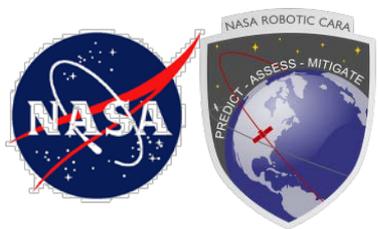




Summary of Aqua, Aura, and Terra High Interest Events

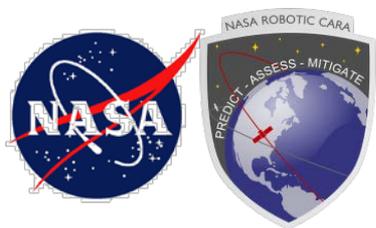
**Lauri Newman, Presenter with contribution of the CARA Team
Spring 2015 A-Train Mission Operations Working Group (MOWG)**

3 June 2015



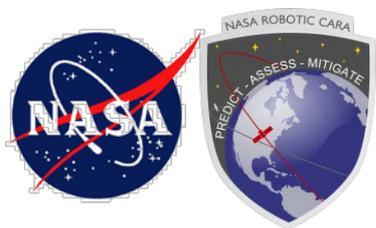
Agenda

- **Aqua, Aura, and Terra HIEs since last MOWG**
- **History of Aqua, Aura, and Terra High Interest Events (HIEs)**
- **Lessons Learned**



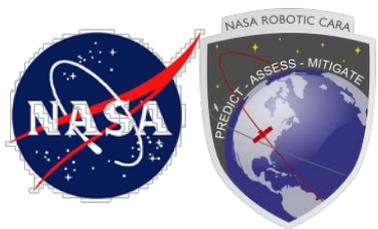
Tactical Work Tiers

- **CARA level of support recorded using a metric called “work tiers”**
- **The four tiers are defined as:**
 - Tier 1: Notify O/O (email/phone call)
 - Contact in addition to summary report
 - Can be high or low risk
 - Tier 2: Brief O/O (slide package)
 - Tier 3: Plan mitigation action
 - Tier 4: Execute mitigation action/waive nominal maneuver

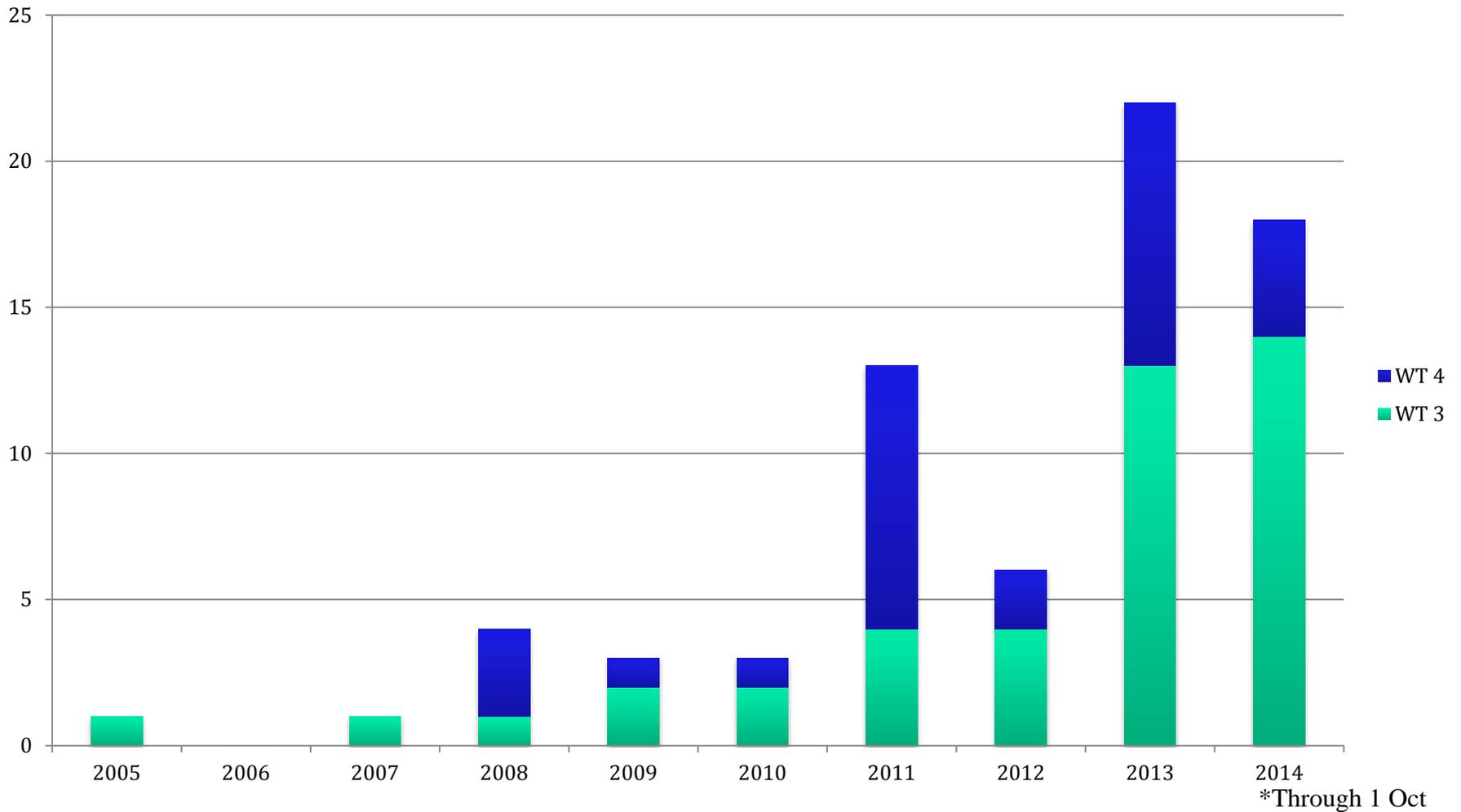


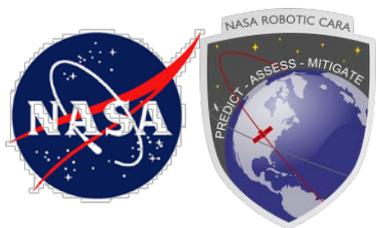
Summary of Aqua, Aura & Terra Worktier 3 and 4 Events (1 Apr. 2014 to 1 Oct. 2014)

Primary	Secondary	TCA	Result
Aqua	Fengyun 1C debris (35226)	02 Apr 2014	RMM waived
Aura	Cosmos 2251 debris (39552)	23 Apr 2014	RMM waived
Aura	Cosmos 2251 debris (34327)	20 Jun 2014	RMM performed
Aqua	Thorad Agena D debris (04861)	21 Jun 2014	RMM waived
Aura	Cosmos 2251 debris (37958)	28 Jun 2014	RMM waived
Aqua	AnalystSat (89390)	18 Jul 2014	RMM waived
Aqua	Fengyun 1C debris (30627)	20 Jul 2014	RMM waived
Aqua	AnalystSat (80601)	05 Aug 2014	RMM waived
Aura	Iridium 33 debris (35679)	16 Aug 2014	RMM waived
Aura	CBERS 1 debris (31872)	26 Aug 2014	RMM waived
Aura	Fengyun 1C debris (36712)	02 Sep 2014	RMM performed



Aqua, Aura & Terra HIE History





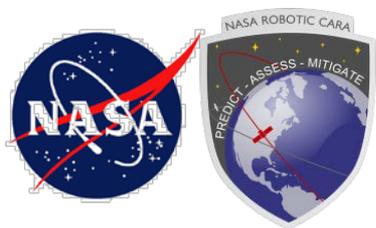
Lessons Learned

- **Single-obs tracking**

- Sparsely tracked objects are an unfortunate reality of CARA operations
- Terra vs. 32081: new track with “bad data” was included in OD solution for secondary object and risk became high
- CARA and JSpOC discussed tracking and OSAs threw out the bad data
- Event no longer presented high risk based on new OD
- Improvement: CARA now sends JSpOC a flag indicating when a single obs is included, so OSAs can evaluate if manual update to OD is required

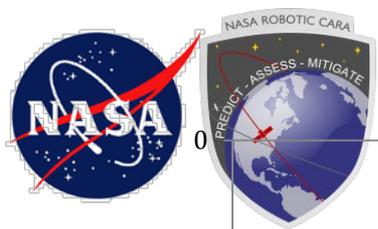
- **Missing ASW OCMs**

- Aura vs. 87178, TCA: 3/17 at 08:04 UTC
- Post-maneuver risk (conjunction was identified in O/O results)
- CARA confirmed with JSpOC that ASW OCMs should have been received in addition to O/O OCMs
- JSpOC corrected the manual error in their script that prevented the data from being delivered to CARA
- JSpOC QA'd their other scripts to ensure this error did not exist in other places

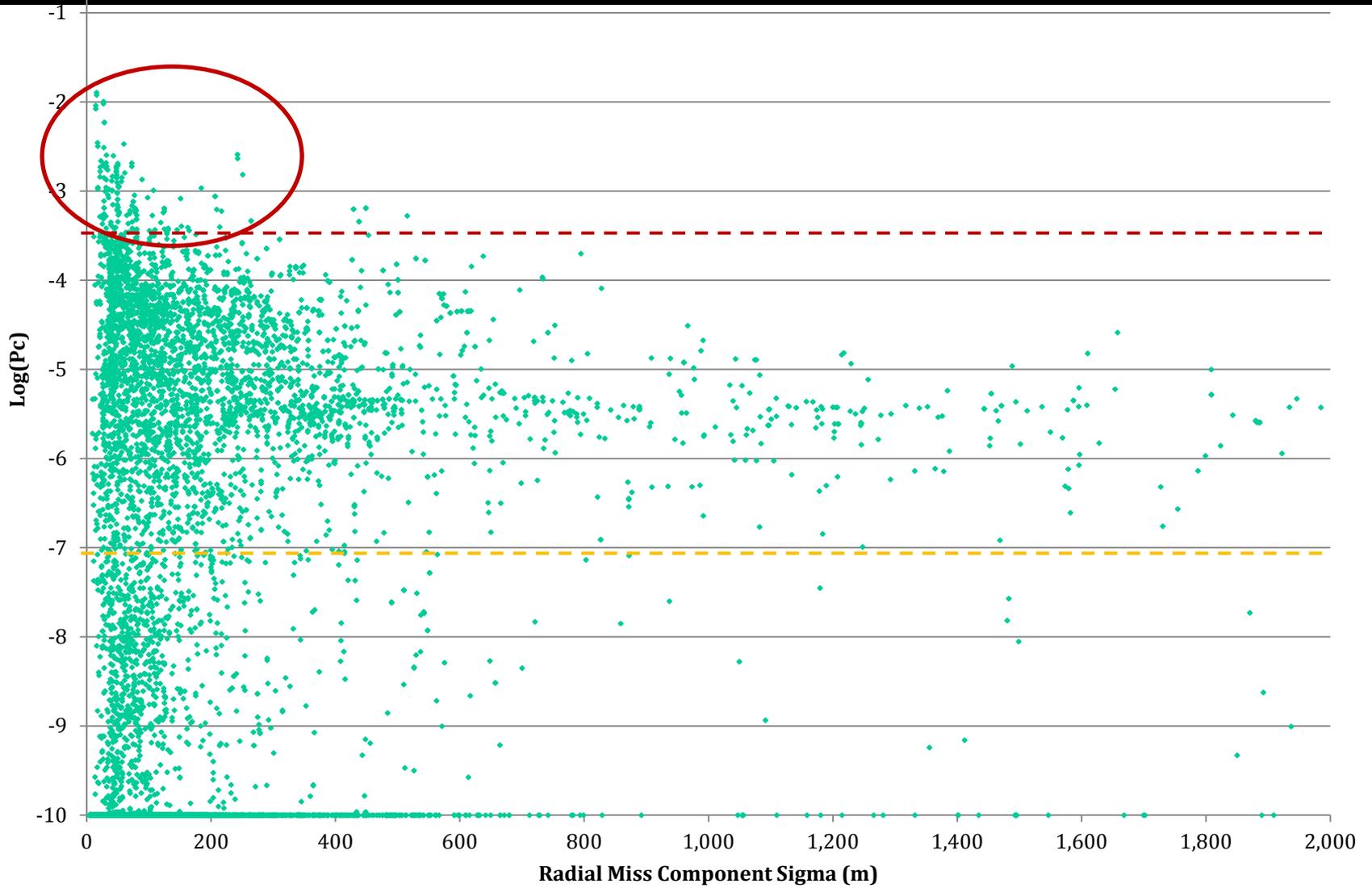


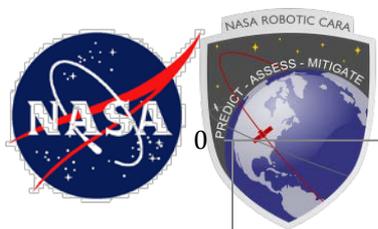
Investigation of Events Where $P_c \sim 1e-5$

- **Interest had been expressed in events where P_c was only one order of magnitude below the CARA Red Threshold**
 - Event could get worse (P_c increases) or could get better (P_c decreases)
- **Aqua, Aura, and Terra each use a combined HBR of 20 m for automated P_c calculations**
- **Review: P_c is the integral of the position probability density function, represented by the combined covariance projected into the conjunction plane, over the Hard Body Region**
- **The following charts show P_c vs. uncertainty by component for two months of Aqua and Aura data in 2013**
 - Note the concentration of high risk (Red) events only exists toward the left of the plots
 - Note the “tail” of the scatter plots trails off at roughly $P_c = 1e-5$

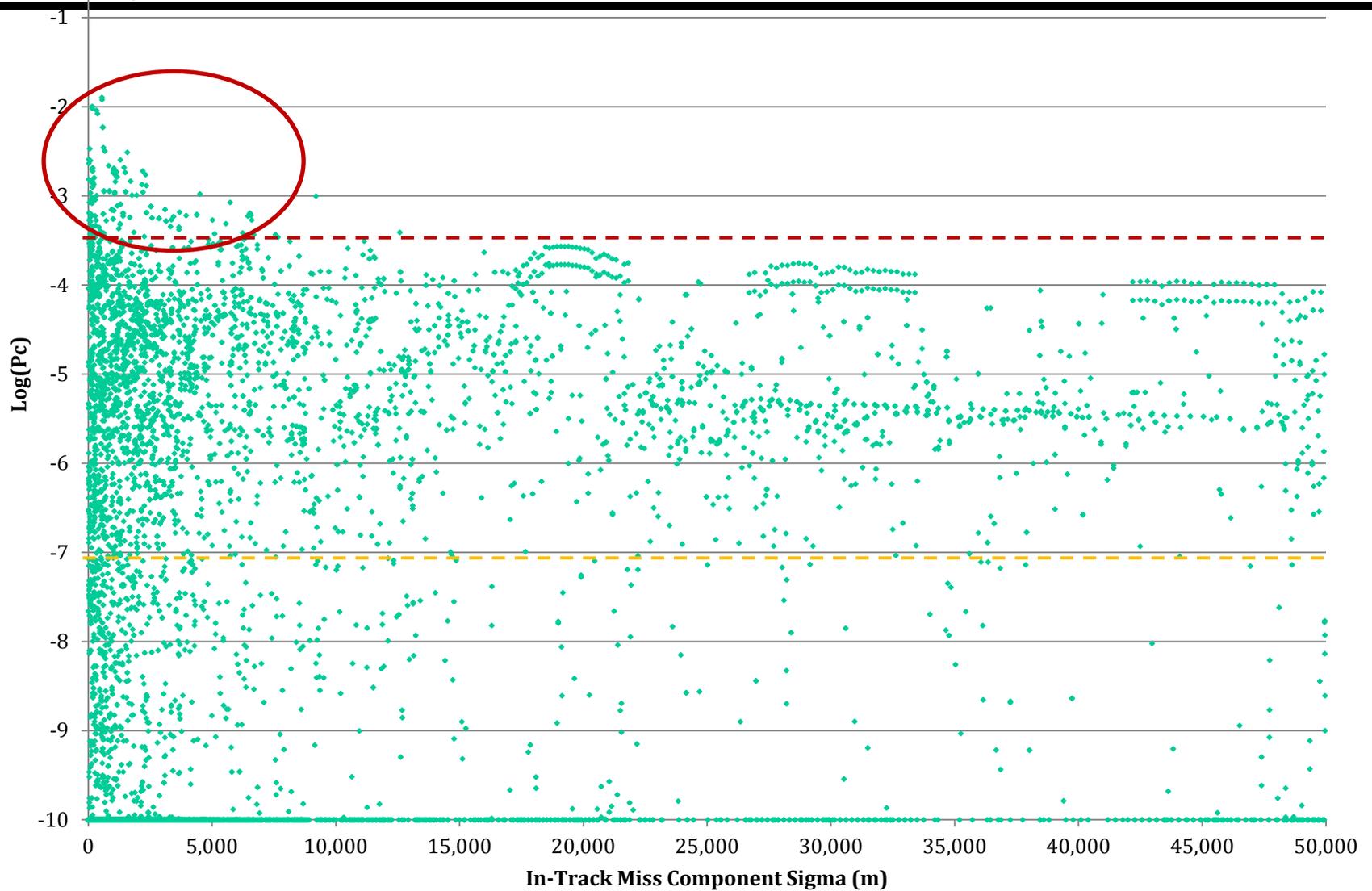


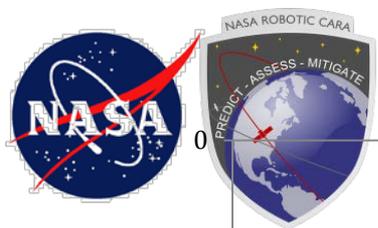
Pc vs. Radial Miss Component Sigma: LEO 2





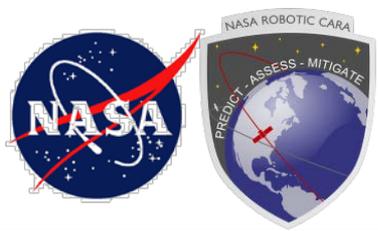
Pc vs. In-Track Miss Component Sigma: LEO 2





Pc vs. Cross-Track Miss Component Sigma: LEO 2





Summary / Lessons Learned

- **High risk events only possible when uncertainties are small enough**
- **Some objects such as AnalystSats have large uncertainties, and also have such sparse tracking that the amount of covariance contraction necessary for the event to become high risk is unlikely to occur**
- **We can now visualize what is meant by “washing out” the uncertainties, and its impact on P_c**