



---

# **Comprehensive Concepts for Post VIPR Environmental Particulate (EP) FOD Research Activities**

Michael Venti (Ctr), NASA Armstrong Flight Research Center  
Mark Woike, NASA Glenn Research Center

March 23, 2016



# Post VIPR EP FOD Status

- NASA was approached by AFRL in Sep. 2015 to consider developing a comprehensive research concept for EP FOD
- Currently in the conceptual planning stages, preliminary legwork started including discussions with industry, other government agencies and thru AFRL/FAA allied nations and airworthiness authorities
- Idea for a CoE on FOD has been briefed to NASA ARMD Management
- Also briefed to NASA Convergent Aeronautical Solutions Program and along with other NASA ARMD representatives
  - Be applicable to N+3 air vehicle designs
  - Focuses on mitigation in addition to understanding impact
  - NASA may be able to bring other analytical tools to bear on the problem
- Discussions with Air framers and the FAA were held on 12/3
  - FAA interested to be active partner
  - Interested in effect on vehicles internal systems in addition to engines (Cabin/Avionics)



# Post VIPR EP FOD Status

- AFRC has identified a AF owned test stand at Edwards for regeneration
  - Requires minimal to moderate modernization
- Resources required to fully develop design and generate cost estimates for standing the EP FOD research effort up
- Effort more realistically would become system vs center of excellence bringing all available research assets to bear in coordinated effort
  - Smaller scale modeling/academia labs/allied nations/OGA

CONCEPTUAL



# EP FOD Research

## MOTIVATION

- **Airspace reduction can be crippling during volcanic eruption event**
- **Safety of operations – People vs money**
- **Taxed ATC system**
- **Loss of airlift capability – Military and Commercial**
- **Loss of critical aircraft transportation if airspace restrictions are too conservative , more data is needed to ‘right’ size airspace restrictions**

## CHALLENGE

- **Current knowledge base is dispersing**
- **Problem still exists and is growing**
  - **Sand**
  - **Volcanic Ash**
  - **Other**
- **No facility/ies currently exists with expertise in volcanic ash, testing and hardware**
- **Engine model, technology, and type variance not understood**
- **Need range of concentration and material data over significant runtimes**

## APPROACH

- **Collaborative infrastructure and process**
- **Standup joint use FOD research system.**
  - **DoD and commercial use**
- **Explore regenerating legacy test site**
- **Consider ground and flight FOD research**
- **Evaluate fuel savings technologies as part of facility for multiple WS for USAF/DoD**
- **Develop optimized test matrix, with properly chosen test apparatus, to obtain comprehensive decisional data set at reasonable cost**
  - **Maximize run time, number of variables**
  - **Minimize cost of investigation**

## PROPOSED SOLUTION

- **Establish working group to understand future ruling, regulations, guidance and coordination of resources**
- **Stand up test facilities/resources capable of executing research effort**
  - **Small scale labs answering fundamental questions**
  - **Large scale test site capable of testing multi engine types and multi thrust ratings**
- **Self contained adaptable aircraft systems (Environ/Fuel/Hyd/Elect)**
- **Evaluate fundamental mechanisms, gas path, cabin environment and systems**
- **5 year start to finish**

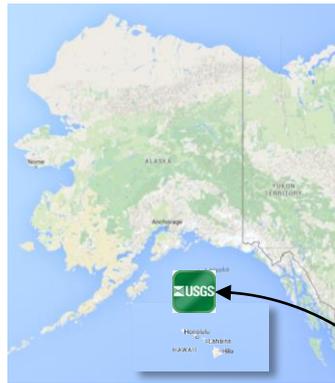
# Comprehensive Concept – Partnering Approach



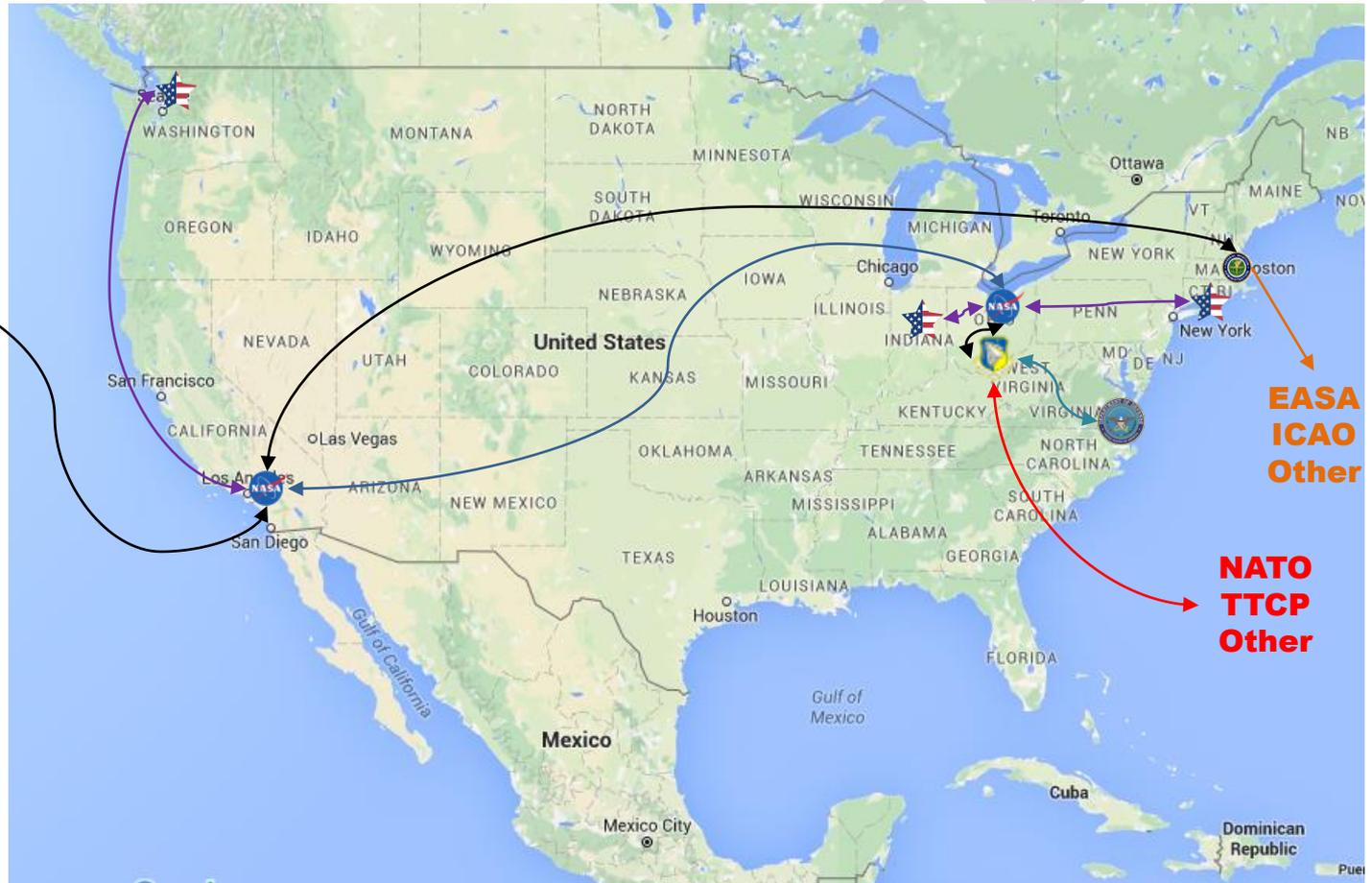
## Agreement Examples:

- NASA-AFRL = SAA
- NASA-OEM/Ind = Contract
- AFRL-Outside = TTCP

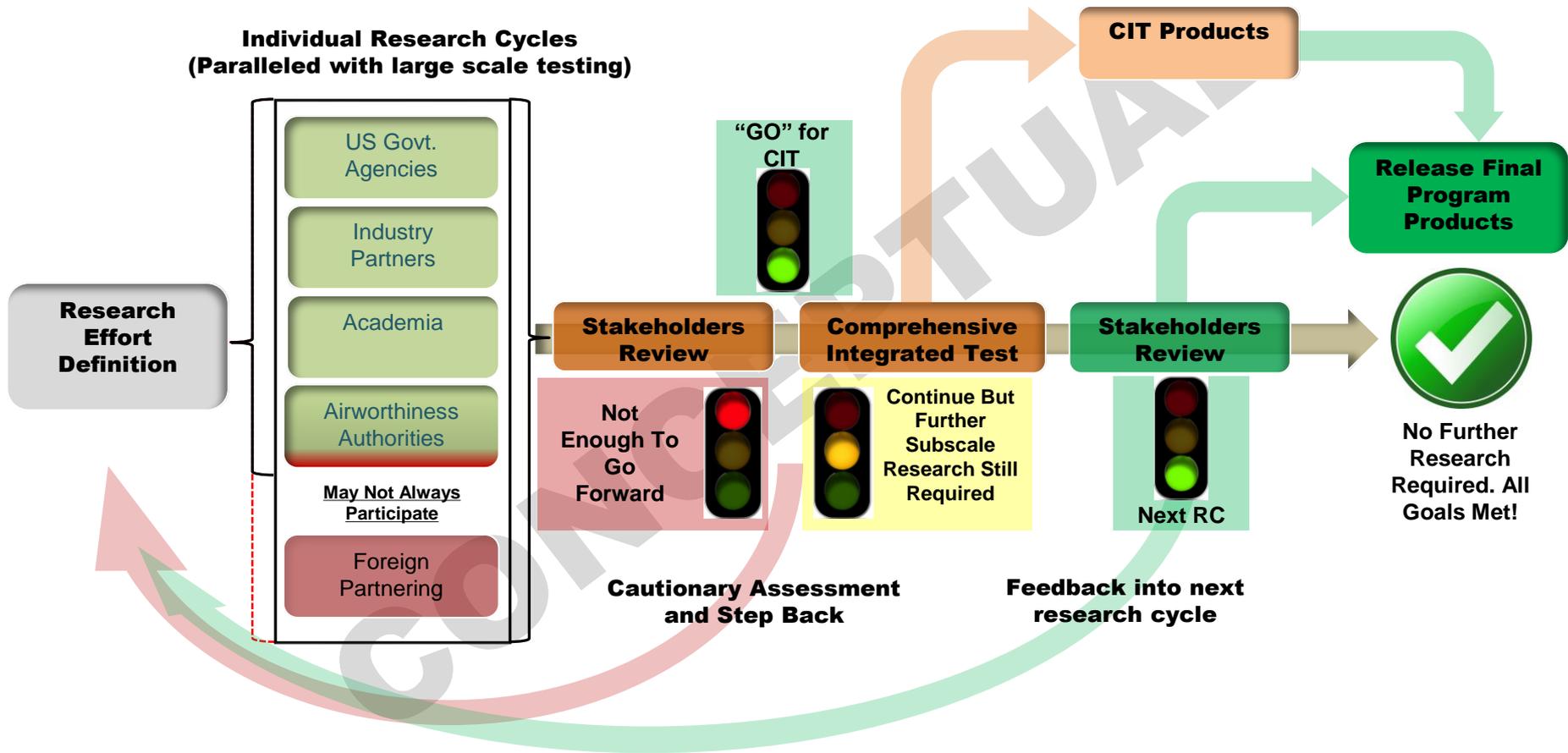
**Contract/Working Mechanisms Must Be Clearly Identified**  
**Upfront >90%**



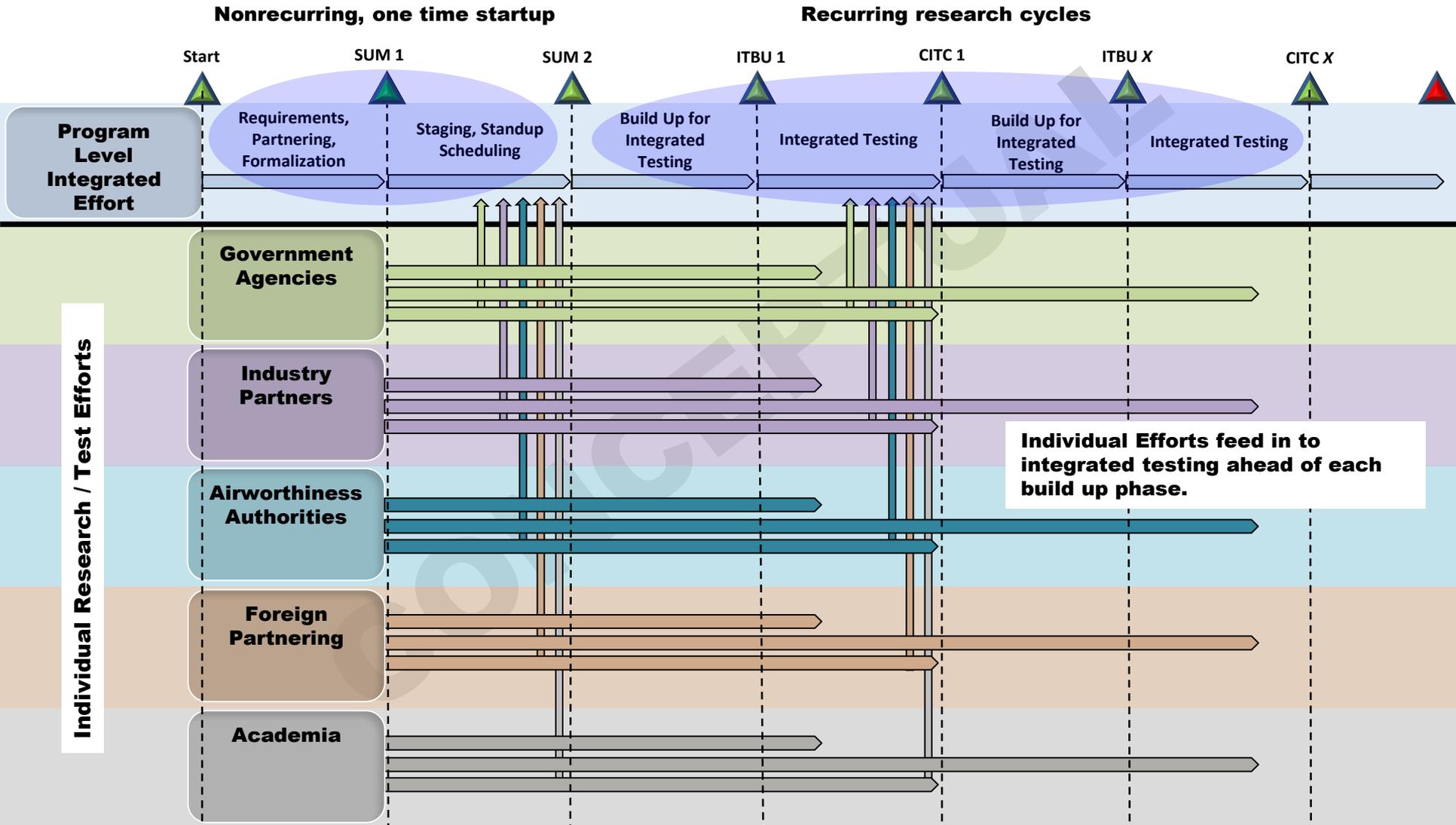
- NASA-NASA
- NASA-OGA
- NASA-OEM
- AFRL-DoD
- AFRL-Outside
- FAA-OAA



# Comprehensive Concept – Technical Approach



# Comprehensive Concept – Roadmap /Schedule



# VIPR Genesis

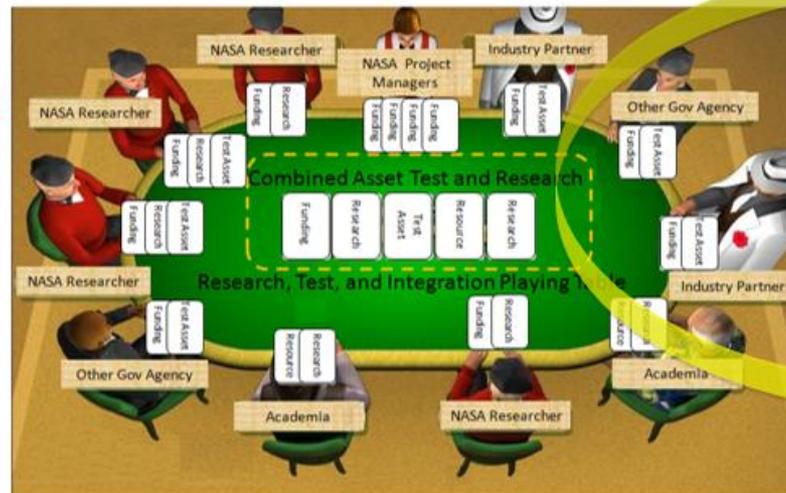


## THE PLAYERS

## Go Test

A non-adversarial version of 'Go Fish' where resources and personnel are pooled to produce integrated tests to conduct research.

**THE POT**  
Pooled Assets and Resources.



**THE PAYOFF**  
Identified Integration and Test Opportunities that Address Real World Industry Needs.

## Everyone is a winner!!

- The sum of the pot is greater than any individual contribution.
- The payoff is a higher TRL research opportunity than any single entity could accomplish by itself.

CONFIDENTIAL

# Next Steps – EP FOD Research



- Continue the planning of the FOD research program
- Resources in place to develop preliminary design and cost estimate for proposed EP FOD Engine Infrastructure.
  - Parties to support core sustainment need identifying
- Future Meetings/Get togethers
  - Audience
  - Location
  - Intervals
  - Point of contact

CONCEPTUAL



# Cheat Sheet/Acronyms/References

---

- VIPR – Vehicle Integrated Propulsion Research
- EP FOD – Environmental Particulate Foreign Object Damage
- OGA – Other Government Agencies
- NATO – North Atlantic Treaty Organization
- FAA – Federal Aviation Administration
- RC – Research Cycle
- CIT – Comprehensive Integrated Test
- SUM – Stand Up Milestone
- ITBU – Integrated Test Build Up
- CITC – Comprehensive Integrated Test Complete
- CoE – Center of Excellence

# COE on EP FOD Conceptual Plan



## Concept Only – EP FOD Research Facility

1. Variable angle inlet direction
2. Variable height from ground
3. Variable for/aft/left/right
4. Block house
5. Fuel barn
6. Systems (ECS/Elect/Hyd) test lab
7. IT for remote test operators
8. FOD ingestion rig area
9. Staging area for multiple engines
10. Safety equipment (medical/spill/fire)

