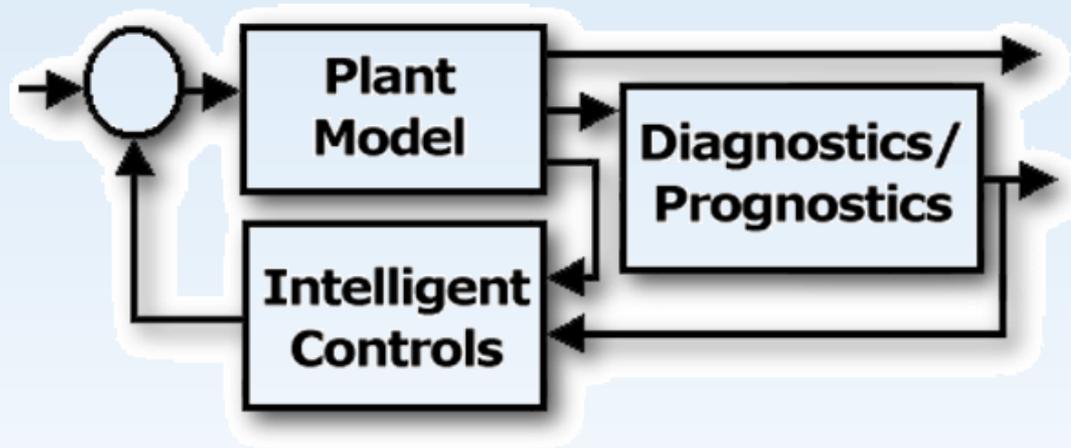


Propulsion Control and Diagnostics Research under NASA Aeronautics Research Mission Programs



4th NASA GRC PCD Research Workshop
Dec 11-12, 2013, Cleveland, OH

Dr. Sanjay Garg
Branch Chief
Ph: (216) 433-2685
email: sanjay.garg@nasa.gov
<http://www.grc.nasa.gov/WWW/cdtb/>

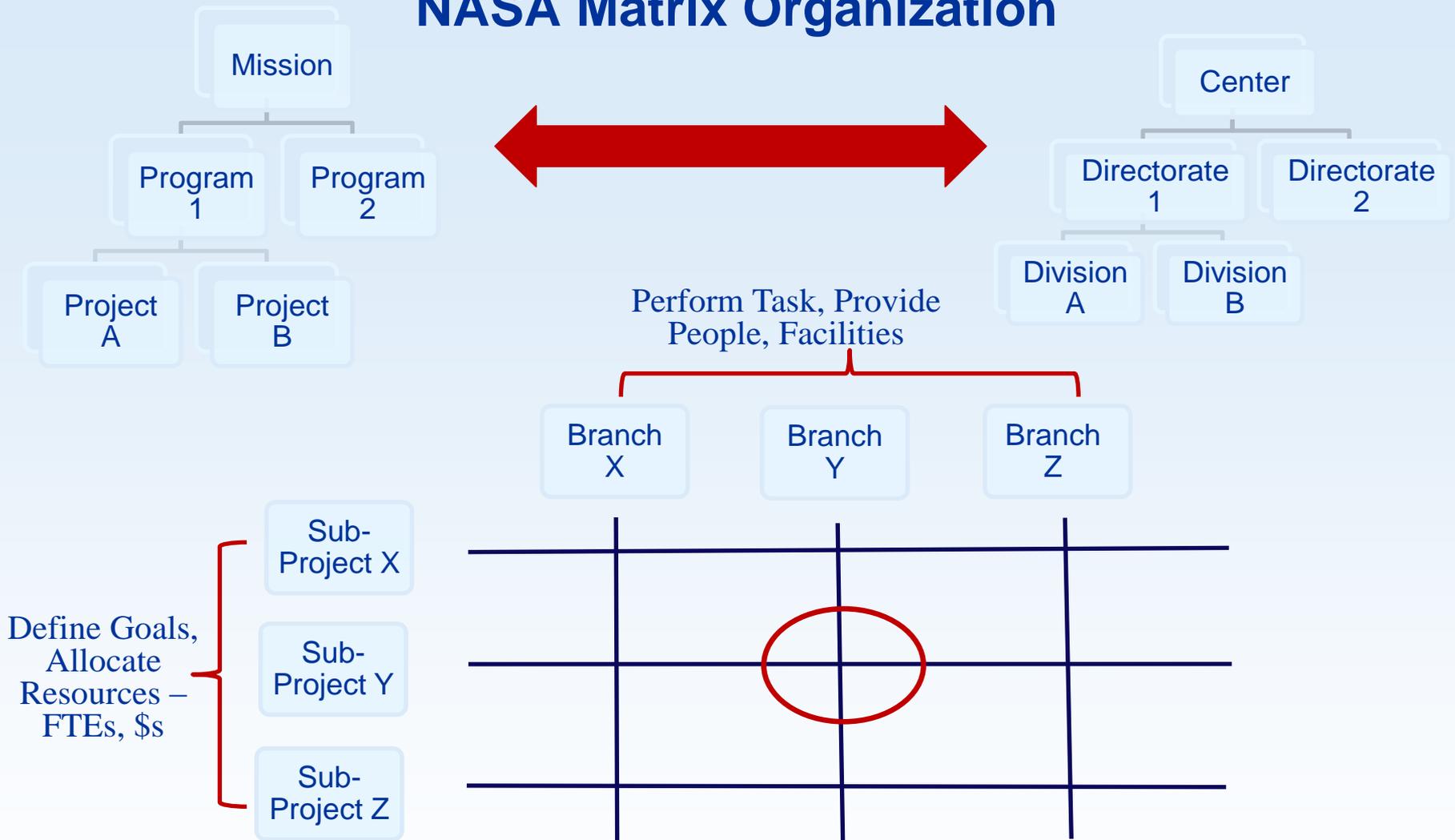
Glenn Research Center

Controls and Dynamics Branch

at Lewis Field



NASA Matrix Organization



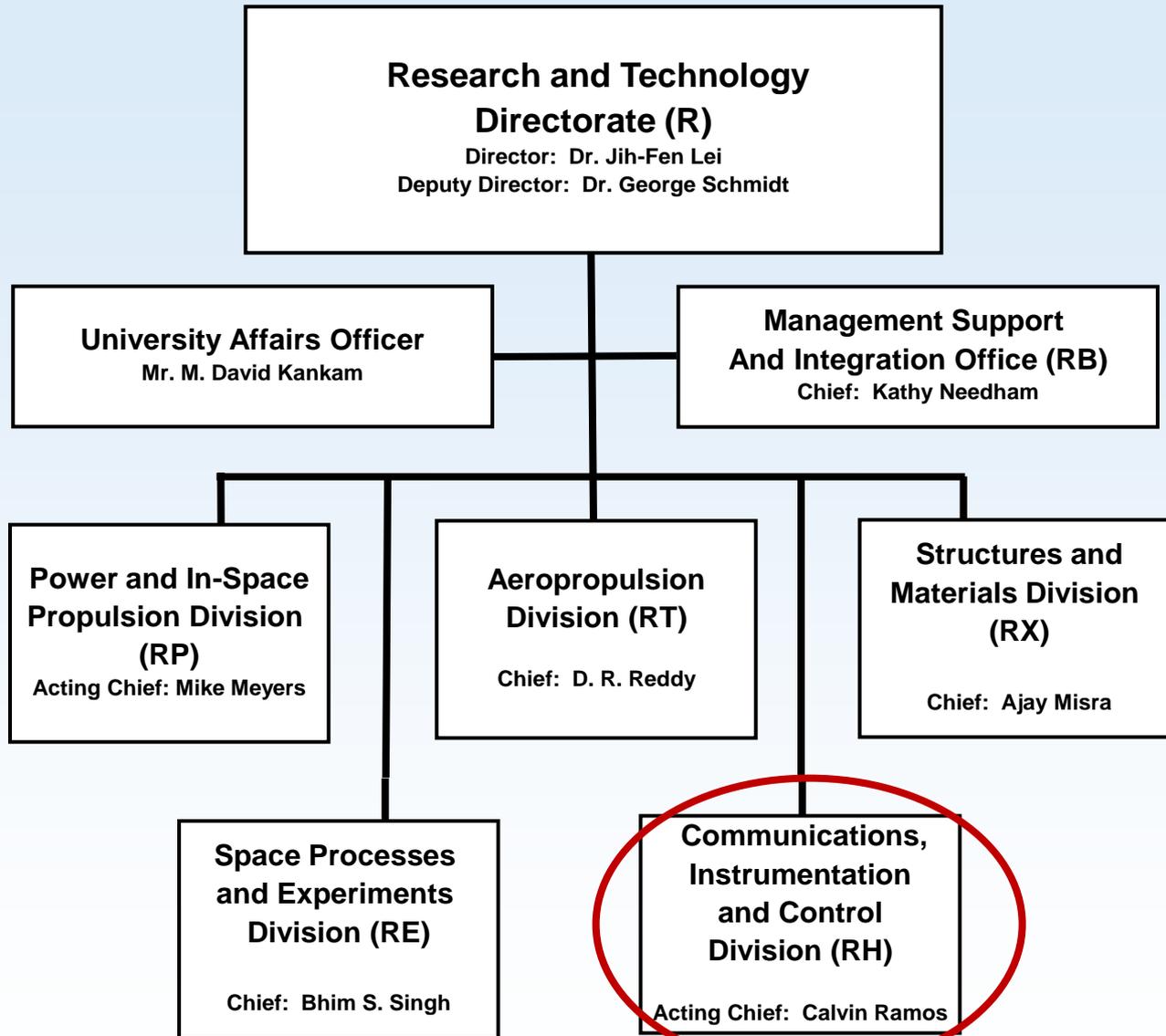
We work with Project Management to identify and implement research and technology development tasks which are consistent with project objectives

Glenn Research Center

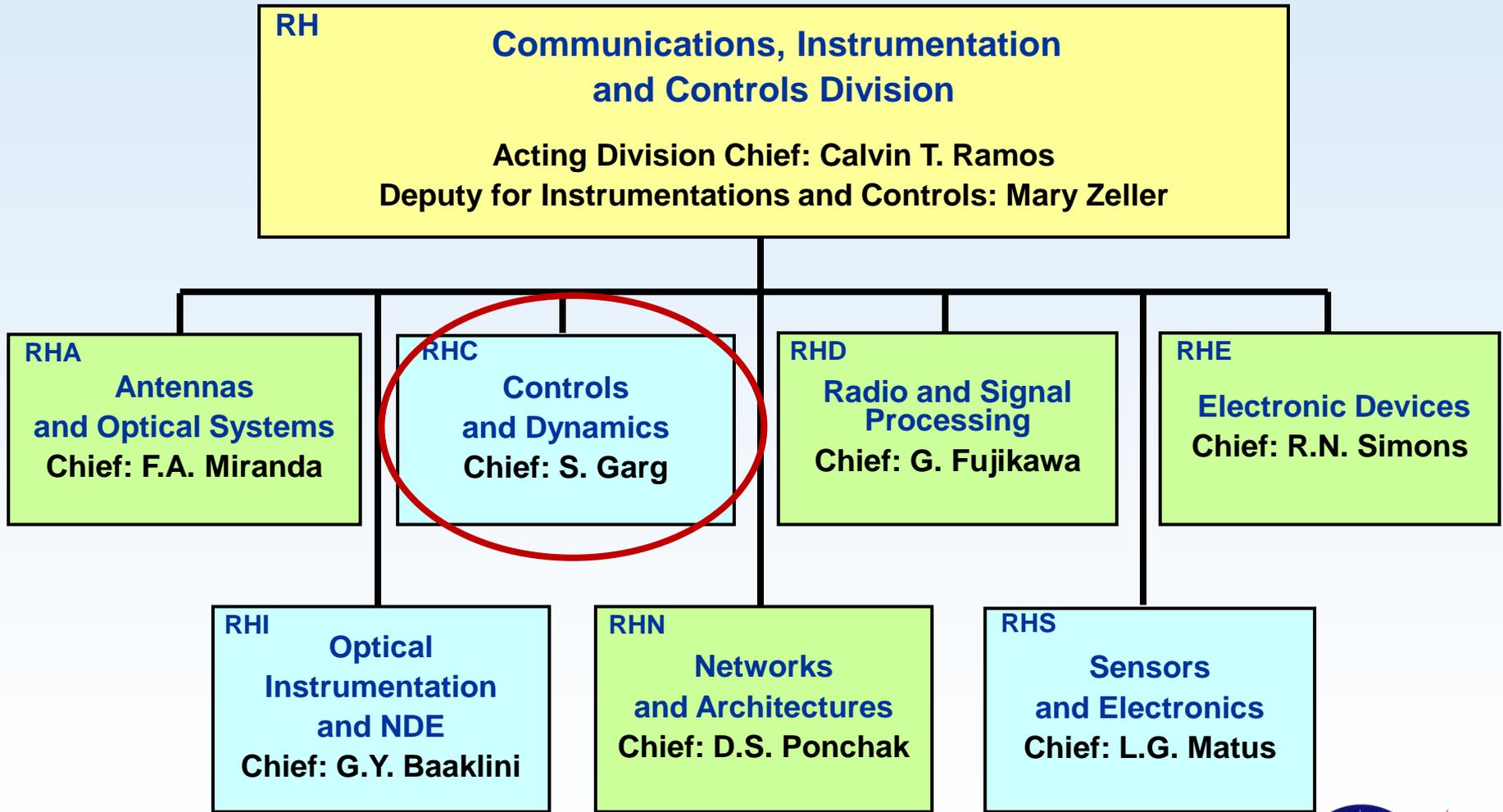
Controls and Dynamics Branch

at Lewis Field





Code RH Division Organizational Structure



Glenn Research Center

at Lewis Field

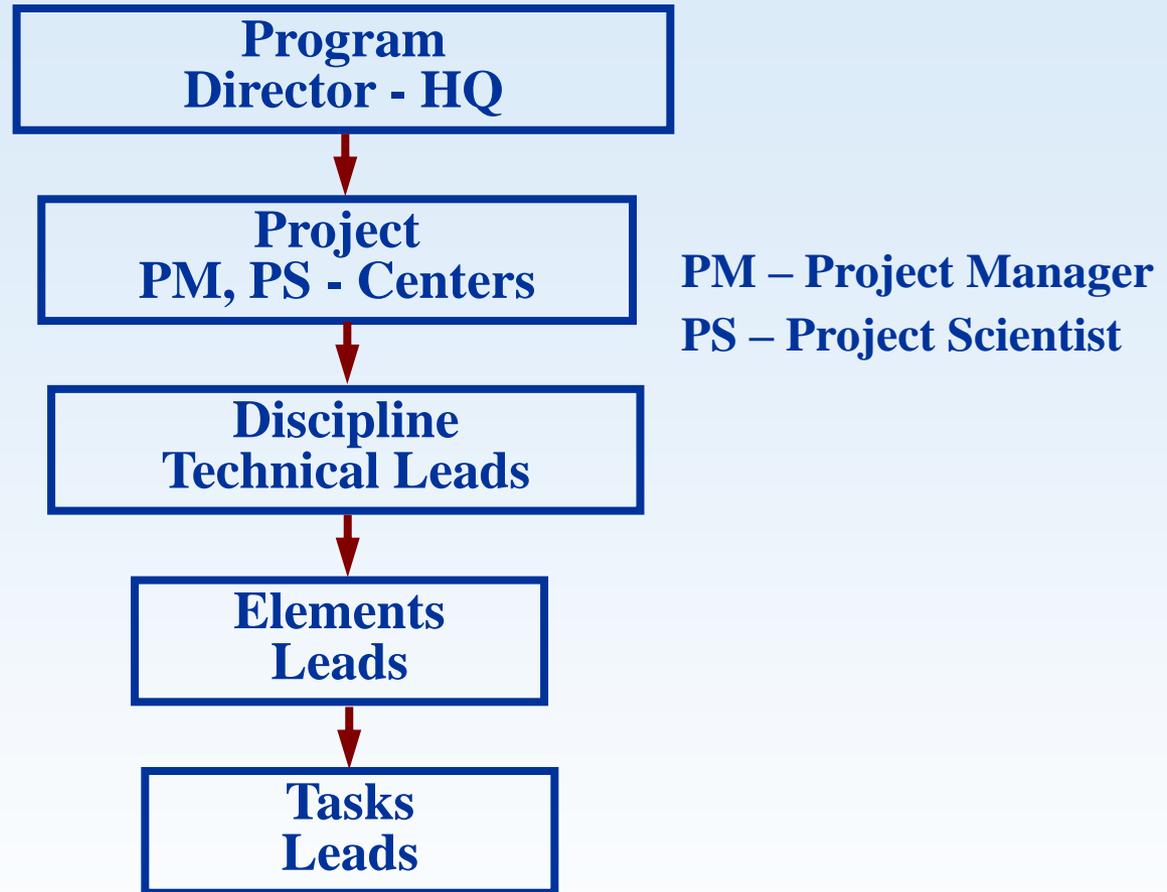


Controls & Dynamics Branch Overview

- Mission
 - Research, develop and verify aerospace propulsion dynamic modeling, health management, control design and implementation technologies that provide advancements in performance, safety, environmental compatibility, reliability and durability
 - Facilitate technology insertion into the mainstream aeropropulsion community
- Capabilities
 - 24 engineers and scientists - most with advanced degrees and extensive experience in aeropropulsion controls related fields
 - Extensive computer-aided control design and evaluation facilities including real-time and man-in-the-loop simulation facility
 - Strong working relationship with controls technology groups in the aerospace propulsion industry, academia and other agencies



NASA ARMD Management Structure



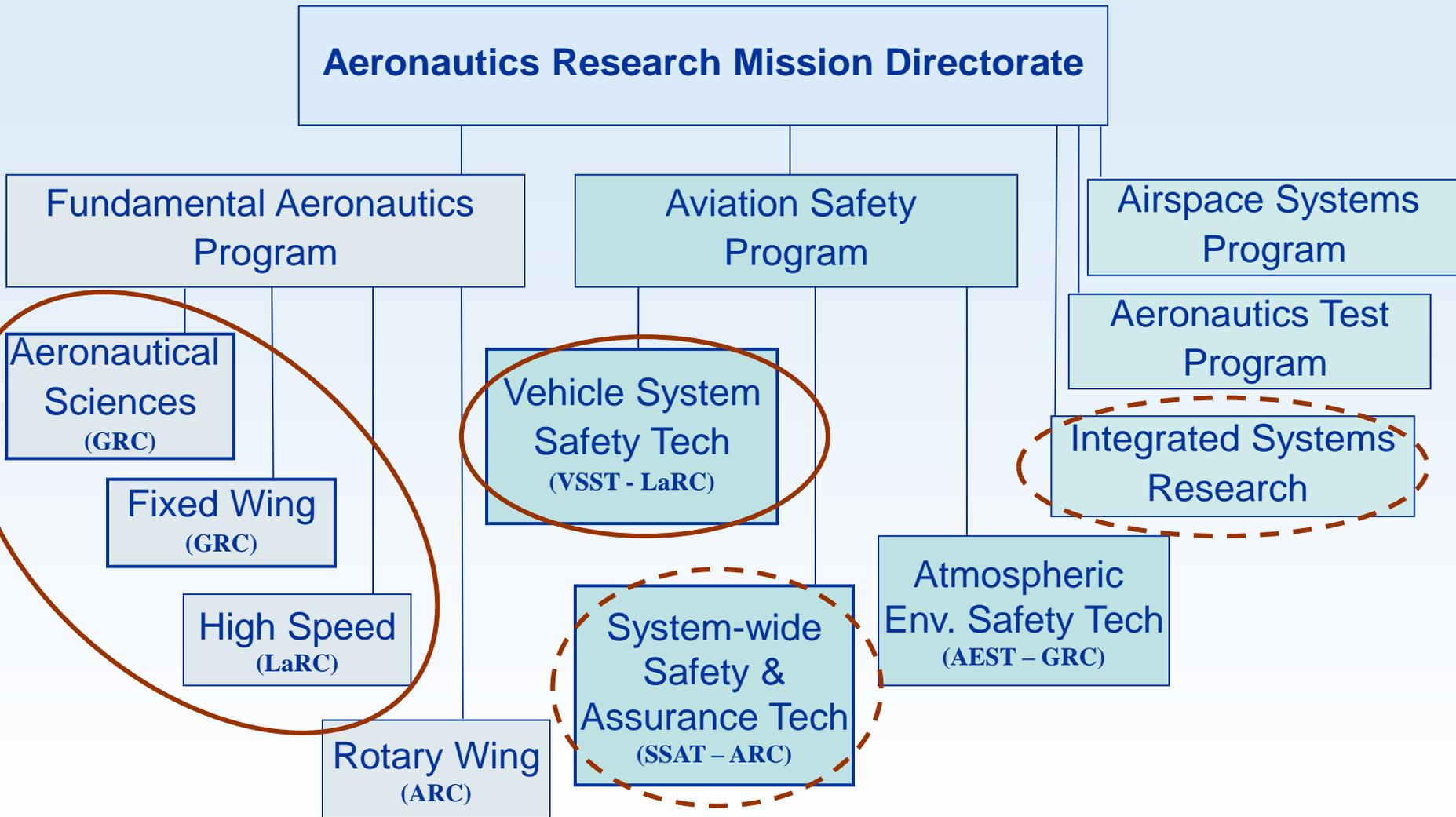
- **Each Center: ARC, DFRC, GRC, LaRC; has a center Point of Contact (PoC) who coordinates with Program Directors and Project Managers**
- **Line Management coordinates with Discipline Technical Leads**

Glenn Research Center

at Lewis Field



NASA Aeronautics Program Structure Effective FY13



Glenn Research Center

Controls and Dynamics Branch

at Lewis Field



CDB Tasks Under NASA Aeronautics Research

Fundamental Aeronautics Program (FAP)

- Aeronautical Sciences (AS)
 - Distributed Engine Control – Session 4
 - Model-Based Engine Control (now under VSST) – Session 3
 - Pressure Gain Combustion
 - Active Combustion Control – Session 5
- Fixed Wing (FW)
 - Dynamic Systems Analysis – Session 6
- High Speed (HS)
 - Aero-Propulso-Servo-Elasticity – Session 1
- Hyp / AFRL SAA – CCE Dynamic Modeling and Control – Session 1

Aviation Safety Program (AvSP)

- Vehicle System Safety Technologies (VSST)
 - Gas Path Health Management – Session 3
 - Enhanced Engine Control – Session 2
- System-wide Safety Assurance Technologies (SSAT)
 - Run Time Validation of Complex Systems – Poster

Glenn Research Center

Controls and Dynamics Branch

at Lewis Field



Engine Simulation Software Packages

The following engine simulation software packages, developed in Matlab/Simulink and useful for propulsion controls and diagnostics research, are available from NASA GRC software repository

- **MAPSS** – Modular Aero-Propulsion System Simulation
 - Simulation of a modern fighter aircraft prototype engine with a basic research control law:
<http://sr.grc.nasa.gov/public/project/49/>
- **C-MAPSS** – Commercial Modular Aero-Propulsion System Simulation
 - Simulation of a modern commercial 90,000 lb thrust class turbofan engine with representative baseline control logic:
<http://sr.grc.nasa.gov/public/project/54/>
- **C-MAPSS40k**
 - High fidelity simulation of a modern 40,000 lb thrust class turbofan engine with realistic baseline control logic:
<http://sr.grc.nasa.gov/public/project/77/>

Additionally, a one hour educational video on “Fundamentals of Aircraft Engine Control” is available at:

<http://mediaex-server.larc.nasa.gov/Academy/SilverlightPlayer/Default.aspx?peid=135553bc3b7b4171b7c54ee0578489211d>

Glenn Research Center

Controls and Dynamics Branch

at Lewis Field



Recent Software Package Releases

Various other software packages, specially for propulsion system related analyses, are available from the NASA GRC software repository:

- **Extended Testability Analysis (ETA) Tool**
 - Extends the testability analysis capabilities of Qualtech Systems Inc.'s Testability Engineering And Maintenance System (TEAMS) software:
<https://sr.grc.nasa.gov/public/project/82/>
- **Systematic Sensor Selection Strategy (S4) Software**
 - Optimally select a sensor suite from a larger pool of candidate sensors based on their performance in a diagnostic system:
<https://sr.grc.nasa.gov/public/project/81/>
- **Time Accurate Secteded-One Dimensional Reactive Code for simulation, prediction, and control of combustion instabilities**
 - Utilizes a simplified computational fluid dynamics (CFD) algorithm to simulate combustion and acoustic processes, including instabilities, in combustors with complex shapes:
<https://sr.grc.nasa.gov/public/project/85/>



CDB Technologies Available for Licensing

NASA GRC Innovation Projects Office provides information on partnering with NASA including technologies available for licensing:

<https://technology.grc.nasa.gov/index.shtml>

The follow CDB developed technologies are listed as available for licensing:

- **Optimized tuner selection for engine performance estimation**
The patented Glenn methodology applies a systematic approach using a Kalman filter algorithm to produce a model tuning parameter vector that can more accurately estimate aircraft engine performance:
<https://technology.grc.nasa.gov/tech-detail-coded.php?cid=GR-5136&mini=y>
- **High speed idle engine control mode**
Patent pending: HSI control mode increases the speed of the engine fan and core shafts at low vehicle airspeeds, thus allowing for faster engine response: <https://technology.grc.nasa.gov/tech-detail-coded.php?cid=GR-5163&mini=y>
- **Atmospheric Turbulence Modeling for Aero Vehicles**
Patent pending: This model is more representative of the actual fractional order nature of atmospheric disturbances than conventional methods:
<https://technology.grc.nasa.gov/tech-detail-coded.php?cid=GR-5178&mini=y>

Collaboration Opportunities

- NRA (NASA Research Announcements)
 - Open to industry and universities
 - Very focused on specific topics
 - Announced by Projects on a periodic basis

<http://www.aeronautics.nasa.gov/nra.htm>
- SBIR (Small Business Innovative Research)
 - Open to small businesses
 - Very broad areas of call. Topics determined by Programs/Projects

<http://sbir.gsfc.nasa.gov/>
- Space Act Agreement – no direct NASA funding
 - Open to industry/universities/govt. agencies
 - Ideal for collaboration on mutual areas of interest without exchange of funds or with inflow of funds to NASA efforts
 - Opportunity for industry to leverage NASA investment in projects
- Student and Faculty Programs

<http://www.nasa.gov/centers/glenn/education/index.html>

Glenn Research Center

Controls and Dynamics Branch

at Lewis Field

