

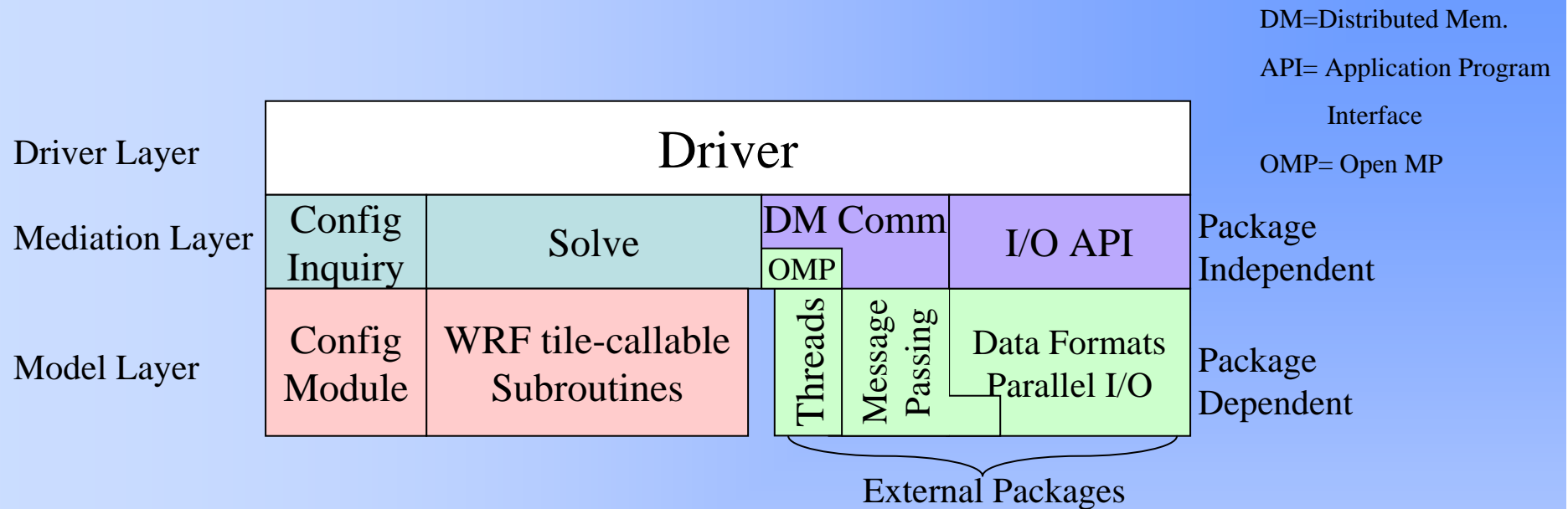
WRF in the Era of NUOPC¹ and ESMF²: Implications and Possible Options

WRF Executive Oversight Board
NOAA/OAR/ESRL/GSD, Boulder, CO
31 July 2007

1 – National Unified Operational Prediction Capability

2 – Earth System Modeling Framework

Current WRF Software Framework with embedded NWP System



- **Objective:** Insulate scientists from parallelism and other architecture-specific details.
- **Structure:** Three-level hierarchy tightly controls how scientists/programmers can work with WRF codes.
- **Pro:** Supports researchers interested in portability and experiment designs based on available options.
- **Con:** Operational support and development of new code often require entering and possibly modifying highly complex, hierarchical software.

Recent Actions Affecting WRF and ESMF

Background:

- Directive from NOAA Administrator C. Lautenbacher (Dec. 2004):
 - All NOAA models will be reconfigured to run under ESMF architecture within 5 years.
- WRF-ESMF Convergence Workshop (2006) concluded that convergence opportunities are limited:
 - “**high-level coupling** of WRF... as an ESMF component [is most]... appropriate near-term strategy”, along with “use of [some] ESMF low-level utilities.” (done, for ARW)
 - a longer-term option is to modify WRF framework to “use ESMF components internally (e.g., ESMF-compatible interfaces).”
- NUOPC draft Concept of Operations (2007), Sec. 6.1.1 Model Execution:
 - “NWP systems will be configured from interchangeable components **implemented under ESMF** or a suitable alternative.”
 - WRF software framework, or CMI, is not under consideration.
- NCEP and Navy have implemented and/or will soon implement ESMF-compliant models in operations.

Continue use
of WRF CMI

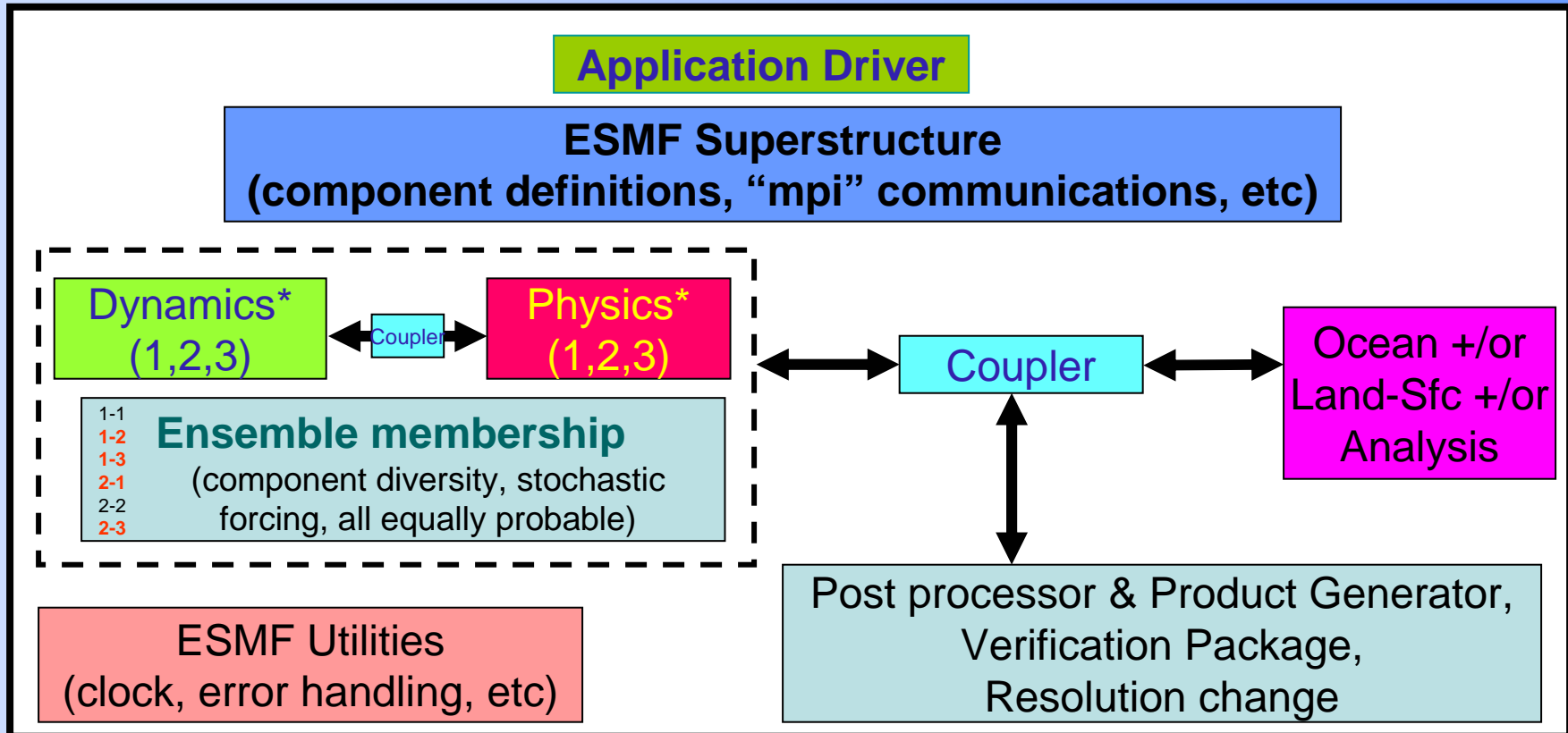
Use ESMF
alone

Implications for WRF Community Modeling

- **Two code repositories, one under ESMF and one under WRF, would be much more difficult and costly for sustaining an interoperable community code.**
- **Separate repositories, even if managed by one organization, likely to make the research-operations partnership unsustainable.**
- **Need practical way forward that...**
 1. **Does no harm (does not seriously impede progress of any sector or org.)**
 2. **Contains no single points of failure**
 3. **Preserves single, shared code repository as basis for community modeling.**

Three options for limited-area modeling in an ESMF future:

Option 1: Current ESMF-Only “Component-based” NWP System

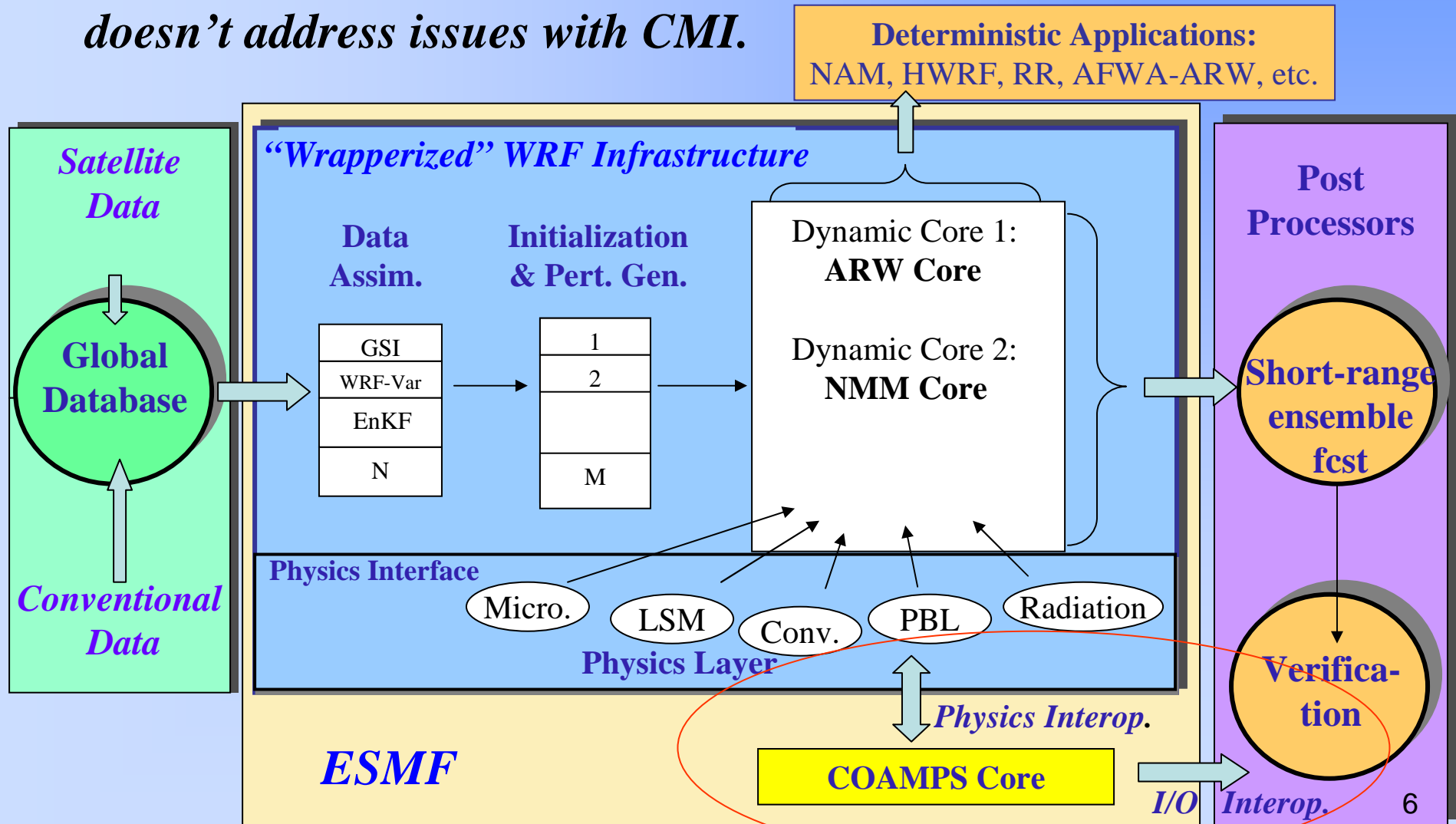


- **Objective:** Gives maximum flexibility to scientist for coupled multi-model architectures.
- **Structure:** “Lightweight” superstructure & optional infrastructure (utilities); scientist is responsible for writing standardized interfaces, drivers and couplers.
- **Pro:** Scientist can perform code development w/o entering ESMF software; facilitates operations maintenance.
- **Con:** ESMF does not currently support a range of functions valuable to researchers (nested grids, etc.).

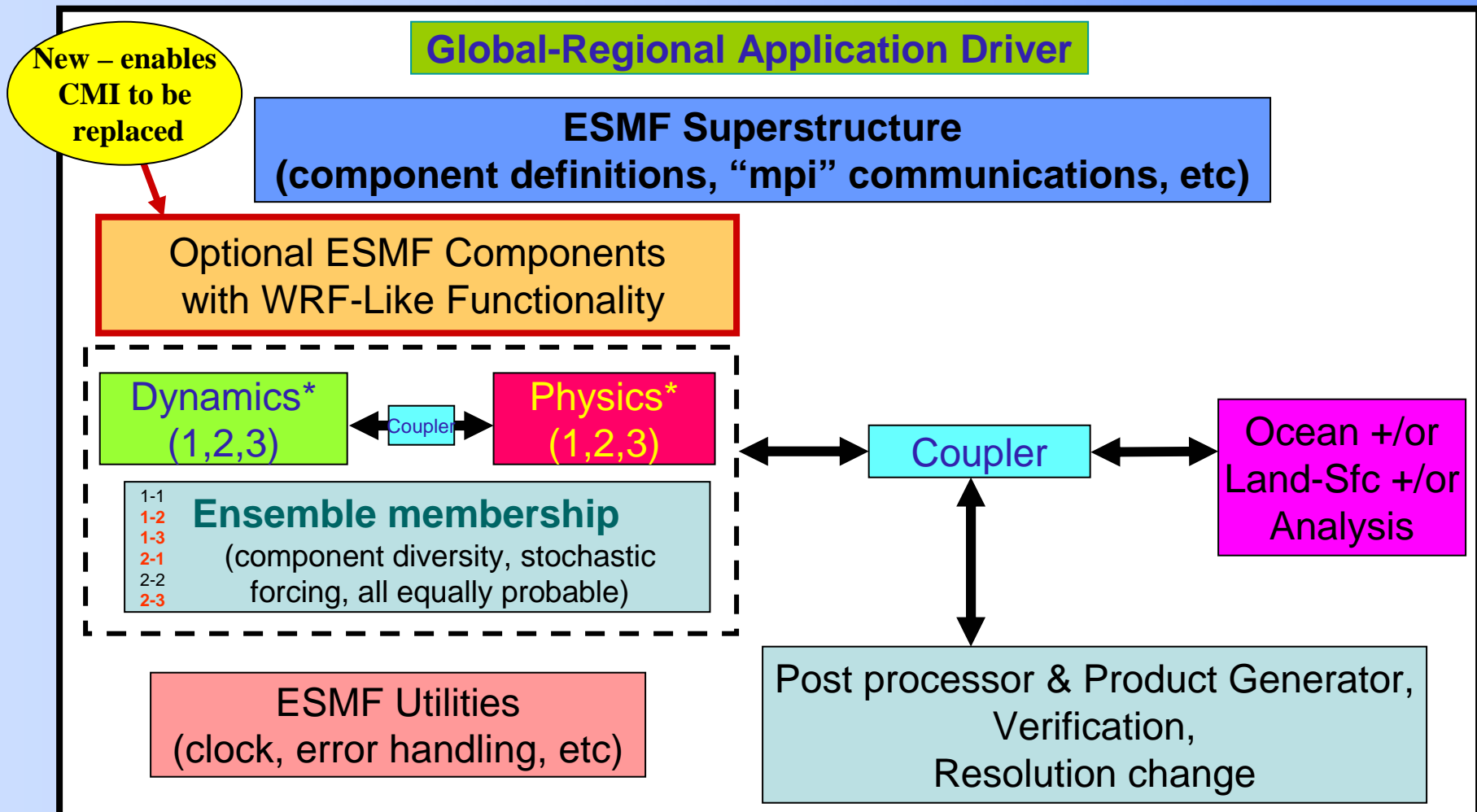
Option 2: Couple ESMF and WRF

(E.g. - Can provide WRF interoperability with COAMPS)

“Wrapperized” framework coupling now exists (ARW only), but doesn’t address issues with CMI.



Option 3: Extend ESMF to Provide Key Functionalities of WRF CMI as ESMF Options



- *Would require technical feasibility study and substantial investment of resources.*

Likely consequences of failure to find practical solution to WRF-ESMF conundrum

- Under NUOPC, **operations centers** gradually abandon WRF software framework and **adopt solely ESMF architecture**.
- Most of **research** community continues to **use WRF software framework**.
- Management and support of a **common baseline code** for research and operations becomes **too costly to sustain**.
- **Research and Operations** diverge on largely **independent paths** with unique, highly **incompatible modeling systems**. Huge resource waste.
- **Pace of influx** of new science and technologies into U.S. operations becomes **sub-optimal**, despite considerable leveraging opportunities realized through implementation of (draft) NUOPC concept of operations.

Loss of the WRF process... a hypothetical example:

- Galperin QNSE turbulence scheme for stable BL **installed** in WRF (2007). ✓
- Galperin scheme released to wide research community in WRFv3.0 (2008).
- Many researchers use, evaluate and improve Galperin scheme.
- Based on research results, DTC leads formal T&E and interoperability effort to elevate Galperin scheme to WRF reference status.
- ***But... no simple path into operations w/o starting over at first step, because operations will use incompatible models in different framework.***

Summary Assessment

(by WRF Program Coordinator)

Six critical questions...

- | | |
|--|-----|
| • Can U.S. operations centers gain substantial leveraging opportunities <u>among themselves</u> by transitioning to an ESMF-only architecture (Option 1)? | Yes |
| • Are there advantages for researchers to have continued access to most <u>functionality</u> of current WRF CMI? | Yes |
| • Can the existing “wrapperized” WRF-ESMF meet requirements of U.S. operations (Option 2)? | No* |
| • Can the existing ESMF (alone) meet requirements of the mesoscale research community (Option 1)? | No |
| • Would collapse of community infrastructure (managed/ supported code, DTC T&E, etc.) lead to less efficient infusion of new science and technology into operations? | Yes |
| • If resources are made available, can the chief functions of WRF CMI be replicated as options in ESMF (Option 3)? | TBD |

*May meet short term needs for at least one OPC.

Recommendation (by Program Coordinator)

Appoint a team to...

- **Identify chief functional requirements** of WRF science codes to be supported by a software framework (from perspective of limited-area WRF users).

Appoint a technical/management team to...

- **Determine status** of each function in ESMF.
 - function exists now
 - function is planned (timetable?)
 - function is not currently planned
- **Analyze potential** to develop and/or accelerate desired functions needed for ESMF.
 - maintain external “look and feel” of WRF for users.
 - ensure user interaction is straightforward.
- **Develop cost and time estimates** for all new functions.

...and **report to ExOB.**

By actively engaging in ESMF development (including resources), the WRF partnership can:

- preserve/extend benefits of community modeling*
- accelerate transition to ESMF end state, and*
- ensure design that minimizes impact to WRF users.*

Questions?

Proceed with open discussion