FLIGHT SERVICING OF ROBOTIC REFUELING MISSION 3

A Krenn, M Stewart, D Mitchell, K Dixon, M Mierzwa, and S Breon

INTRODUCTION

» Goddard Space Flight Center designed payload
- Designed to store 50 liters of liquid methane on orbit with zero boil off
- Intended to perform cryogenic transfer in orbit

» Kennedy Space Center performed hazardous liquid methane testing and flight servicing
- Required development of new hardware and procedures
- Utilized unique processing area
- Procured liquid methane
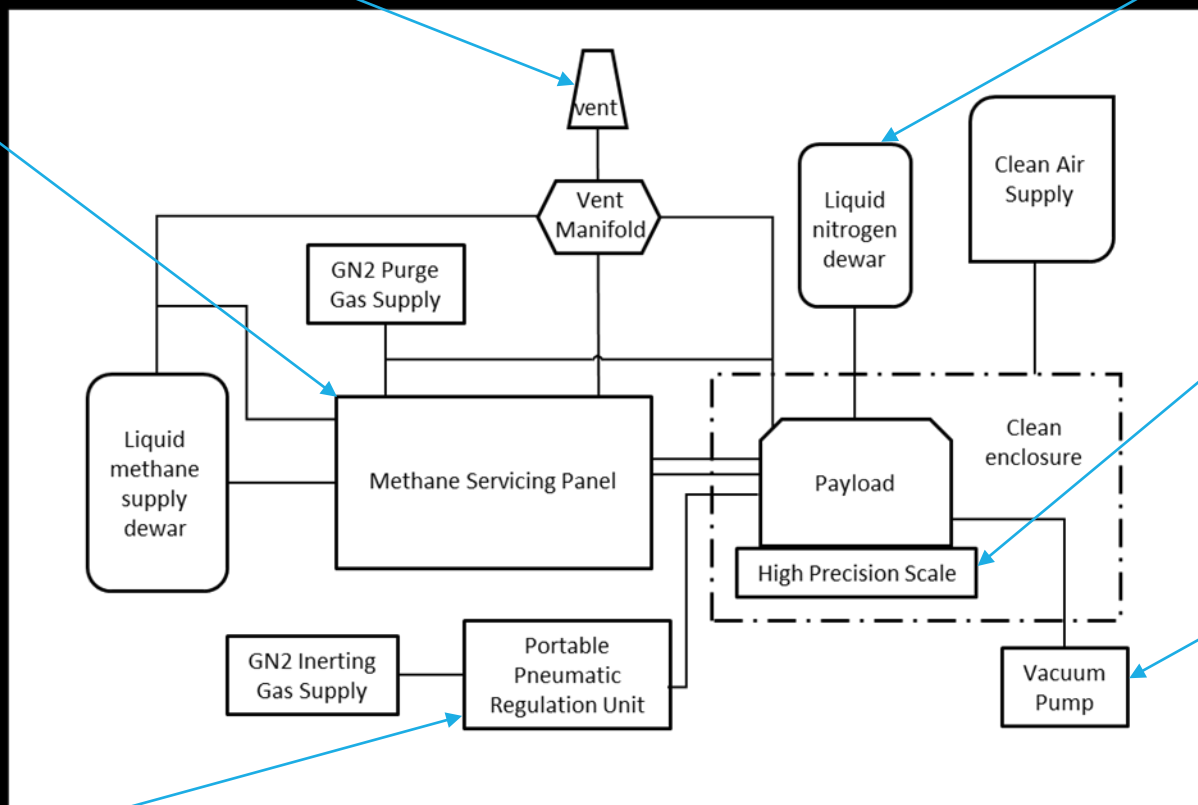- Performed 3 sets of hazardous testing

GROUND SUPPORT EQUIPMENT (GSE)

KSC designed/built panel: liquid methane flow control, vent gas routing, purge gas control, pressure indications

Maintain an inert environment inside the payload compartment (external to the liquid space) to allow for payload power-up during haz ops

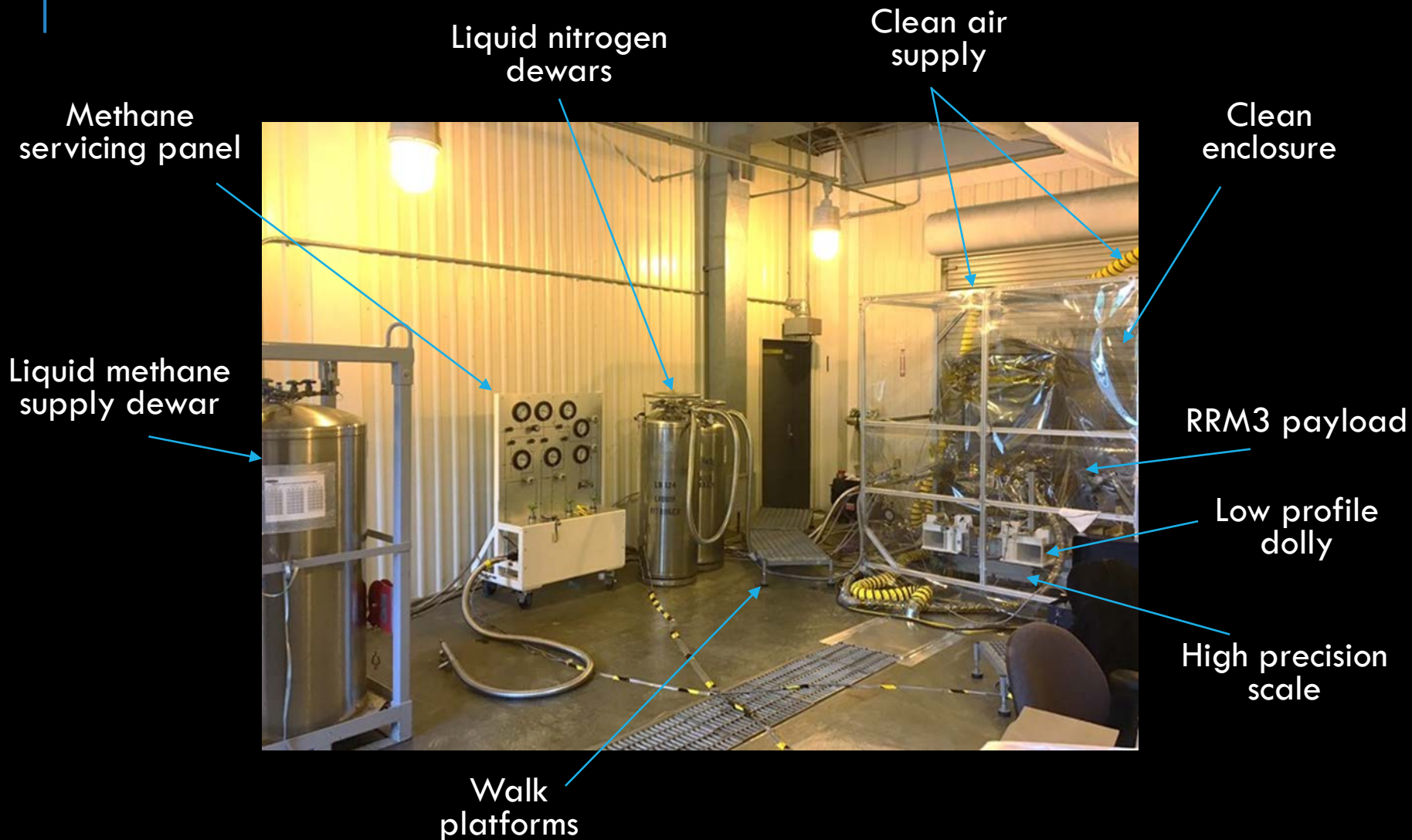Venting occurred 35 feet from the building

Provided cold nitrogen to a cooling loop in the payload for methane sub-cooling

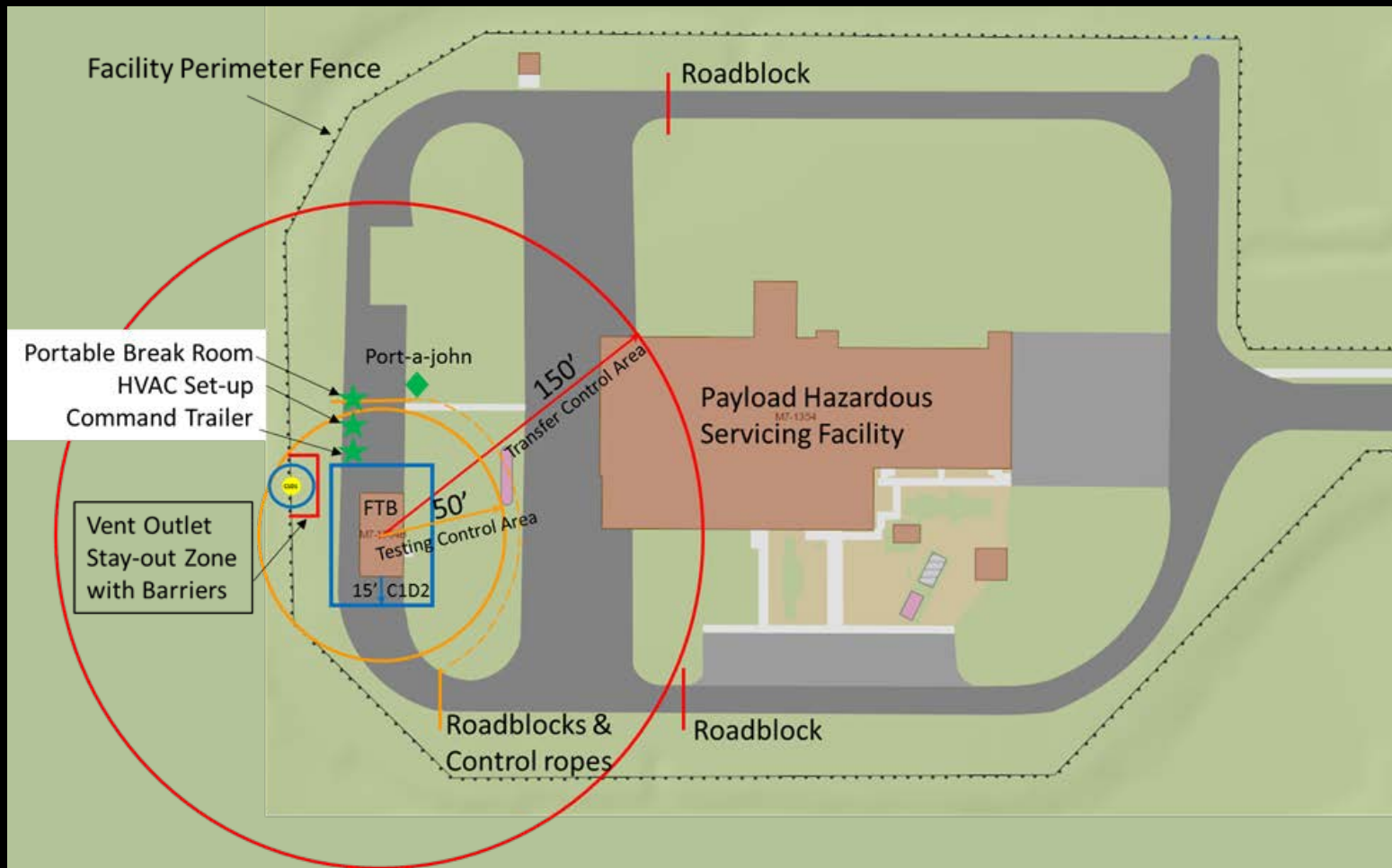On-board methane mass determination

Establish vacuum on source and receiver dewar annular spaces, and receiver dewar liquid space

All GSE was locally controlled (no software)
All connections were made with flex hoses

EQUIPMENT LAYOUT

Liquid nitrogen dewars

Clean air supply

Clean enclosure

Methane servicing panel

Liquid methane supply dewar

RRM3 payload

Low profile dolly

High precision scale

Walk platforms

HAZARDOUS METHANE TESTING

METHANE PROCUREMENT

» MIL-PRF-32207 liquid methane propellant grade B (99.9% pure) requested by GSFC

» One supplier in the country located (CA)
- Supplied grade B methane for EDU testing/GSE V&V
- Shut down just prior to methane procurement for flight

» 98.2% methane was purchased and flown upon RRM3
- Impurities result in changes in thermophysical properties such as saturation pressure, density, and heat capacity
- Changes in thermophysical properties impact cryo fluid management during ground handling (maximum hold times) and transfer operations in orbit
- A detailed analysis was performed to properly account for the impacts of the specific impurities in the methane that was purchased

CONCLUSION

›› KSC accomplished a successful fill and drain of the RRM3 Engineering demonstration unit in November of 2017. This testing also served as verification and validation testing for the Methane servicing panel (2 fill and drains)

›› Ground testing of the RRM3 payload, including methane transfers within the payload was successfully accomplished in May, 2018 (3 fill and drains)

››Pre-flight ground testing of the payload was successfully accomplished in October, 2018 (3 fill and drains)

››Flight fill was accomplished on October 28, 2018

›› All methane venting was accomplished safely and without incident for 17 methane transfers (9 fills and 8 drains)