



Artificial Gravity Research Project Overview

International Countermeasures Research Working Group Meeting
Prague – June 30th, 2015

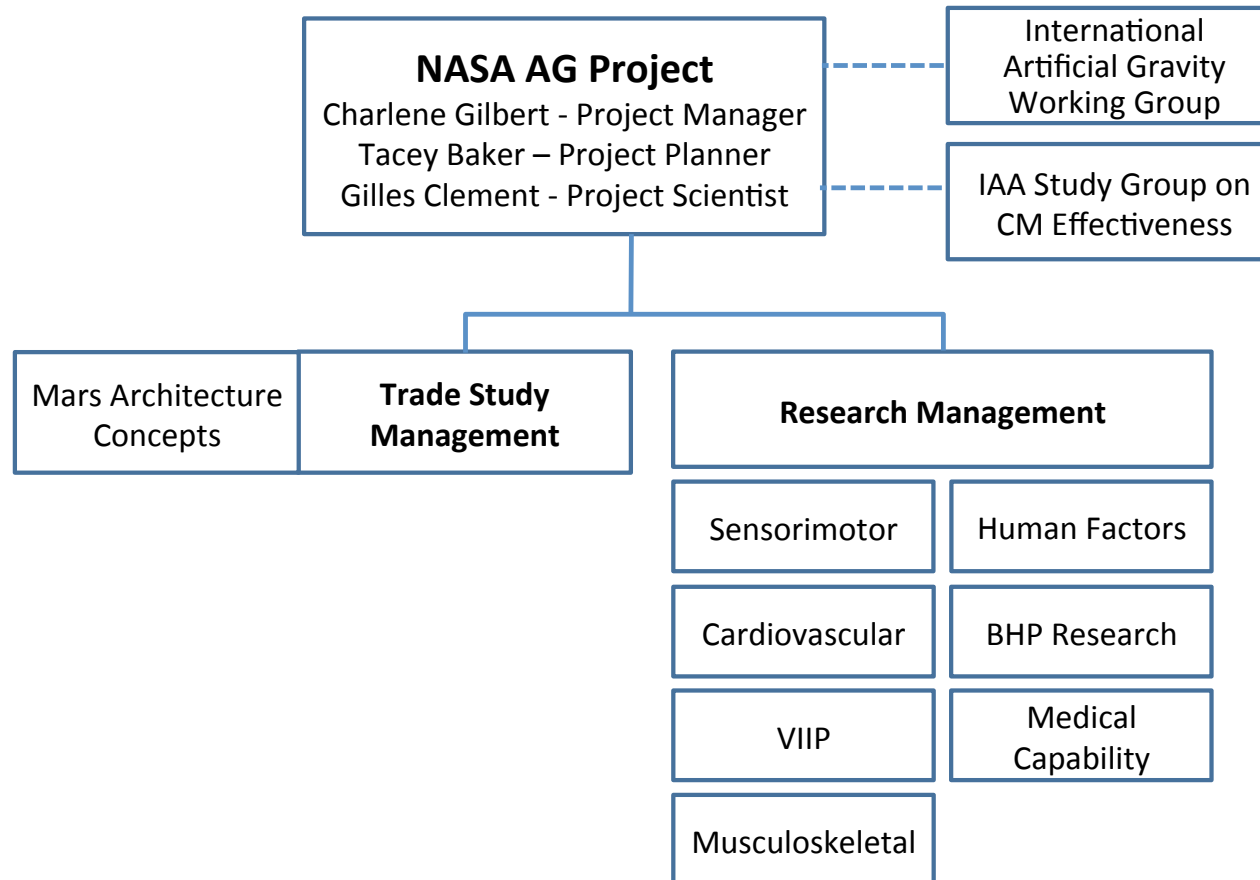
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NASA AG Project

- **Goal**
 - Determine the design trade space associated with AG for Mars DRM vehicles and habitats.
- **Objectives**
 - Implement an evidence-based, peer-reviewed, coordinated R&D project to investigate AG.
 - Determine the optimal design characteristics for a AG countermeasure.
- **Milestone**
 - Decision criteria whether AG can protect crew health and performance during human deep space missions expected NET 2022.

AG Project Structure



AG Project Status

- **March 2014** – HRP approval to initiate the Artificial Gravity project to develop evidence-based recommendations for or against the use of AG in deep space transit vehicles by 2022.
- **September 2014** – Creation of Intern'l AG Working Group as a sub-group of the International Countermeasure Group.
- **December 2014** – External AG Advisory Panel.
- **March 2015** – Evidence Report on Artificial Gravity.
Available at: <http://www.xxx.xxx>
- **May 2015** – Research Plan, in progress.
- **June 2015** – Project Management Plan, in review.
- **July 2015** – Research solicitation.

AG Research Plan

1. AG Level

- G dose-physiological response relationship
- Humans, rodents, cells
- Parabolic flight, unloading, centrifugation, bioreactor, random positioning machine, computational models

2. AG Duration and Frequency

- Continuous rotation
- Intermittent rotation

3. Health Consequences of AG

- Cross-coupled and Coriolis accelerations
- Gravity gradient
- Intracranial pressure

4. Validation of AG Prescription

- Comparison between animal centrifugation on the ground and in space
- Tests of a human centrifuge in space

Research Plan Summary

Gap	Objective	Task	AG Level				AG Duration				Validation of AG Parameters											
			2015		2016		2017		2018		2019		2020		2021		2022					
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	AG level	G dose-response in humans during parabolic flight G dose-response in humans during water immersion G dose-response in humans during head-up tilt G dose-response using computational models G dose-response in cell cultures using rotating bioreactor G dose-response in rats during centrifugation on Earth G dose-response in rats during centrifugation on the ISS																				
2	Mars gravity	Martian gravity in rats during centrifugation on the ISS Martian gravity in volunteers during body unloading Martian gravity in volunteers during HUT bed rest Martian gravity in returning ISS crew during HUT																				
3	AG duration	Continuous rotation in humans in slow rotating room Continuous rotation in humans in large-radius centrifuge Intermittent rotation in humans during bed rest Intermittent rotation in osteoporotic patients Intermittent rotation in rats on Earth Intermittent rotation in rats on board the ISS																				
4	Health	Health consequences of CC & Coriolis accelerations Health consequences of gravity gradient Centrifugation on intracranial pressure in healthy subjects Centrifugation on intracranial pressure in analog VIIP patients																				
5	Validation	Effectiveness of the AG prescription in rats on the ISS Human short-radius centrifuge on space operations Short-term effects of the AG prescription in humans in orbit																				