Radioisotope Power Systems Program

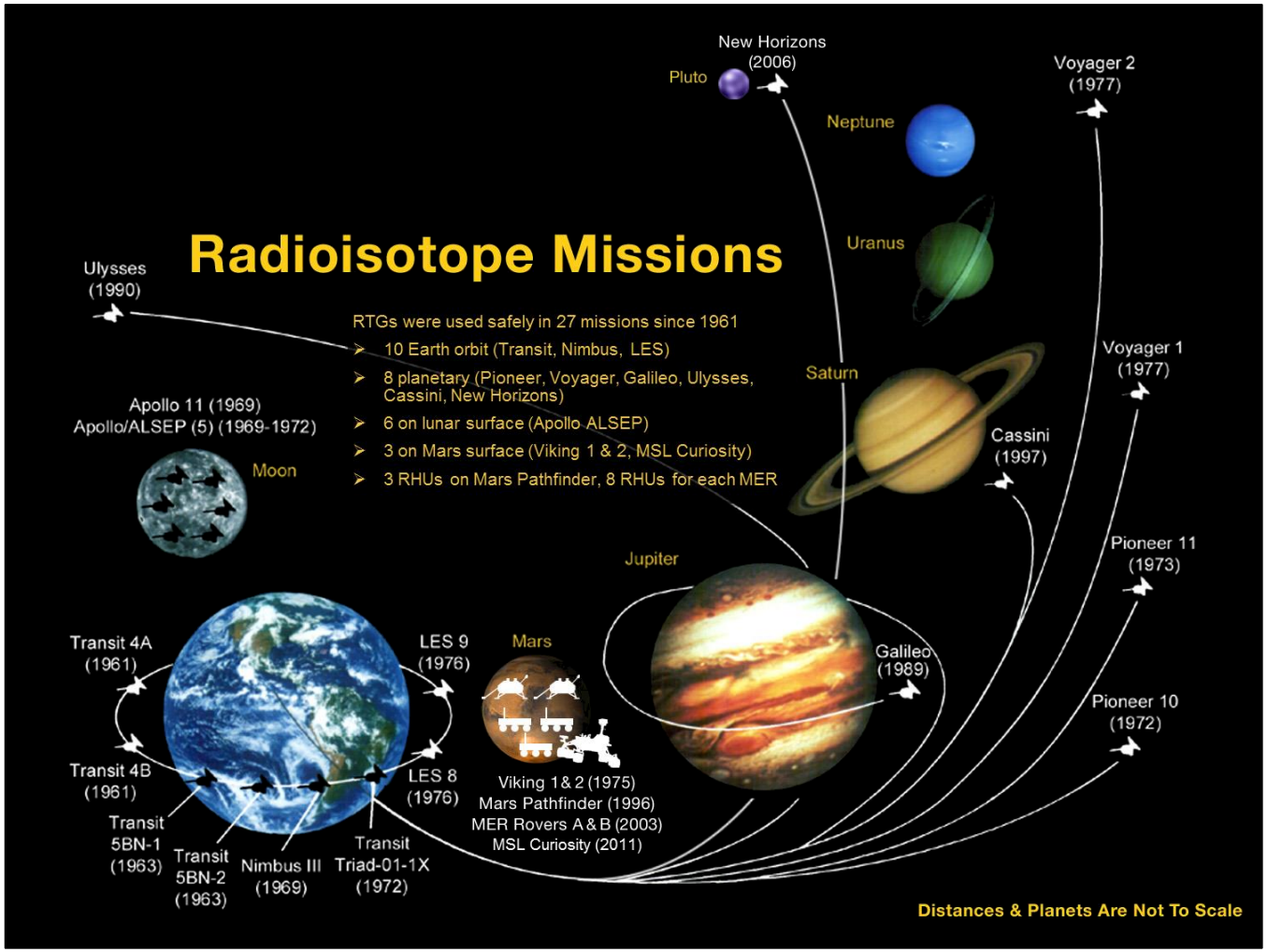
NASA'S RADIOISOTOPE POWER SYSTEMS PLANNING AND POTENTIAL FUTURE SYSTEMS OVERVIEW

June F. Zakrajsek (NASA), Dave F. Woerner (JPL), Dirk Cairns-Gallimore (DOE),
Stephen G. Johnson (INL), Louis Qualls (ORNL)

IEEE-2016 Paper 2255

Contents

- RPS Purpose
- System Formulation & Mission Integration (aka PP&A)
- RTG Integration
- RPS Sustainment
- Technology Maturation Process
- MMRTG
- eMMRTG
- Summary



To make RPS ready and available to support the exploration of the solar system in environments where the use of conventional solar or chemical power generation is impractical or impossible to meet the needs of the missions

RPS Program Purpose

- Strategic leadership
- Acquires flight hardware, through DOE, to supports missions
- Maintains a robust technology development portfolio
- Works to reduces National Environmental Policy Act (NEPA) and launch safety approval schedule risk
- Maximizes utilization of the available Pu-238 supply in the development of RPS for science missions;
- Provides insight to DOE implementation of RPS-related production infrastructure operations;
- Provides insight to DOE implementation of the Plutonium-238 Supply Project.

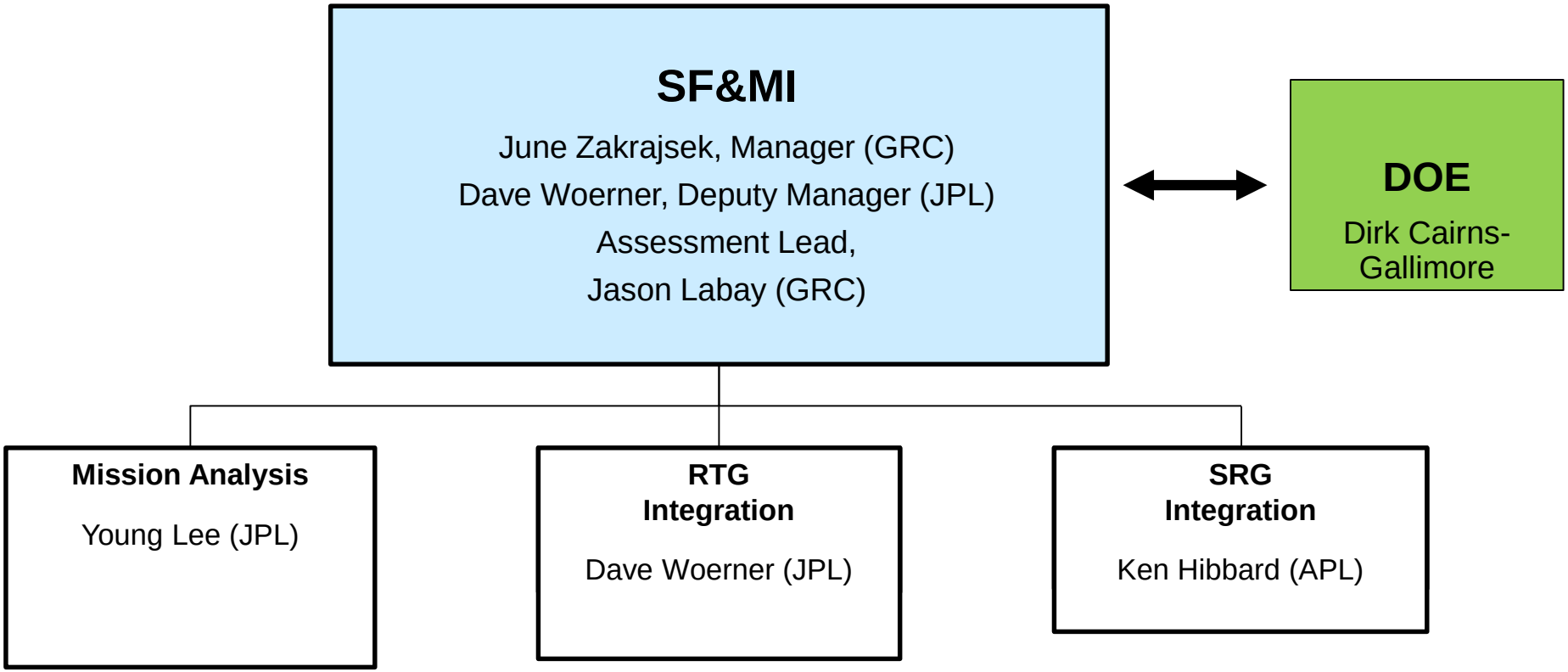
Systems Formulation & Mission Integration

(aka Program Planning and Assessment)

- Customer / User engagement
  - Missions – Mars 2020, NF
  - Assessment Groups (OPAG, SBAG, etc.)
  - Developing User's Guide for MMRTG – See LPSC peripheral session & RPS website
- Develops requirements and sustainment strategy
  - eMMRTG: Improves EODL power by > 50% compared to MMRTG
  - Stirling/Dynamic RG: Higher power, robust, reliable
- Assesses State of Art for RPS technologies
  - RFI for Stirling
- Mission Studies to inform system needs to support planetary science: NPAS
- Developing life performance prediction models
  - MMRTG LPPM
  - Stirling Risk Informed Life Models and Prediction Models
- Performs as the Surrogate Mission
  - Cross Flight Center with DOE Mission Team

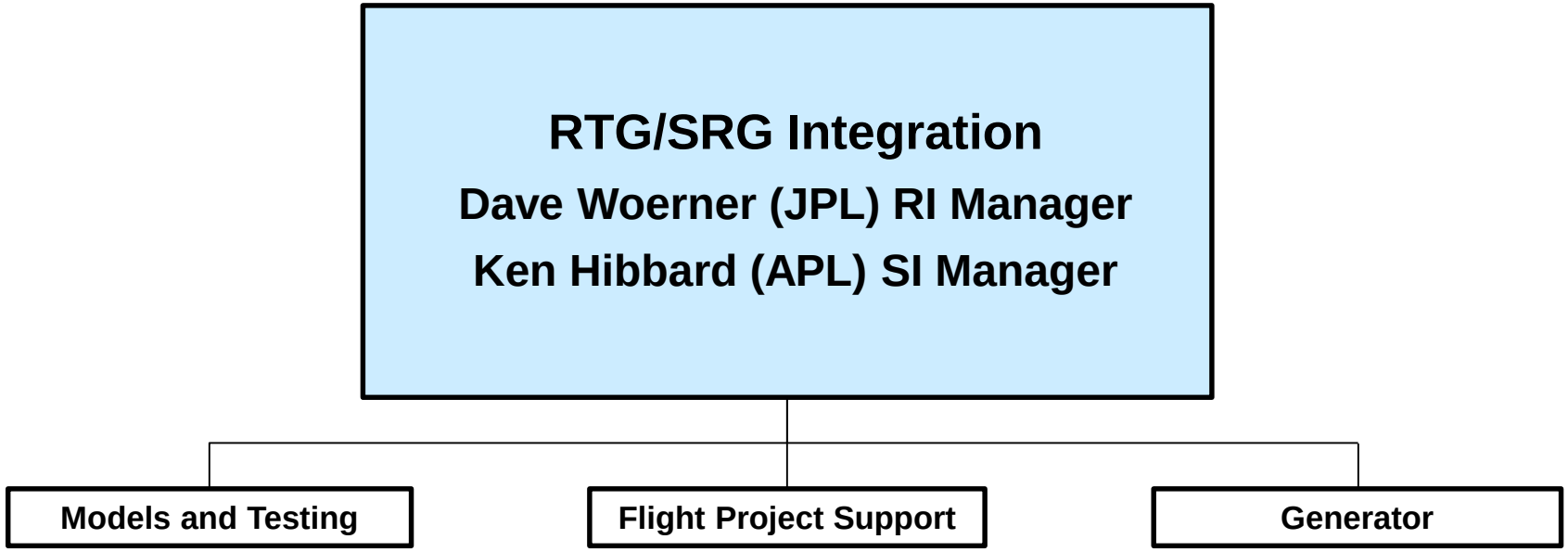
Systems Formulation & Mission Integration

(aka Program Planning and Assessment)



Systems Formulation & Mission Integration

(aka Program Planning and Assessment)



- LLPM
- RILT

- Mars 2020
- New Frontiers
- MMRTG Info Release

- eMM*
- Concepts
- Requirements

RPS Sustainment

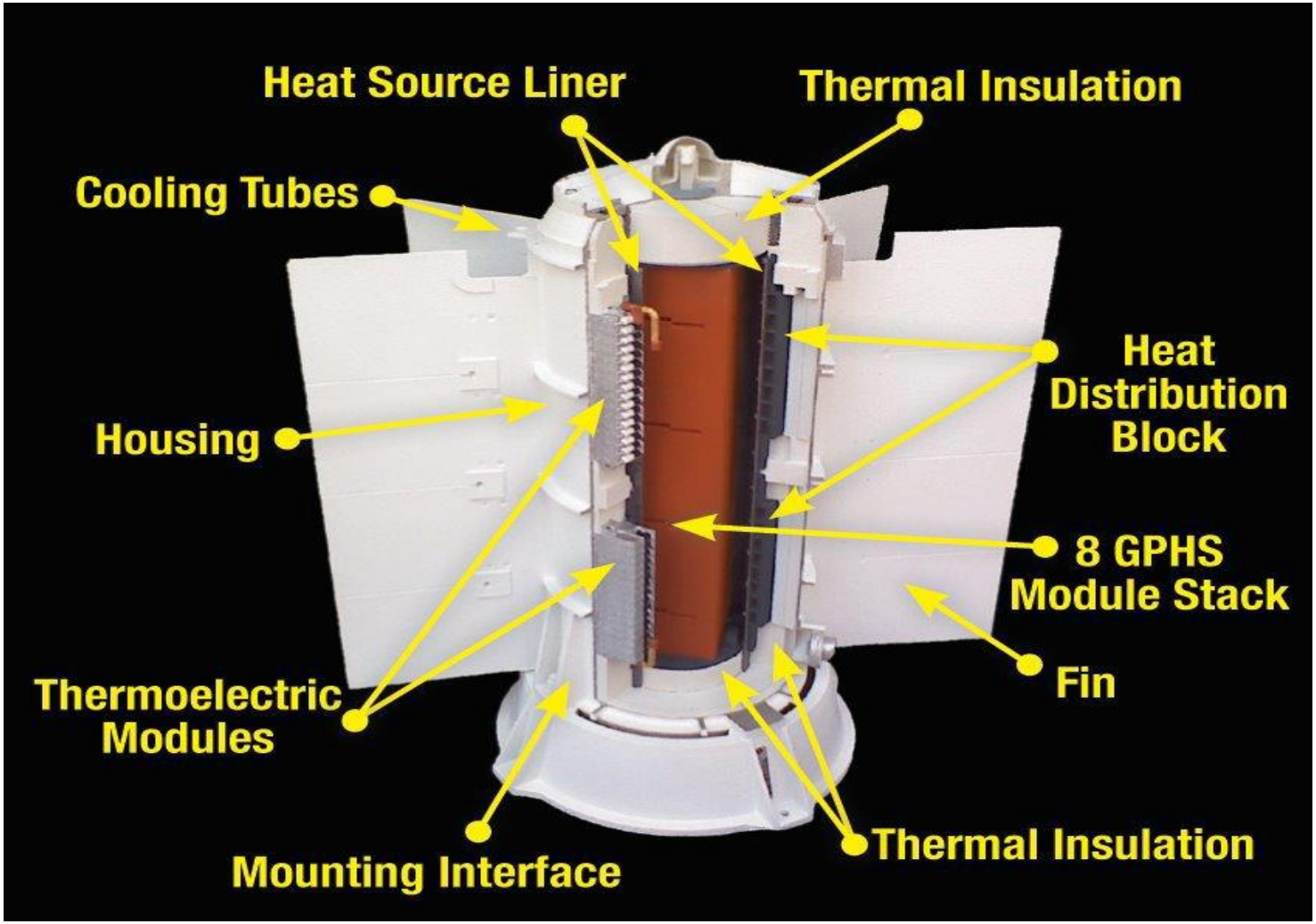
- Program Requirement driven
  - The RPS Program shall sustain current and future RPS capabilities and the necessary support functions to provide for future missions as required
- RPS Program Sustainability Definition:
  - Long term investment to maintain critical or key Government and Contractor competencies, skills, and facilities. Investment means to strategically (content and timing) and economically balance these critical and key assets across the RPS Program Portfolio to meet NASA needs.
- Sustainability Process
  - Identify current critical and key RPS capabilities
  - Identify RPS critical and key capabilities that can be supported by funded in-line work
  - Identify risk of losing a RPS capability
  - Develop sustainment recommendations

Cost Prohibitive To Reestablish RPS Capabilities

4 RPS Capability Sustainment Areas

- Thermoelectric principles, materials, and couple development, modeling, testing, and production, and supporting laboratories
- Stirling principles, convertor development, modeling and testing, and supporting laboratories
- Nuclear risk analysis, probabilistic risk assessment, accident scenario modeling and analysis, risk communications, radiological contingency planning, and compliance engineering and planning.
- DOE facilities used to integrate and fuel RPS
  - Qualified staff
  - Key facilities in an operational mode
  - Base level of safety and technical analysis capabilities
  - Nuclear materials and systems transportation and storage
  - Procurement of necessary

MMRTG

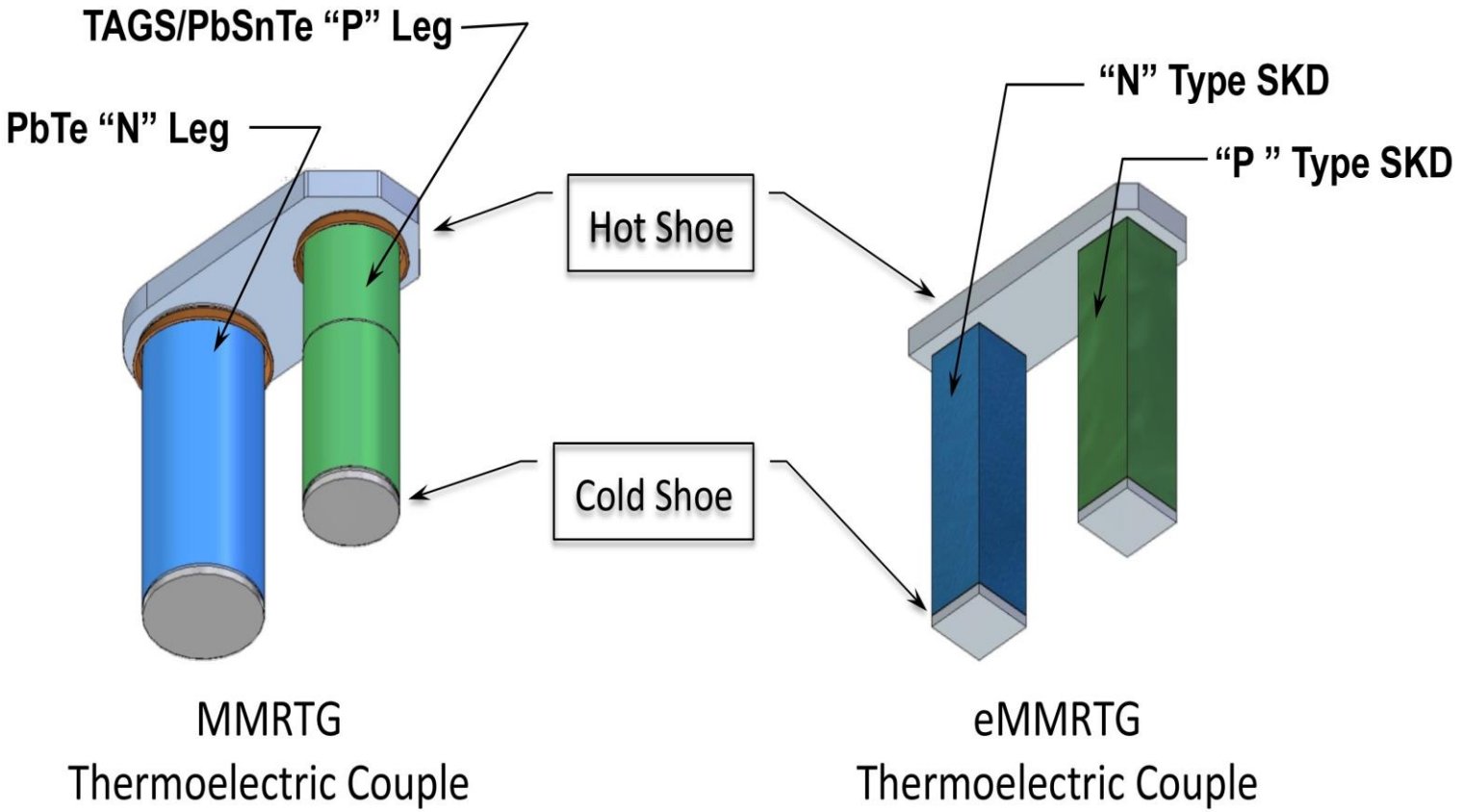


IEEE-2016 Paper 2255

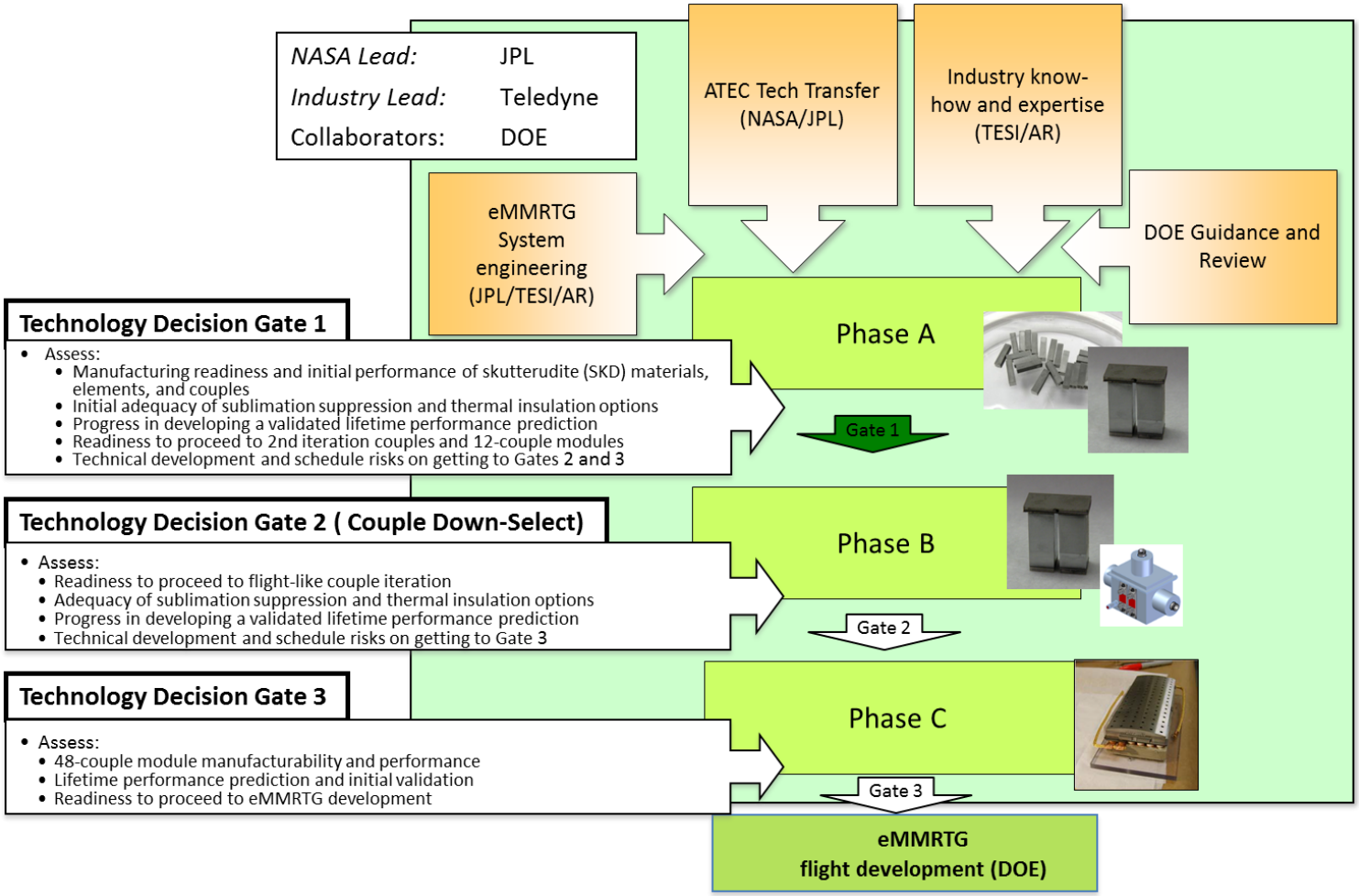
MMRTG Nominal Performance

Parameter	MMRTG
Power, electrical (BOM*)	110 We
Power, thermal (BOM*)	2,000 W_th
Design Lifetime	17 yrs (14 yrs operational)
Diameter, fin-tip to fin-tip	64 cm (25 in)
Height	66 cm (26 in)
Mass	45 kg (94 lbs)
Voltage Range	23-36 V dc
Max Fin Root Temperature	200 C
Random Vibration Qual Limit	0.2 g2/Hz
Pyrotechnic Shock Qual Limit	6,000 g

SKD Technology Potential

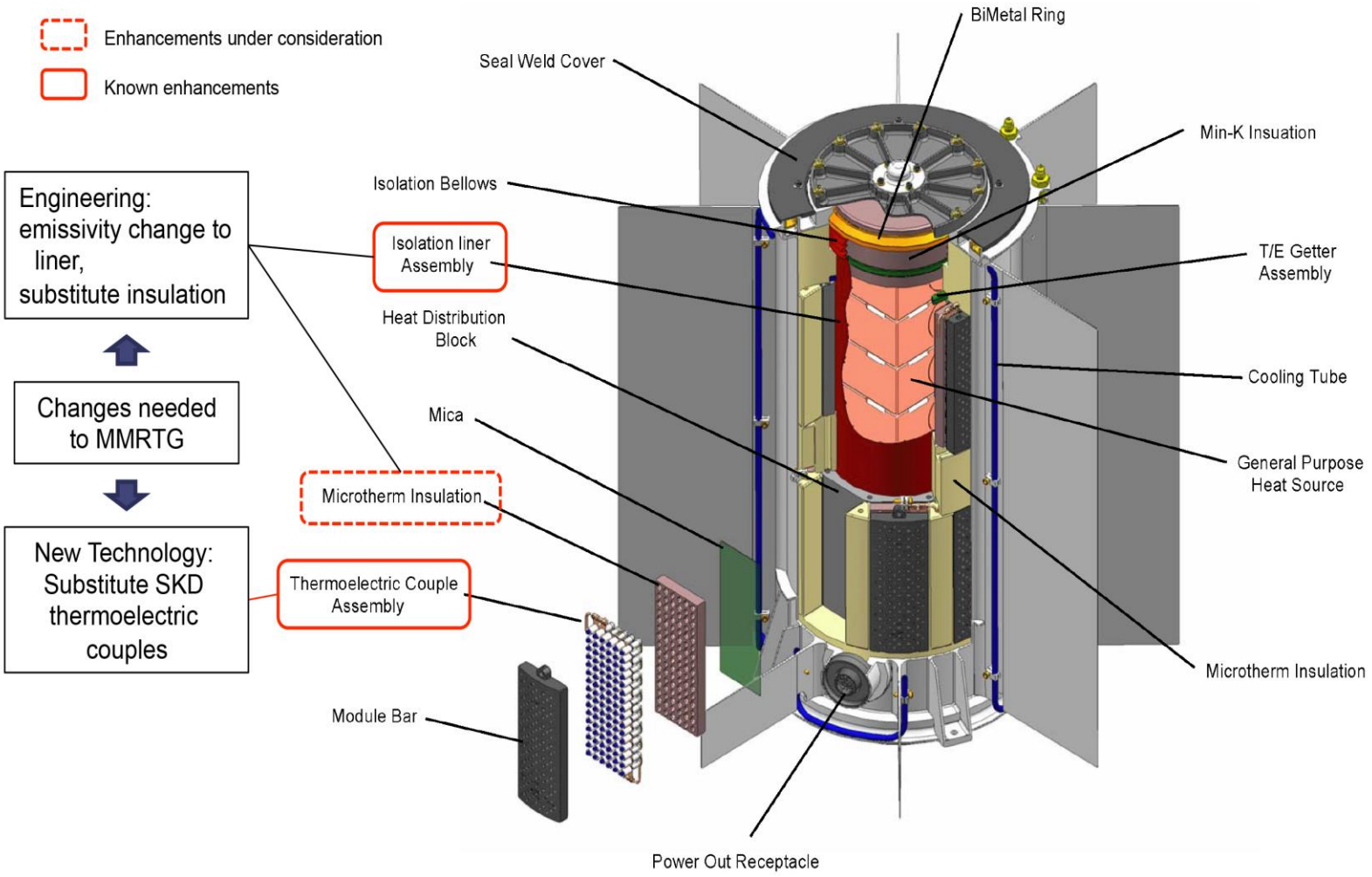


Technology Maturation Process - eMMRTG Specific



IEEE-2016 Paper 2255

eMMRTG



IEEE-2016 Paper 2255

eMMRTG **Projected** Nominal Performance

Parameter	eMMRTG
Power, electrical (BOM*)	141
Power, thermal (BOM*)	2,000 W_{th}
Design Lifetime	17 yrs (14 yrs operational)
Diameter, fin-tip to fin-tip	64 cm (25 in)
Height	66 cm (26 in)
Mass	43 kg (94 lbs)
Voltage Range	23-34 V dc
Max Fin Root Temperature	200 C
Random Vibration Qual Limit	0.2 g2/Hz
Pyrotechnic Shock Qual Limit	6,000 g

IEEE-2016 Paper 2255

Summary

- Make RPS ready and available to support the exploration of the solar system in environments where the use of conventional solar or chemical power generation is impractical or impossible to meet the needs of the missions

- RPS Program works closely with the Department of Energy to implement a process by which potential RPS systems and missions are studied and assessed to inform optimal investments

- Process is being applied today in both thermoelectric and Stirling/Dynamic applications of radioisotope power
  - Supporting Mars 2020
  - Support New Frontiers
  - Develop eMMRTG Technologies and potential eMMRTG
    - » ~50% more power at end of mission

Glenn Research Center
Jet Propulsion Laboratory
Applied Physics Laboratory

Idaho National Laboratory
Los Alamos National Laboratory
Oak Ridge National Laboratory
Sandia National Laboratories