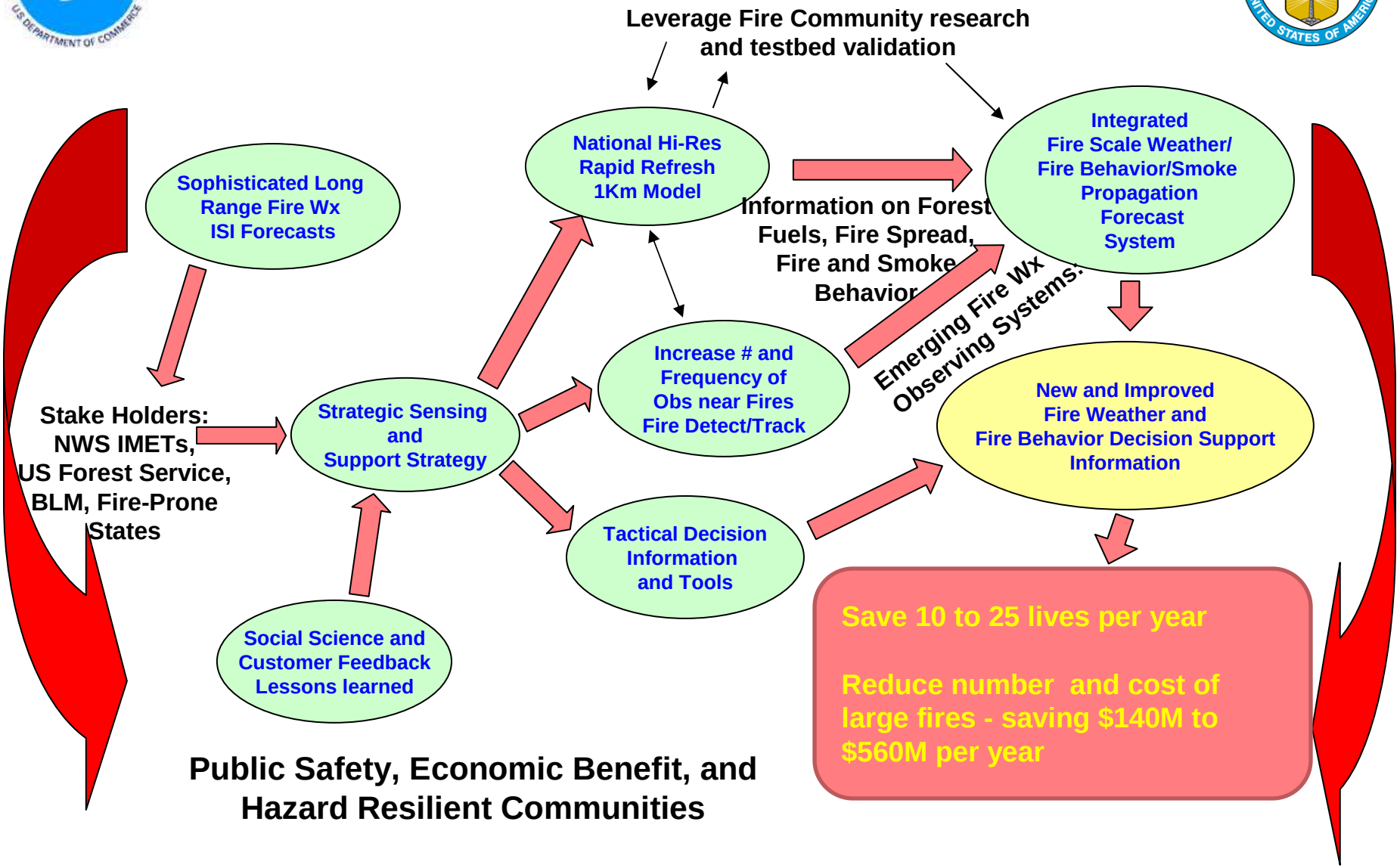
Research Needs and Opportunities

- **Short-term**
  - Fire-scale/dynamic/relocatable fire weather prediction model
  - UAS to identify potential, large-scale prescribed burn dates and times (challenge to get sensors on smaller UAS)
  - Validate/verify ingest of RAWS, GPS-Met data into MADIS
  - Faster detection/tracking of new and existing fires
  - Dry lightning potential
  - Debris flow hazard assessment and precipitation forecasting
  - Full scale analysis of social sciences for fire weather
- **Long-term**
  - On-demand, indexed Red Flag WWA decision-support system
  - Fully coupled weather and fire dynamics with links to smoke prediction at localized time and spatial scales
  - On-demand, 15-minute, fully coupled fire weather/behavior model at 10s meters

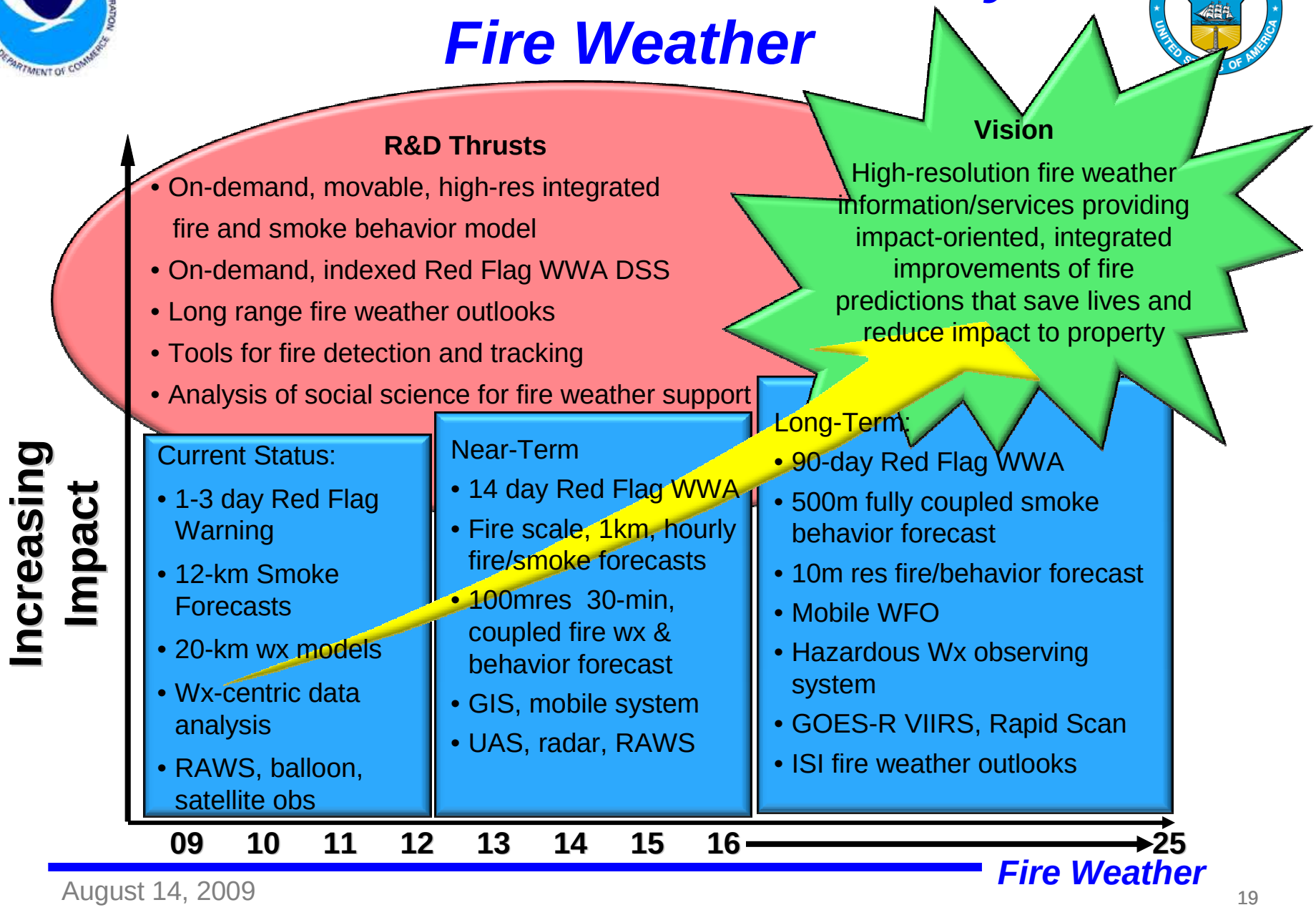
Fire Weather
Alternative Solutions



End-to-End Process



Focus Area Team Summary: Fire Weather



Performance Measures: Fire Weather

Proposed	Current (2009)	FY 2016 Target Example	FY 2025 Target Example
IMET Response to Incidents	24 hours	22 hours	18 hours
IMET Response to EOCs	24 hours	12 hours	8 hours
Fully Trained IMETs/NOAA Response to All Hazard Incidents	77/60%	234/100%	234/100%
Forecast Period (Temperature/Winds/RH) (days)	5/2/2	14/14/14	21/21/21
Accuracy for winds/moisture measurements	+/- 5% and +/- 2%	+/- 2.5% and +/- 1%	+/- 2% and +/- 1%
Red Flag Warning Forecast	3 days	14 days	90 days
Red Flag Probability of Detection	87 %	91%	95%
Red Flag Lead Time	9.9 hours	10 hours	24 hours
Red Flag Resolution	County scale	Town scale	Indexed, 5 km
Fire Weather Model (Guidance)	4 km/1-2 x daily	0.5 km/hourly/nested	
Smoke Prediction (spatial/temporal resolution)	12 km/daily	1 km/4 x daily	0.5 km/hourly
Fully Coupled Fire and Weather Model (spatial/temporal)	Not available	0.75 m/30 min	10 m/15 min
Flash Floods and Debris Flow (Watch/Warning LT)	24 hr/12 hr	48 hr/24 hr	5 days/48 hr
Number of houses destroyed in WUI		5% decreases	20% decrease