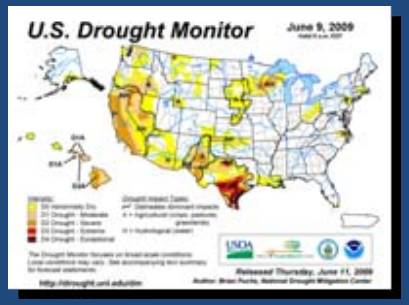
NWS SCIENCE AND TECHNOLOGY ROADMAP

Preparing for Tomorrow… Today



NWS S&T Roadmap and Goals for 2025: Beacon for Research Needs

(v1.1 *under review, debate, coordination*)

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Office of Science & Technology
National Weather Service
October 14, 2009

Outline

- **S&T Roadmap: Preparing NWS for 2025**
  - *Roadmap Schedule, Milestones and Status*
  - *Strategic S&T Themes*
  - *Framework for R2O/O2R*
- **NWS S&T Needs and OAR Research Alignment**
  - *NWS Roadmap Identified S&T Needs/Opportunities*
  - *Current NWS-OAR Alignment*
  - *Future OAR-NWS S&T alignment*
  - *Summary of Alignment*
- **The way forward: Getting to Green**

Roadmap
Schedule, Milestones, and Status

PHASE I	
✓ Establish Framework Team	17 Nov 2008
☑ Framework Brief to Corporate Board	10 Dec 2008
PHASE II	21 Dec 2008zz
✓ Roadmap plenary workshop	3 Feb 2009
✓ Capstone Group completes initial draft	27 Mar 2009
✓ Update for NOAA/NWS leadership	Apr 2009
(Progressive updates)	
⊡ Focus Area Teams complete robust outlines (briefing)	30 Jun 2009
21/22 Completed	
PHASE III	
• Stakeholder input compiled	Oct 2009
• Draft Capstone Document	Nov 2009
⊡ Full Documentation of Focus Area Plans	Nov 2009
21/22 Completed	
❑ All S&T Roadmap documents published	early 2010

Status 10/14

- ✓ Completed
- • In progress
- ❑ Milestone

S&T Roadmap Strategic Themes:
Aligned with NWS Strategic Themes

NWS Strategic Themes (Draft)		S&T Draft Themes for Roadmap
- Maximize use of observations - Integrate, implement next generation data assimilation/ earth system model - Develop and integrate forecast uncertainty information	Science-service Focus Areas	✓Integrated observing and analysis system ✓Integrated environmental modeling: data assimilation, prediction, post-processing (e.g. ensembles)
- Increase accuracy, consistency, and lead-times for high-impact weather - Decision Support Systems		✓Next generation Forecast and Decision Support System
- Improve access and exploitation of environmental data		✓4D Digital Weather Information Database (WIDB) ✓Transforming dissemination/communication/ outreach capabilities
- Maximize the value of environmental information		✓Incorporating social sciences strategies in research and operations
Accelerate transition of applications from research to operations		

S&T Roadmap Strategic Themes:
Integrated Observation/Analysis System

Current

Individual Systems
- Public
- Private
- Universities

Radar
Satellite
Surface; in-Situ
Upper Air
Etc

Analysis

Inventory systems, and metadata standards

Assess interdepend-encies, oversampling, gaps, levels of criticality

Strategies

National Mesonet

Network of networks

Integrated Radar (Lidar, gap-fillers, MPAR)

Global Systems

Multisensor platforms

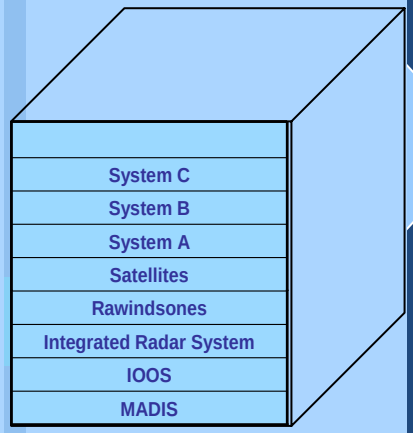
Optimization with OSEs, OSSEs

Standards, Architectures, Protocols

Maximize value of investment

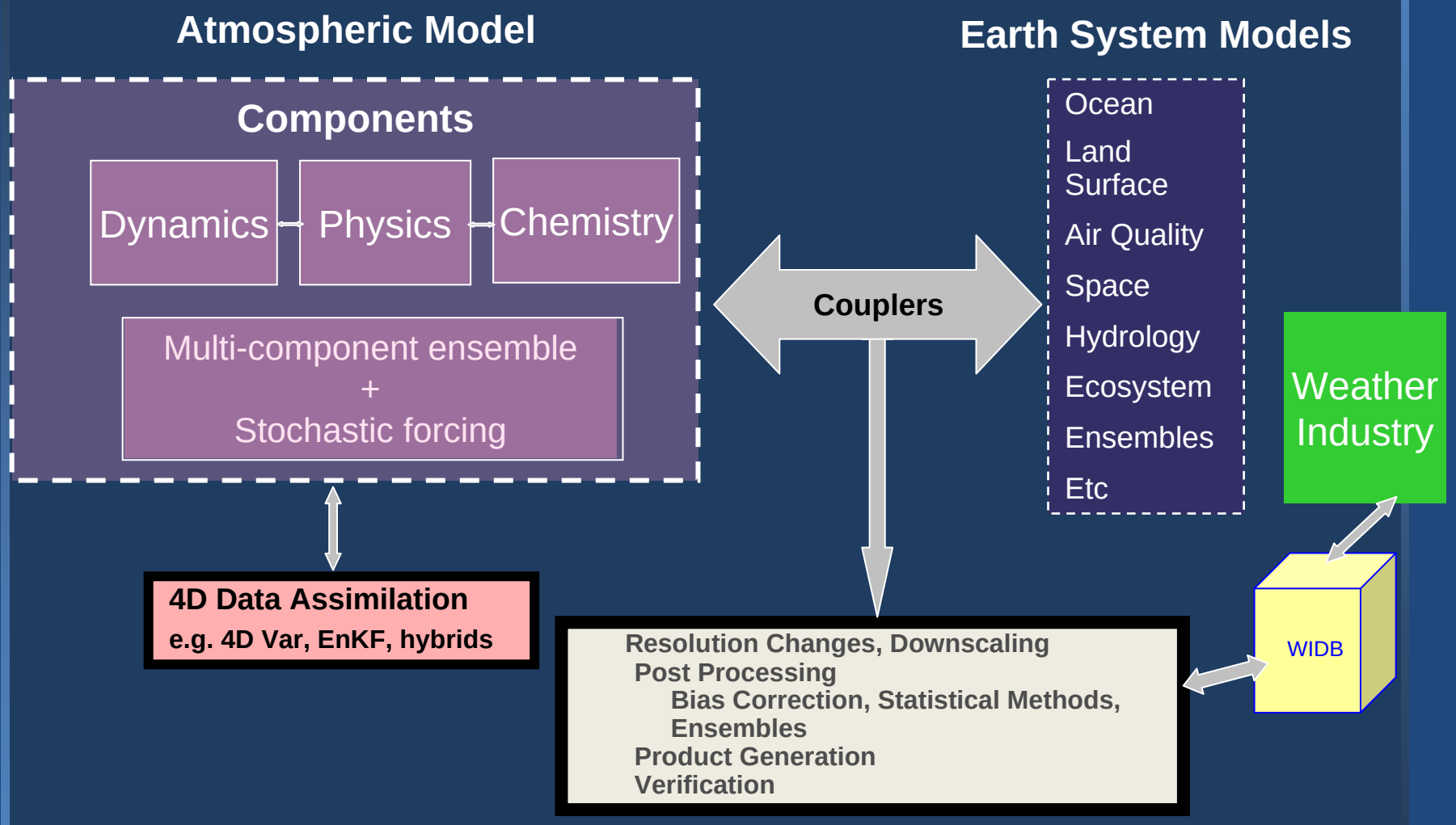
Future

Weather Information Database



Open Architecture

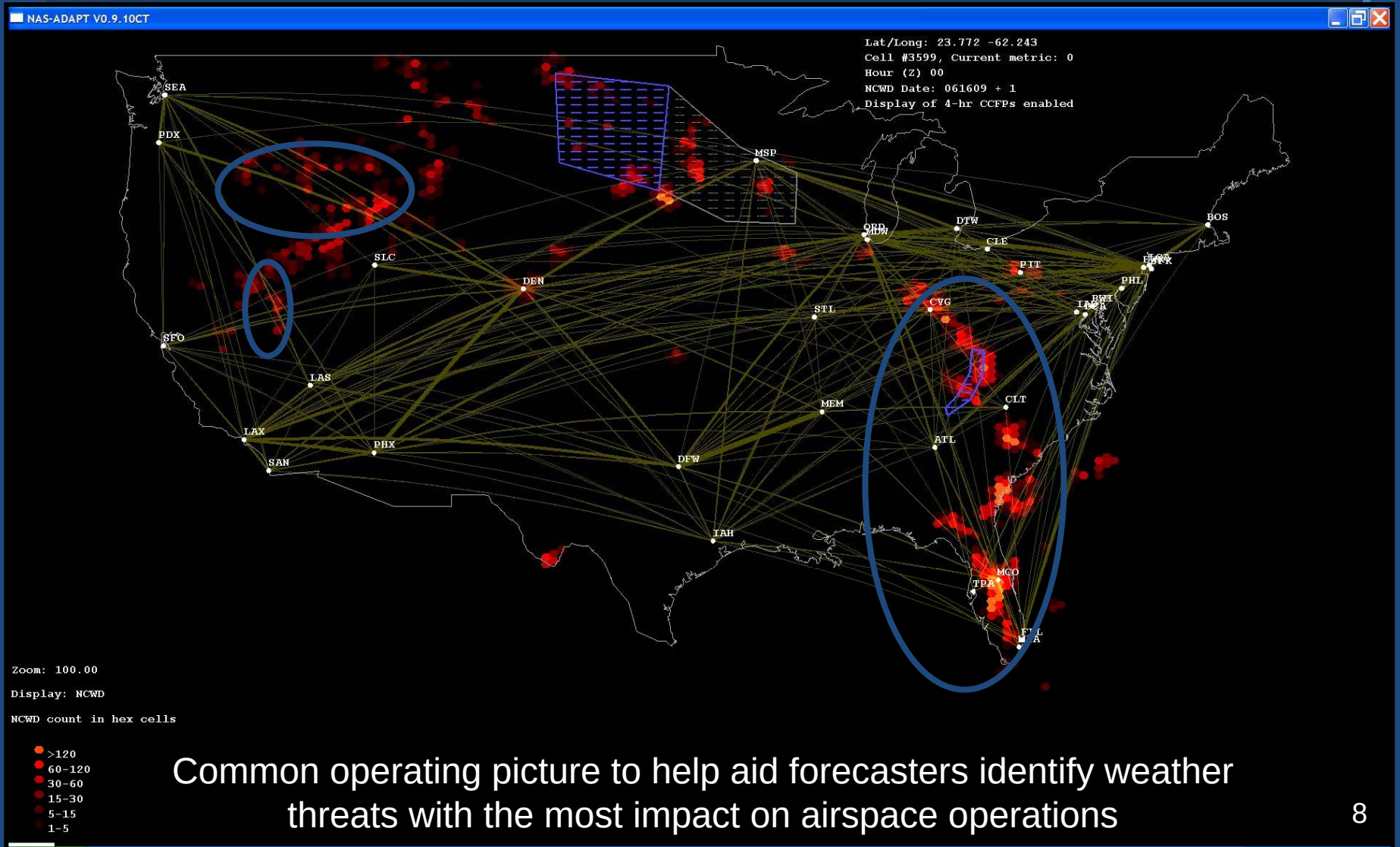
S&T Roadmap Strategic Themes:
Integrated Environmental Modeling System



S&T Roadmap Strategic Themes:
Next Generation Forecast and Decision Support System

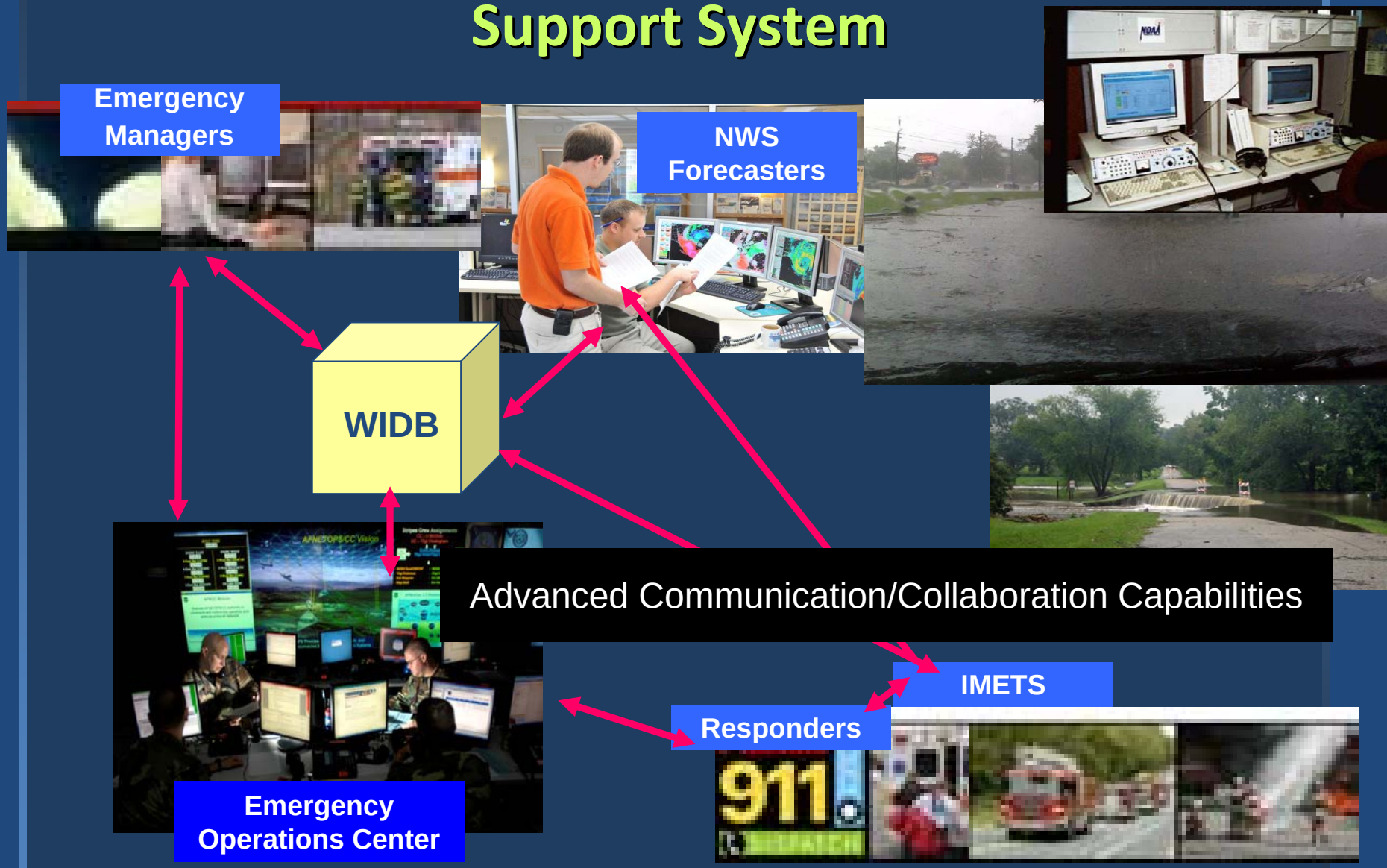
- **Warn on forecast for high impact events**
  - *Tools and capabilities to support new science-service advancements*
- **Tools to enable forecasters to focus on:**
  - *What matters, areas of forecast uncertainty and where they add maximum value*
- **Verification tools/capabilities**
- **Dynamic training capabilities**
- **Decision Support Systems with customer-centric information architectures**

S&T Roadmap Strategic Themes:
Next Generation Forecast and Decision Support System

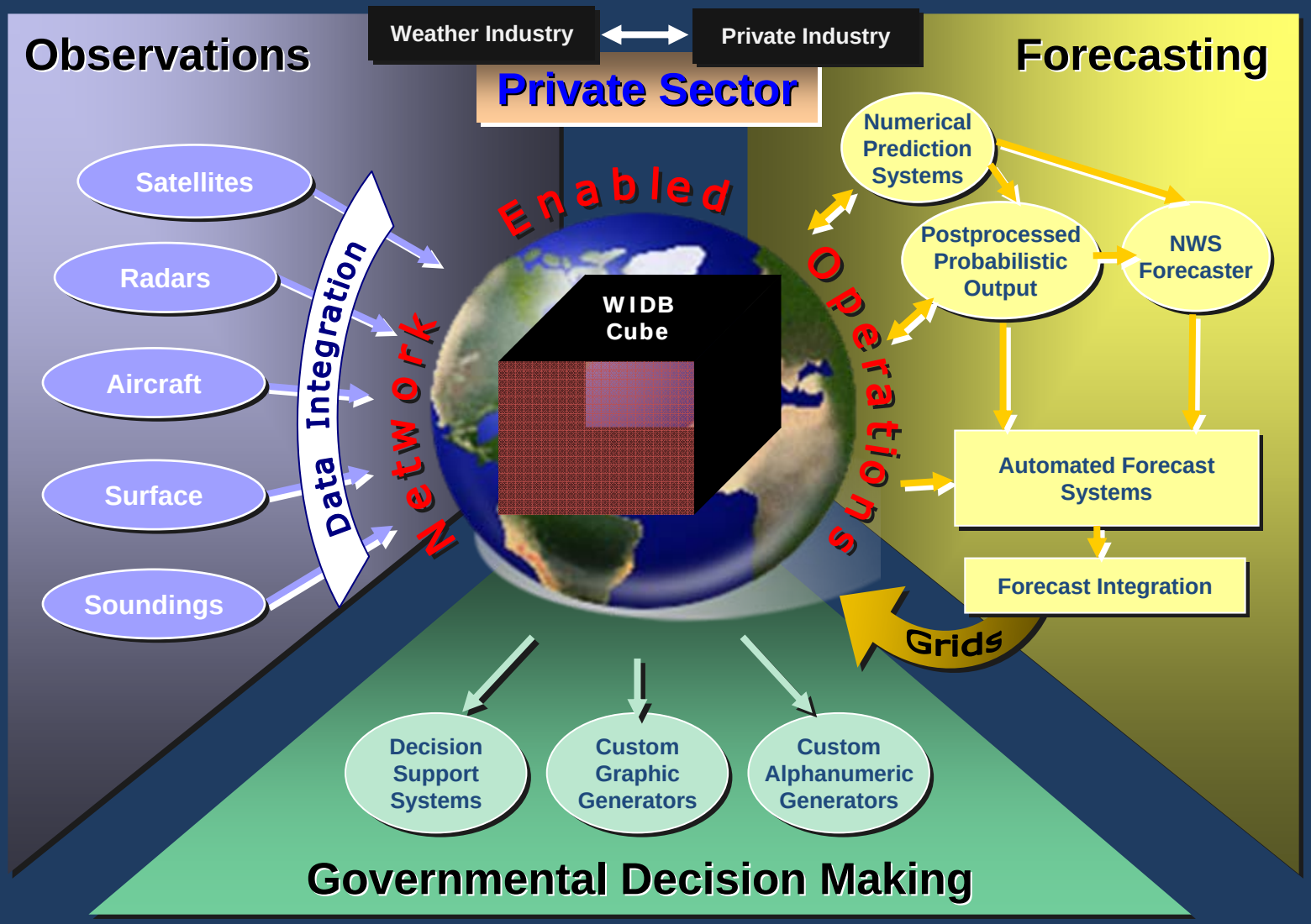


Common operating picture to help aid forecasters identify weather threats with the most impact on airspace operations

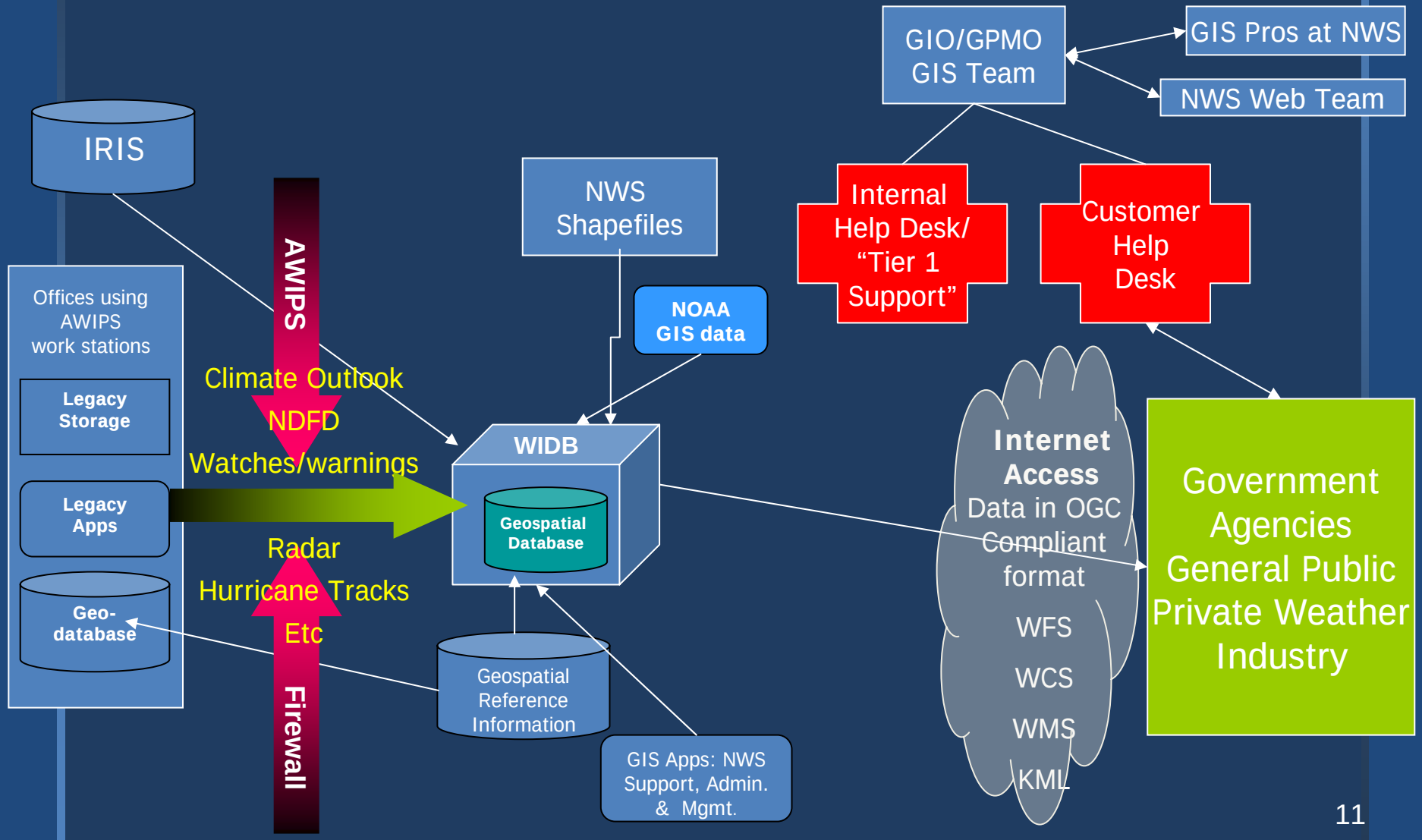
S&T Roadmap Strategic Themes:
Next Generation Forecast and Decision Support System



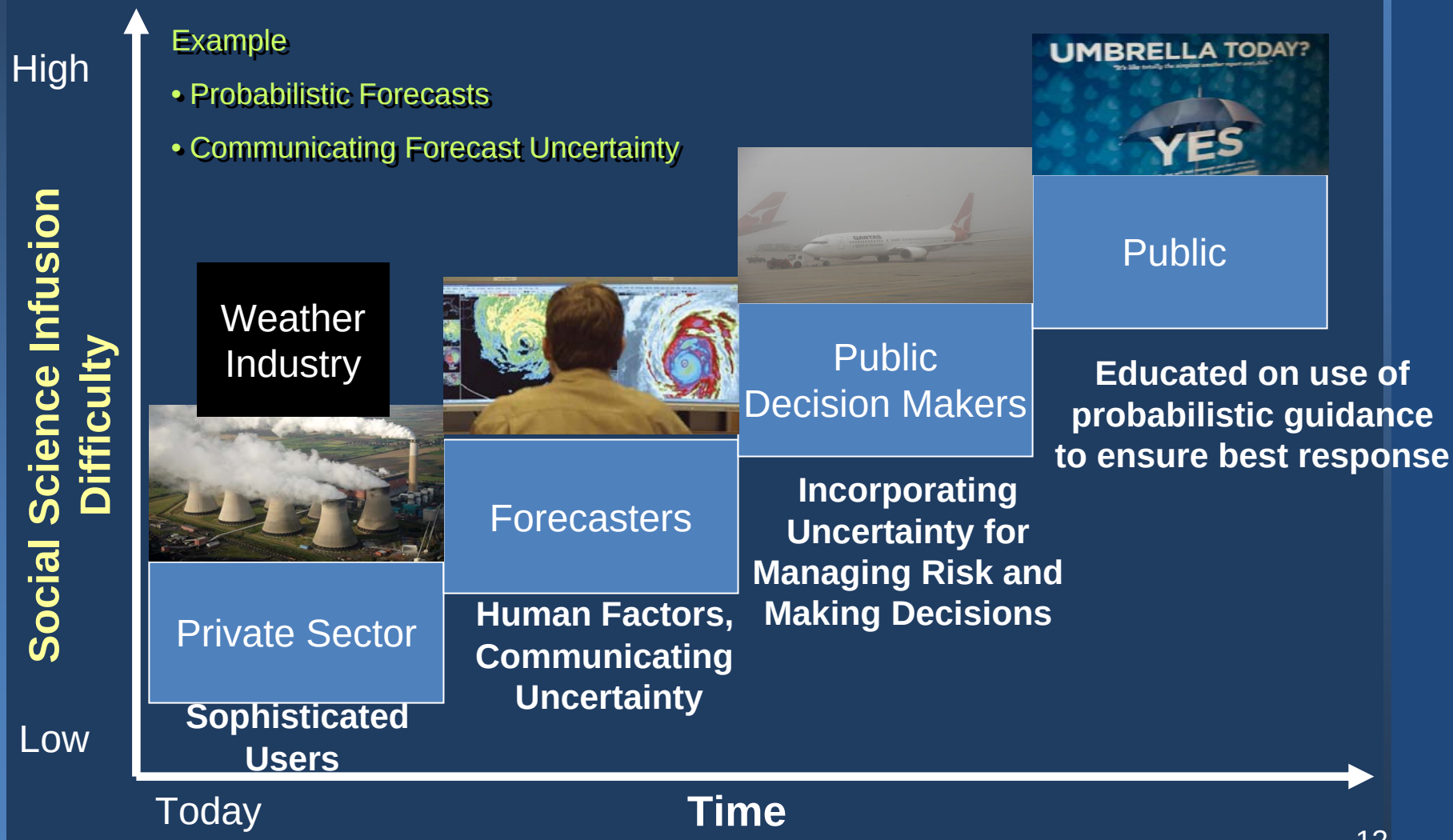
S&T Roadmap Strategic Themes:
Weather Information Database (WIDB)



S&T Roadmap Strategic Themes:
Transform Dissemination/Communication/ Outreach Architectures



S&T Roadmap Strategic Themes:
Incorporate Social Sciences Strategies in Research & Operations



Framework For R2O/O2R

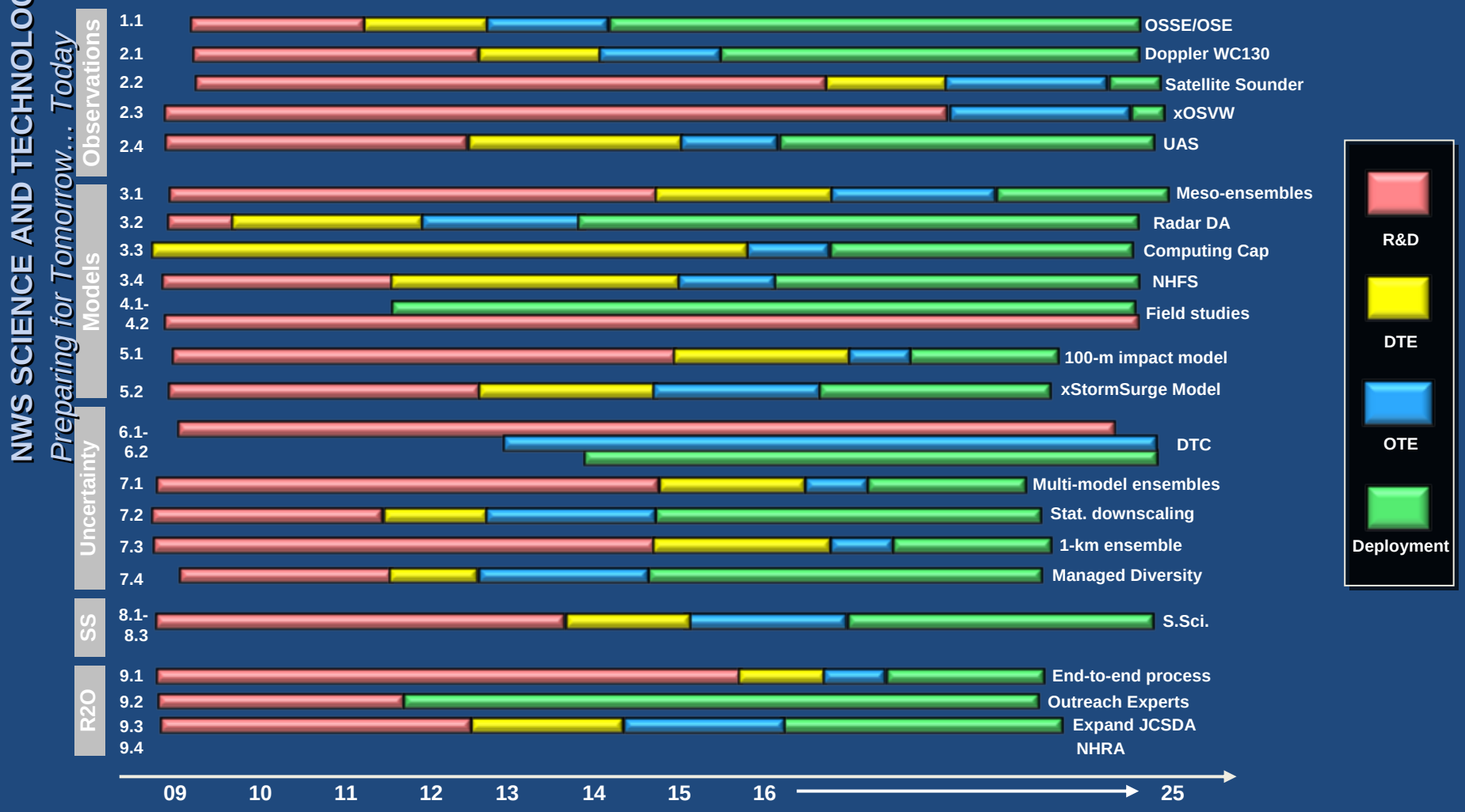
Framework for R2O/O2R:
Guiding Principles

- **Clearly communicate NWS S&T needs to research community**
- **Identify innovations, capability improvements early for programming actions**
  - *Connect the dots across multiple agencies, organizations with varying interests*
- **Streamline transition of research to operations**
  - *Apply consistent methodology for validating, verifying best transition candidates*
  - *Program for resources critical for ensuring smooth transitions (HFIP, AWIPS)*
- **Strengthen O-to-R processes**

Framework for R2O/O2R:
Phased Implementation into NWS Operations

Phase	Key Q	Key Metric	Facility
R&D	Does it work?	Peer-reviewed Publication	Universities, Government Labs, Private Industry
Developmental Testing	Works with operational systems?	Feasibility/ Engineering Analysis Successful	Testbed with operations- like environment
Experimental Testing	Meets operational performance criteria?	Go/No Go based on: Objective Performance (e.g. accuracy) Subjective Feedback Production Readiness	Operational proving ground for clinical tests and full "dress rehearsal"
Operations	Maintains required performance?	Objective criteria: accuracy and reliability	Operations

Framework for R2O/O2R:
Phased Implementation into NWS Operations
Tropical Weather S&T Action Plan



Framework for R2O/O2R:
Testbed System & Ops Proving Ground

VISION

NWS S&T Needs and OAR Research Alignment

NWS and OAR Alignment:
NWS Roadmap S&T Needs/Opportunities

- ✓ **S&T Needs Collected for 22 NWS S&T Focus Areas**
  - ✓ *Teams spanned research to operations*
    - ✓ **OAR Labs**
    - ✓ **Goal Teams**
    - ✓ **Regions, NCEP, OCWWS, OCIO and OST**
  - ✓ *Identified research needs and opportunities in S&T Action Plans to achieve stretch goals for 2025*

NWS and OAR Alignment:
NWS Roadmap S&T Needs/Opportunities
Example: Tropical Cyclones

R&D Needs and Opportunities

- Cause of rapid intensity changes
- Key observations needed for improved forecasting
- Air-sea fluxes under quiet and disturbed conditions
- Predictability limits
- Vortex-convection-environment interactions
- Microphysics of convection at high-resolution
- Social Science

Vision

Finer scale and highly accurate track, intensity and inundation forecasts that trigger appropriate responses resulting in reduced loss of life and economic impacts

Increasing Impact

- Track forecast to 7 days
- Detailed storm-surge/inundation forecasts
- Improved tropical cyclone precip. estimates

- Wind radii forecasts to 5 days
- Wind& surge impact guidance to 36-hr
- Improved rapid intensity change, POD and FAR

- Halved track & intensity forecast errors
- Warnings and forecasts prior to cyclogenesis
- Communication of accurate high-resolution information

09 10 11 12 13 14 15 16 → 25

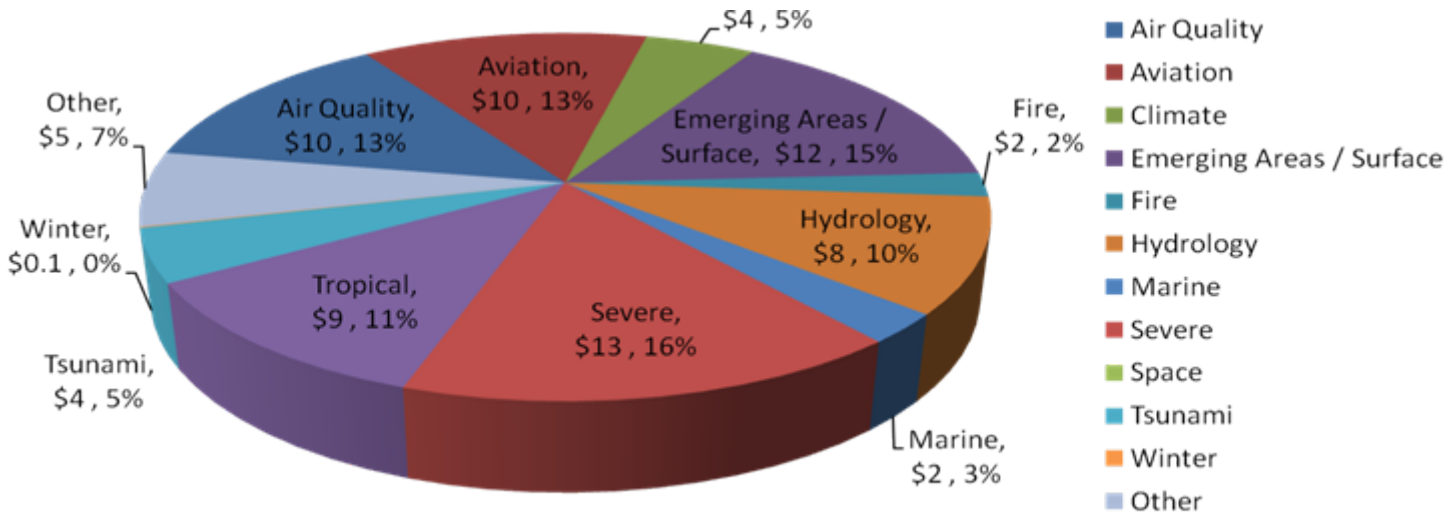
Time

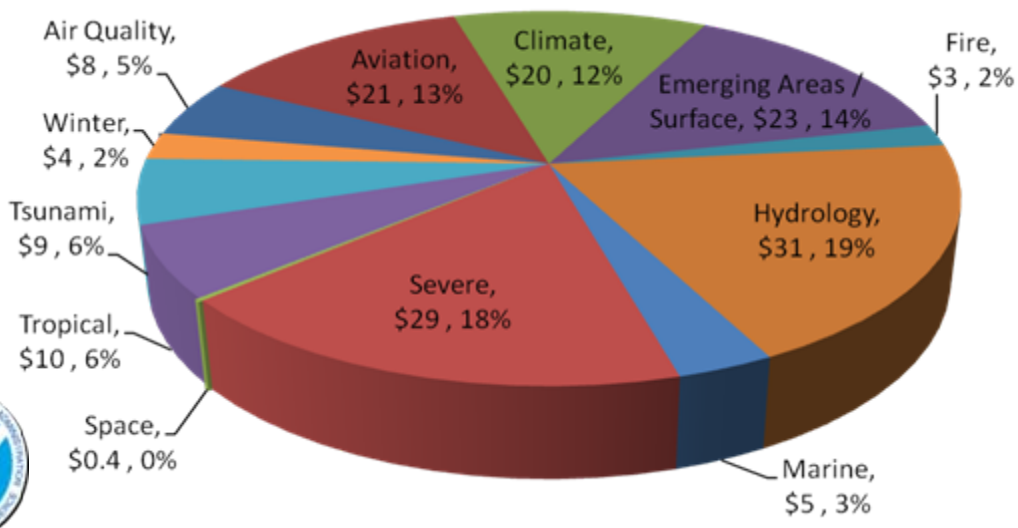
NWS and OAR Alignment:
Current and Future

- ✓ **Analysis of Current and Near-Term Alignment**
  - ✓ *Portfolio Analysis of FY08 (W&W); NEP-NEC brief Sept 2009, Knight-Berchoff*
  - ✓ *Crosswalk to NOAA 5 Year Research Plan Goals (OAR with all LOs)*
- ✓ **Analysis of Future S&T needs Alignment:**
  - ✓ *Analysis of OAR research alignment with NWS research needs to meet 2025 stretch goals*

NWS and OAR Alignment:
FY08 Portfolio Alignment, W&W

OAR research in NWS science-service areas: $77.6M





NWS development, in science-service areas, $164.3 M

NWS and OAR Alignment:
FY08 Portfolio Alignment, WW

- Within W&W Goal, model analysis suggests strong alignment between OAR & NWS R&D portfolios:
  - NWS is a potential beneficiary for 94% of the projects in the OAR transition queue
  - NWS is developing plans to incorporate 76% of OAR's W&W projects not supported by NWS resources
  - OAR has the capability to meet 85% of NWS research needs
  - W&W data allows OAR & NWS to examine the balance between research OAR and external partners provide NWS

NWS -OAR Alignment:
Future

- **NWS compiled OAR information presented/ provided for ongoing and planned research corresponding to S&T needs captured by 22 Focus Area Teams**

NWS -OAR Alignment:
Future

- **NWS/OST met with NOAA Research Council and OAR Laboratory representatives during summer 2009**

NOAA Research Council	Silver Spring, MD	6/22/09
National Severe Storms Laboratory	Norman, OK	7/14/09
Earth System Research Laboratory	Boulder, CO	7/15/09
Air Resources Laboratory	Silver Spring, MD	8/07/09
Atlantic Oceanographic and Meteorological Laboratory	Miami, FL	8/18/09
Great Lakes Environmental Research Laboratory	Telecon, follow-up email	9/1/09

- **NWS provided overview of S&T Roadmap 2025 goals, summary S&T needs; requested comment**
  - *Summary S&T needs identified by 22 Roadmap Focus Area teams*
- **NOAA Research Council discussion:**
  - *Pointed to specific research activities & goals for OAR (+ all LOs) captured in NOAA 5-yr Research Plan (FY08-12), near-term (provided in backup)*
- **OAR labs presented ongoing & planned research**
  - *Additional information provided: research papers, web-sites, briefs*

NWS -OAR Alignment:
Future

- **Comparison with S&T needs for 2025 summarized as**
  - *encompassed by OAR efforts*
  - *partially covered by the scope of OAR efforts*
  - *not covered by the scope of OAR efforts*

Future Alignment:
Science-Service Areas

Science-Service Areas:

Corresponding OAR Research:

Extensive/ Limited/ Dormant

Green: 7

Mixed: 1 Marine

- *NOS partnerships not shown*

Yellow: 3

Hydrology*, Climate ISI/IA*, Space Weather

* *Discussion Item*

Red: 1 Winter Wx

- *External Partners*

Draft Research Needs and Opportunities and Lab links	OAR Research Activity: Now	OAR Research Activity: Future
Fire Weather		
Simulations (high-resolution) of integrated fire weather/behavior		
Methods for on-demand, indexed Red Flag Watches, Warnings & Advisories decision-support system		
Hydrology		
Physically based hydrologic models and ensembles		
Remote sensing and data assimilation		
Integrated inland, river, estuary and ocean modeling		
Aviation		
Enhanced predictions of initiation and evolution of convection, onset of turbulence, icing, impared visibility		
Optimal generation of single authoritative source for current weather information		
Methods to enhance weather integration into NextGen decision making		
Severe Weather		
Improved understanding of tornado formation and severe weather microphysics		
Resolution of observations and models needed for WoF		
Remote sensing and data assimilation		
Winter Weather		
Better understanding of conditional and symmetric instability		
Snow band formation and snow intensity		
High-resolution detection of precip rate, type		
Marine		
Improve wave model physics from shelf to shore (and storm surge)	NOS	
Include/improve global and regional modeling in coupled Earth System Modeling		
Social science studies/assessments		
New observation technologies		
Tropical Weather		
Investigate causes of rapid intensity changes		
Key observations needed for improved forecasting		
Air-sea interaction		
Predictability limits		
Climate		
Data continuity for climate observations		
Earth system modeling for IA/ISI, with alternative downscaling and ensemble prediction capabilitites with uncertainty information	Limited work on ISI/IA	
Coupled data assimilation, initialization, reanalysis and reforecast		
Air Quality		
Advanced simulations of generation and reactive chemical transport of airborne particulate matter		
Advanced chemical data assimilation, boundary conditions		
Improved modeling and analyses of emissions inputs		
Coupling to broader range of environmental models		
Space Weather		
Earth-Space System Model		
Solar Wind and Solar Disturbance Model		
Data Assimilation: Ionosphere, Magnetosphere, and Solar Wind		
Solar Flare and Solar Energetic Particle Prediction Model		
Tsunami		
High-resolution, advanced physics for locally specific and near-shore high impact events		
Improved forecast accuracy and speed via enhanced observations, models & data assimilation		
Employ a community modeling capability to advance R&D		
Social Science Studies/Assessments		
Emerging Areas/Sensible Weather & RE		
Meteorological influences on renewable and sustainable energy systems		
Coupled simulation of air-land-water-ecosystem impacts		
Meteorological influences on human health		

Future Alignment:
Enabling Capabilities

Enabling Capabilities

Corresponding OAR Research:

Extensive/ Limited/ Dormant

Green: 3

Yellow: 6

Post-processing, DSS*, Verification, Dissemination, Social Sciences, IT segment architecture

** Discussion Item (Next-Gen context)*

Red: 1

Customer Outreach & Feedback Technologies - *External Partners*

Draft Research Needs and Opportunities and Lab links	OAR Research Activity: Now	OAR Research Activity: Future
Observation		
Optimizing system architecture and investigating multi-sensor low-cost platforms		
Develop adaptive observing capabilities for supporting probabilistic warnings, such as Warn on Forecast		
Improved sensor technologies to meet existing and emerging missions needs		
Methods to include observational uncertainty in probabilistic and uncertainty forecast information		
Data Assimilation+ Forecast Modeling		
Exploitation of explosive growth in data volumes (e.g. satellites) in data assimilation		
4-D DA with hybrid, EnKF compatible with global ensemble prediction system		
Global grid models with globally consistent resolution		
Common global/regional coupled grid system		
Physics and DA methods for convection resolving (Dx<4 km) models supporting warn-on-forecast (e.g.		
Post Processing		
Improved bias correction methods, stochastic forcing, statistical methods		
Methods for fusing information from multiple sources		
Optimal ensemble generation		
Forecaster Applications		
Advanced warning and decision tools		
Situational awareness tools		
Advanced collaboration tools, including social networking		
Decision Support Services (DSS)		
Quantification of uncertainty		
Data-mining and remote data accessibility		
Integration of social science and uncertainty information		
Remote interactive communication tools		
Rapid response DSS with adaptive modeling		
Verification / Metrics		
Advanced Methods for Real Time Analysis and Analysis of Record		
Object-Oriented Verification		
NextGen Verification; e.g. methods for customer-centric verification		
Dissemination		
Identify essential new technologies and standards for implementation		
Analyze alternative system architectures for dissemination		
Customer Outreach & Feedback Technology		
Methods for effective integration of Hazard Mitigation Plans & customer needs into Customer Relationship Management		
Investigate effective exploitation of government social networking		
Investigate methods to exploit virtual reality and action simulations		
Social Sciences		
Methods for quantifying and improving impacts of NWS information		
Determination/integration of effective uncertainty/probabilistic information into DSS		
IT Segment Architecture		
Integration of state of the science IT for enterprise weather services		
Master database Management		
Net-centric interaction with customers		

NWS - OAR Alignment:
Green

- **Science-Service Areas aligned:**
  - ✓ *Fire Weather*
  - ✓ *Aviation*
  - ✓ *Severe Weather*
  - ✓ *Marine (includes NOS)*
  - ✓ *Tropical Weather*
  - ✓ *Air Quality*
  - ✓ *Tsunami*
  - ✓ *Sensible Weather & Emerging areas*

NWS - OAR Alignment:
Green

- **Enabling Capabilities Areas aligned:**
  - ✓ *Observations*
  - ✓ *Data Assimilation/ Models*
  - ✓ *Forecaster Applications*

Future Alignment:
Proposal for Getting to Green

Focus Area	Additional Research Partners	Increasing Reliance on OAR	Discussion/ Path forward planning	$ Req for FY12 ?
Hydrology			✓ 10/14 mtg	Yes
Climate ISI/IA			✓ 10/14 mtg	Yes
Space Weather	✓ Agreed			Yes
Winter Weather	✓ Agreed			
Post-processing		✓ Planned	▪ 9/22 mtg	Yes
DSS			✓ 10/14 mtg	Yes
Verification/Metrics	✓ Agreed	✓ Planned		
Customer O&F Tech	✓ Agreed			
Dissemination			• Follow-on TBD	
Social Sciences	✓ Agreed	✓ Planned		Yes
IT segment architecture			• Follow-on TBD	

NWS - OAR Alignment:
Getting to Green

- **Areas to be discussed today/tomorrow:**
  - *Climate ISI/IA*
  - *Hydrology*
  - *DSS (as part of Next-Gen)*

- **Areas that OAR and NWS agree will be pursued by additional research partners:**
  - *Winter Weather*
  - *Space Weather (adding OAR kernel)*
  - *Customer Outreach &Feedback Technologies*

NWS - OAR Alignment:
Getting to Green

- **Areas with increasing NWS reliance on OAR research partners:**
  - *Post-Processing-- workshop 9/22*
  - *Social Sciences-- PPBES FY 12 attention*
  - *Advanced Verification Methods*

- **Areas for further discussion, date TBD:**
  - *Dissemination*
  - *IT segment architecture*

Alignment: Status and Way Ahead

- **Current alignment paving the way for future S&T in NWS**
  - *Overall analysis of OAR research alignment with NWS activities: good in FY08*
- **Preparing for longer-term NWS S&T Needs**
  - *Compared NWS 2025 S&T Needs captured in Roadmap with OAR current activities & plans*
    - **discussions at OAR labs and NOAA 5Yr Research Plan**
  - *Affirm areas with strong alignment: focus on strengthening R2O/O2R*
  - *Plan for closing the gaps*

Thank You

Questions and comments?

Email:

nwsostroadmap@noaa.gov

Backup

Focus Area Summaries

- Fire Weather
- Hydrology
- Aviation
- Severe Weather
- Winter Weather
- Marine
- Tropical Weather
- Climate
- Air Quality
- Space Weather
- Tsunami
- Emerging Areas

- Observations
- Data Assimilation+ Forecast Modeling
- Post Processing
- Forecaster Applications
- Decision Support Services I: Tiers 1-2
- Decision Support Services I: Tiers 3-5
- Verification / Metrics
- Dissemination
- Customer Outreach & Feedback Tech
- Social Sciences
- IT Segment Architecture

Separate Attachment

S&T Roadmap Summary: Research Needs & Opportunities

Science-Service Focus Areas

Fire Weather
- Simulations (high-resolution) of integrated fire weather/behavior
- Methods for on-demand, indexed Red Flag Watches, Warnings & Advisories decision-support system

Hydrology
- Physically based hydrologic models and ensembles
- Remote sensing and data assimilation
- Integrated inland, river, estuary and ocean modeling

Aviation
- Enhanced predictions of initiation and evolution of convection, onset of turbulence, icing, impared visibility
- Optimal generation of single authoritative source for current weather information
- Methods to enhance weather integration into NextGen decision making

Severe Weather
- Improved understanding of tornado formation and severe weather microphysics
- Resolution of observations and models needed for WoF
- Remote sensing and data assimilation

Winter Weather
- Better understanding of conditional and symmetric instability
- Snow band formation and snow intensity
- High-resolution detection of precip rate, type

Marine
- Improve wave model physics from shelf to shore (and storm surge)
- Include/improve global and regional modeling in coupled Earth System Modeling
- Social science studies/assessments
- New observation technologies

Tropical Weather
- Investigate causes of rapid intensity changes
- Key observations needed for improved forecasting
- Air-sea interaction
- Predictability limits; cyclogenesis

Climate
- Data continuity for climate observations
- Earth system modeling for IA/ISI, with alternative downscaling and ensemble prediction capabilitites with uncertainty information
- Coupled data assimilation, initialization, reanalysis and reforecast

Air Quality
- Advanced simulations of generation and reactive chemical transport of airborne particulate matter
- Advanced chemical data assimilation, boundary conditions
- Improved modeling and analyses of emissions inputs
- Coupling to broader range of environmental models

Space Weather
- Earth-Space System Model
- Solar Wind and Solar Disturbance Model
- Data Assimilation: Ionosphere, Magnetosphere, and Solar Wind
- Solar Flare and Solar Energetic Particle Prediction Model

Tsunami
- High-resolution, advanced physics for locally specific and near-shore high impact events
- Improved forecast accuracy and speed via enhanced observations, models & data assimilation
- Employ a community modeling capability to advance R&D
- Social Science Studies/Assessments

Emerging Areas/Sensible Weather & RE
- Meteorological influences on renewable and sustainable energy systems
- Coupled simulation of air-land-water-ecosystem impacts
- Meteorological influences on human health

S&T Roadmap Summary: Research Needs & Opportunities

Enabling Capability Focus Areas

Observations
- Optimizing system architecture and investigating multi-sensor low-cost platforms
- Develop adaptive observing capabilities for supporting probabilistic warnings, such as Warn on Forecast
- Improved sensor technologies to meet existing and emerging missions needs
- Methods to include observational uncertainty in probabilistic and uncertainty forecast information

Data Assimilation+ Forecast Modeling
- Exploitation of explosive growth in data volumes (e.g. satellites) in data assimilation
- 4-D DA with hybrid, EnKF compatible with global ensemble prediction system
- Global grid models with globally consistent resolution
- Common global/regional coupled grid system
- Physics and DA methods for convection resolving (Dx<4 km) models supporting warn-on-forecast (e.g. PBL processes)

Post Processing
- Improved bias correction methods, stochastic forcing, statistical methods
- Methods for fusing information from multiple sources
- Optimal ensemble generation

Forecaster Applications
- Advanced warning and decision tools
- Situational awareness tools
- Advanced collaboration tools, including social networking

Decision Support Services (DSS)
- Quantification of uncertainty
- Data-mining and remote data accessibility
- Integration of social science and uncertainty information
- Remote interactive communication tools
- Rapid response DSS with adaptive modeling

Verification / Metrics
- Advanced Methods for Real Time Analysis and Analysis of Record
- Object-Oriented Verification
- NextGen Verification; e.g. methods for customer-centric verification

Dissemination
- Identify essential new technologies and standards for implementation
- Analyze alternative system architectures for dissemination

Customer Outreach & Feedback Technology
- Methods for effective integration of Hazard Mitigation Plans & customer needs into Customer Relationship Management
- Investigate effective exploitation of government social networking
- Investigate methods to exploit virtual reality and action simulations

Social Sciences
- Methods for quantifying and improving impacts of NWS information
- Determination/integration of effective uncertainty/probabilistic information into DSS

IT Segment Architecture
- Integration of state of the science IT for enterprise weather services
- Master database Management
- Net-centric interaction with customers

Comparison to NOAA 5-Yr Research Plan Goals

	S&T Roadmap	NOAA 5Yr Res Plan
	Fire Weather	
	Simulations (high-resolution) of integrated fire weather/behavior	
	Methods for on-demand, indexed Red Flag Watches, Warnings & Advisories decision-support system	*Improve NOAA's incident support services for fires and other high impact events by expanding the number of trained personnel and shortening*
	Hydrology	
	Physically based hydrologic models and ensembles	*Evaluate community-wide rainfall-runoff distributed hydrologic models (3-*
	Remote sensing and data assimilation	*Improve the Advanced Hydrologic Prediction Services (AHPS) through improved multi-sensor precipitation estimation algorithms including dual-*
	Integrated inland, river, estuary and ocean modeling	*Demonstrate a transition zone modeling system to integrate river, estuarine, and coastal models (0-2; Table 7.5). Implement a field project*
	Aviation	
	Enhanced predictions of initiation and evolution of convection, onset of turbulence, icing,	
	Optimal generation of single authoritative source for current weather information	*Provide integrated environmental information and services, particularly watches and warnings, in industry standard formats to support partner and*
	Methods to enhance weather integration into NextGen decision making	*Prototype an aviation database concept with weather elements (3-5; Table*
	Severe Weather	
	Improved understanding of tornado formation and severe weather microphysics	
	Resolution of observations and models needed for WoF	*Evaluate the utility of probabilistic forecasts for hazardous weather and*
	Remote sensing and data assimilation	*Improved detection of severe storms using complete network of low-altitude, high temporal/spatial resolution Doppler radar data (0-2; Table 7.2). Deploy NEXRAD systems with Dual Polarization Capability to*
	Winter Weather	
	Better understanding of conditional and symmetric instability	
	Snow band formation and snow intensity	
	High-resolution detection of precip rate, type	*Deliver improved echo classification techniques that significantly reduce contamination of precipitation estimates using dual-polarization radar*
	Marine	
	Improve wave model physics from shelf to shore (and storm surge)	*Provide decision-support services based upon probabilistic model guidance for coastal emergency management officials for storm surge and*
	Include/improve global and regional modeling in coupled Earth System Modeling	
	Social science studies/assessments	
	New observation technologies	
	Tropical Weather	*UNDER DSS: Provide decision-support services based upon probabilistic model guidance for coastal emergency management officials for storm*
	Investigate causes of rapid intensity changes	*Improve accuracy in intensity forecasts for tropical storms and hurricanes*
	Key observations needed for improved forecasting	*Not Goal; p 41 USWRP advanced data assimilation systems with real-time*
	Air-sea interaction	
	Predictability limits; cyclogenesis	
	Climate	
	Data continuity for climate observations	
	Earth system modeling for IA/ISI, with alternative downscaling and ensemble prediction capabilitites with uncertainty information	*Improve NOAA's predictive capability on weekly, monthly, and seasonal time scales by involving and leveraging the external research community*
	Coupled data assimilation, initialization, reanalysis and reforecast	
	Air Quality	
	Advanced simulations of generation and reactive chemical transport of airborne particulate	*Conduct field campaign to characterize wintertime particulate matter*
	Advanced chemical data assimilation, boundary conditions	
	Improved modeling and analyses of emissions inputs	
	Coupling to broader range of environmental models	*Improve understanding of the connection between climate and shorter-*
	Space Weather	
	Earth-Space System Model	
	Solar Wind and Solar Disturbance Model	*Provide early (1-4 day) space weather watches and warnings for power*
	Data Assimilation: Ionosphere, Magnetosphere, and Solar Wind	
	Solar Flare and Solar Energetic Particle Prediction Model	
	Tsunami	
	High-resolution, advanced physics for locally specific and near-shore high impact events	*Improve tsunami warnings with emphasis on run-up and inundation, and*
	Improved forecast accuracy and speed via enhanced observations, models & data	
	Employ a community modeling capability to advance R&D	
	Social Science Studies/Assessments	

Comparison to NOAA 5-Yr Research Plan Goals, cont'd

S&T Roadmap	NOAA 5Yr Res Plan
Observations	
Optimizing system architecture and investigating multi-sensor low-cost platforms	*Improved detection of severe storms using complete network of low-altitude, high temporal/spatial resolution Doppler radar data (0-2; Table 7.2)*
Develop adaptive observing capabilities for supporting probabilistic warnings, such as Warn on Forecast	*Deploy NEXRAD systems with Dual Polarization Capability to improve the detection of storm characteristics critical to severe storm warnings (3-5; Table 7.2)*
Improved sensor technologies to meet existing and emerging missions needs	*Deploy NEXRAD systems with Dual Polarization Capability to improve the detection of storm characteristics critical to severe storm warnings (3-5; Table 7.2). Develop prototype [digital] phased*
Methods to include observational uncertainty in probabilistic and uncertainty forecast information	
Data Assimilation+ Forecast Modeling	*STRATEGY: Using the testbeds, transfer up to six research results into operations per year (0-2; Table 7.2)*
Exploitation of explosive growth in data volumes (e.g. satellites) in data assimilation	
4-D DA with hybrid, EnKF compatible with global ensemble prediction system	*Determine viability of different data assimilation approaches (e.g., 3-D Var, ENKF, 4-DVar) (3-5; Table 7.2)*
Global grid models with globally consistent resolution	
Common global/regional coupled grid system	
Physics and DA methods for convection resolving (Dx<4 km) models supporting warn-on-forecast (e.g. PBL processes)	
Post Processing	
Improved bias correction methods, stochastic forcing, statistical methods	*Improve the accuracy of global analyses by 25% through better ensemble and statistical post-processing techniques (3-5; Table 7.2)*
Methods for fusing information from multiple sources	
Optimal ensemble generation	*Improve the accuracy of global analyses by 25% through better ensemble and statistical post-processing techniques (3-5; Table 7.2)*
Forecaster Applications	
Advanced warning and decision tools	*Quantify human forecaster value-added contributions (3-5; Table 8.3).*
Situational awareness tools	*Evaluate the utility of probabilistic forecasts for hazardous weather and explore "warn-on forecast" concepts (3-5; Table 7.2)*
Advanced collaboration tools, including social networking	
Decision Support Services (DSS)	
Quantification of uncertainty	
Data-mining and remote data accessibility	*Enable private sector partners to market acquired tools and expertise (3-5; Table 8.3). Provide integrated environmental information and services, particularly watches and warnings, in industry*
Integration of social science and uncertainty information	*Provide decision-support services based upon probabilistic model guidance for coastal emergency management officials for storm surge and related hazards during land-falling tropical storms and*
Remote interactive communication tools	
Rapid response DSS with adaptive modeling	
Verification / Metrics	
Advanced Methods for Real Time Analysis and Analysis of Record	*Improve the accuracy of global analyses by 25% through better ensemble and statistical post-processing techniques (3-5; Table 7.2)*
Object-Oriented Verification	
NextGen Verification; e.g. methods for customer-centric verification	*Improve the forecast and warning verification system to relate more directly to user impact and to enable more rapid feedback loop for service improvement (3-5; Table 7.2)*
Dissemination	
Identify essential new technologies and standards for implementation	*Develop standards and protocols for weather-related electronic data exchange and network related operations (0-2; Table 8.3). Provide integrated environmental information and services, particularly*
Analyze alternative system architectures for dissemination	*Validate methodologies for acquisition, processing, and dissemination of weather-related data (0-2; Table 8.3)*
Customer Outreach & Feedback Technology	
Methods for effective integration of Hazard Mitigation Plans & customer needs into Customer Relationship Management	*Improve the forecast and warning verification system to relate more directly to user impact and to enable more rapid feedback loop for service improvement (3-5; Table 7.2)*
Investigate effective exploitation of government social networking	
Investigate methods to exploit virtual reality and action simulations	
Social Sciences	
Methods for quantifying and improving impacts of NWS information	
Determination/integration of effective uncertainty/probabilistic information into DSS	*Evaluate the socio-economic impact of improved water resources forecasts in terms of dollars saved (3-5; Table 7.2). Quantify human forecaster value-added contributions (3-5; Table 8.3)*
IT Segment Architecture	
Integration of state of the science IT for enterprise weather services	
Master database Management	
Net-centric interaction with customers	