Will XTCE work for your organization? It will for us! Infusion of XTCE to NASA missions

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NASA's XTCE effort

- Like you, NASA's Jet Propulsion Laboratory has investigated ways to share and interpret information across centers and agencies.
  - More consistency across products and with commercial software is required.
- XML Telemetric & Command Exchange (XTCE) standard has been considered for telemetry and command information:
  - Needed: perform an examination of its applicability to the JPL Advanced Multi-Mission Operations System (AMMOS) to meet our needs
- We have recently completed processes to allow us to assess the suitability of XTCE to support our missions.
  - Challenge – To rapidly integrate and test command and telemetry metadata from one agency to another agency's satellite to reduce schedule and cost
  - Solution – We found we can use a common database exchange (XTCE) so integration and test is familiar and straightforward

What is XTCE?

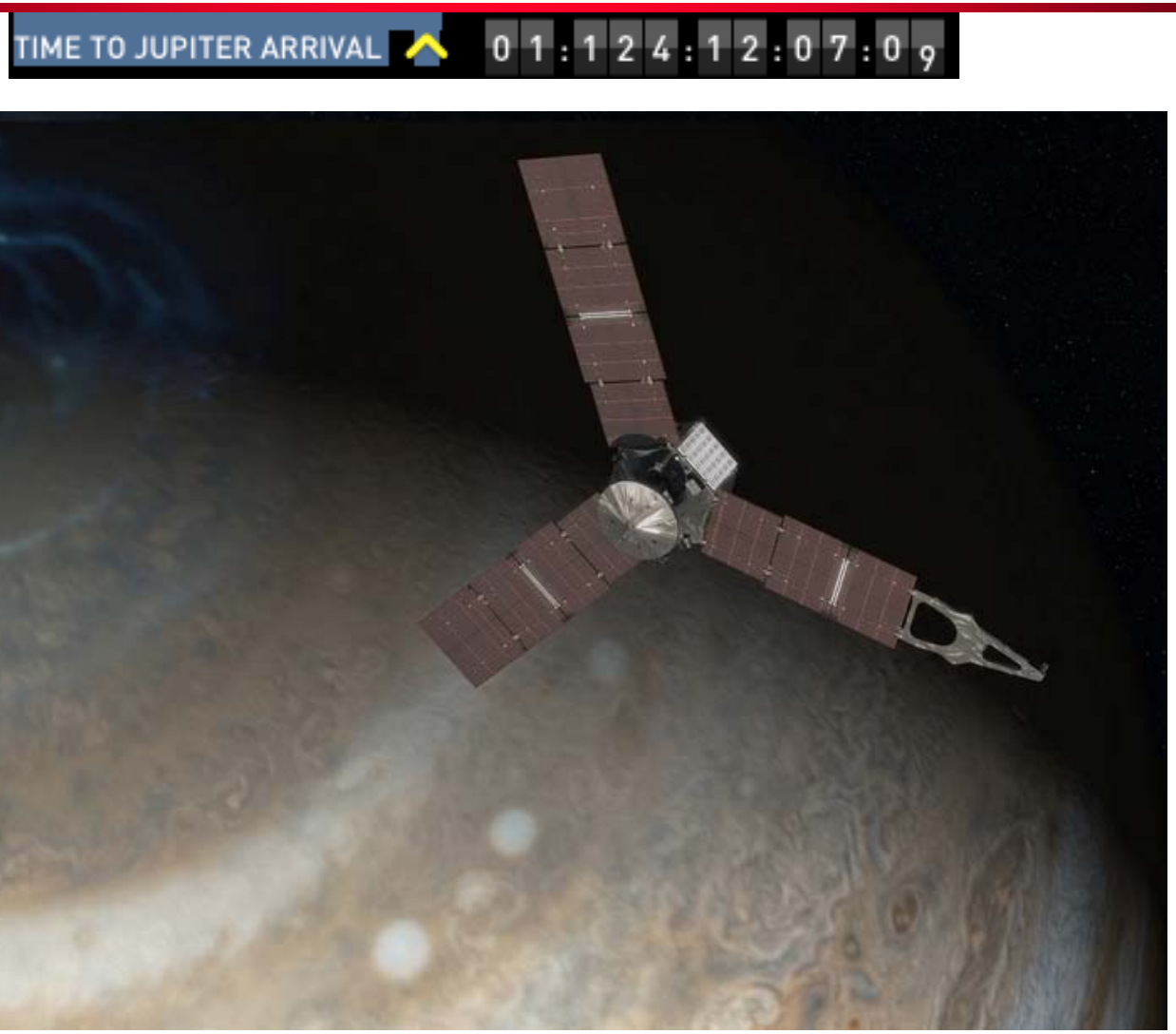
XML **T**elemetric and **C**ommand **E**xchange (**XTCE**)

- Dictionary exchange standard oriented towards mission operations which describes properties including:
  - Commands, arguments, and other aspects of commanding
  - Telemetry, mnemonics, limits and calibrators
  - Packaging: such as packets or minor frames
  - Derivations/Pseudo-telemetry
  - And so forth
- Formalized as both a CCSDS and Object Management Group (OMG) Standard
- GovSat subset published by OMG last year
  - Hosted on both OMG and CCSDS Websites
- Adopted by several civilian space agencies around the world
  - And by several US DoD groups, possibly others

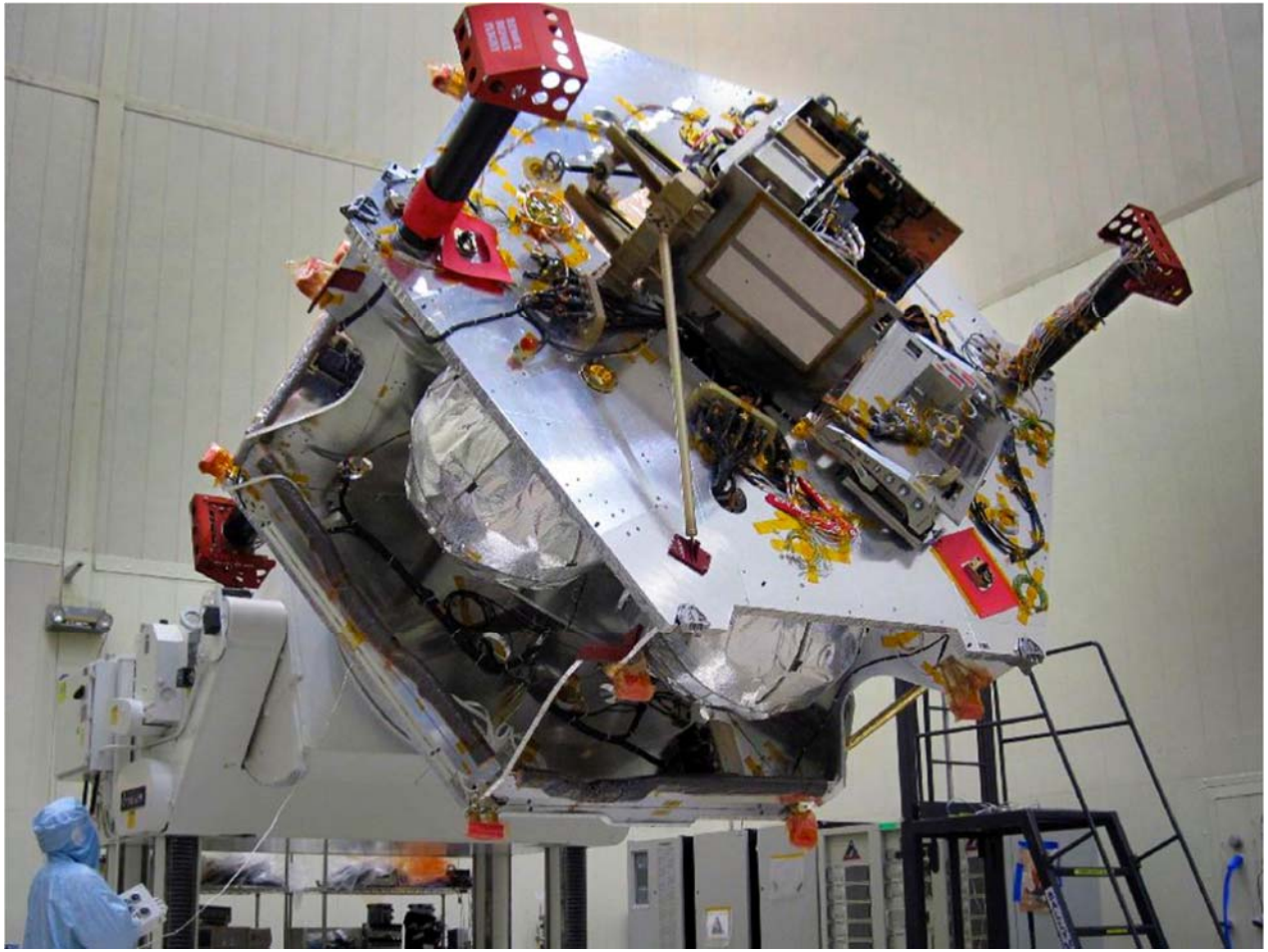
JPL's XTCE Method

- We started by quantifying XTCE's ability to capture the telemetry and command definitions of our current missions
  - The result was a mapping and a percentage of it "in XTCE".
- Next we carefully crafted extensions into XTCE to cover the missing percentage.
  - Goals:
    - Don't break existing syntax
    - Have the extensions clearly appear as such in the XML files (for analysis)
  - Result: **XTCE_AMMOS**
- Thirdly, build tools and use real mission databases to test **XTCE_AMMOS**:
  - Goal: perform **LOSSLESS** round-trip conversion from original database to XTCE w/extensions
  - Juno and Odyssey were chosen

JPL XTCE-Juno mission



The Juno spacecraft



Juno spacecraft at LMSS. Image credit: NASA/JPL-Caltech/LMSS.

JPL, JIRAM, and LM teams during instrument integration

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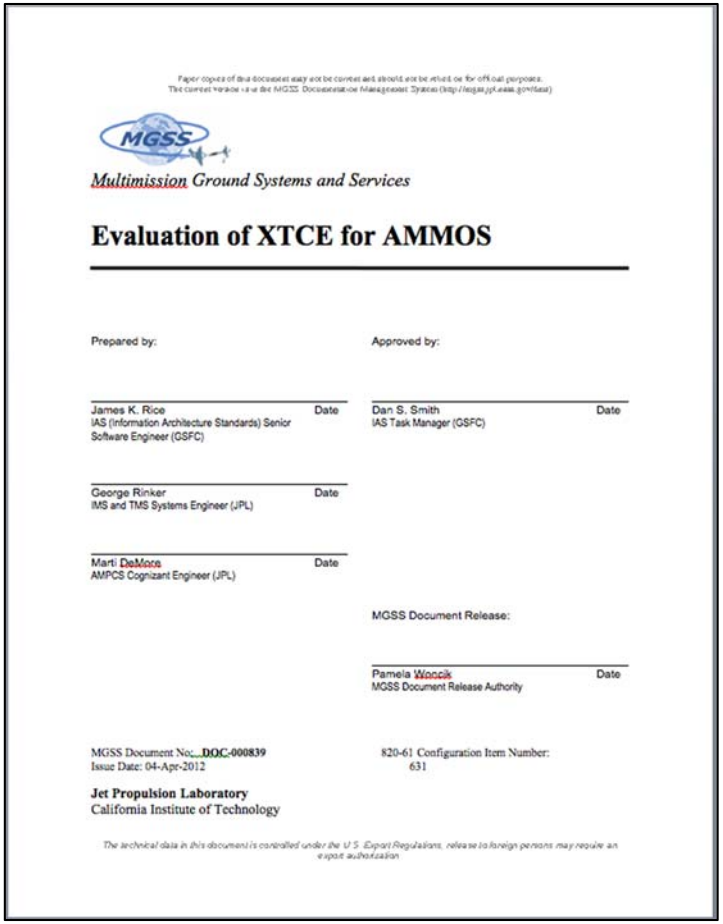
JPL, JIRAM, and LM teams during integration. Image credit: NASA/JPL-Caltech/LMSS.

Evaluated XTCE representation of AMMOS Dictionaries

Purpose: Evaluate XTCE representation of AMMOS Dictionaries

- **Mapped 11 AMMOS Dictionaries to XTCE**
  - Common, Command, Telemetry, APID, EVR, Generic Decom Map, Generic Decom Map by APID, Alarm, Alarm Notification, EVR Notification, Transfer Frame
- **Characterized the mapping (%)**
  - Identified consistencies and gaps
  - Recommended solution for items that did not map (separate schema, ancillary)



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Multimission Ground Systems and Services

Evaluation of XTCE for AMMOS

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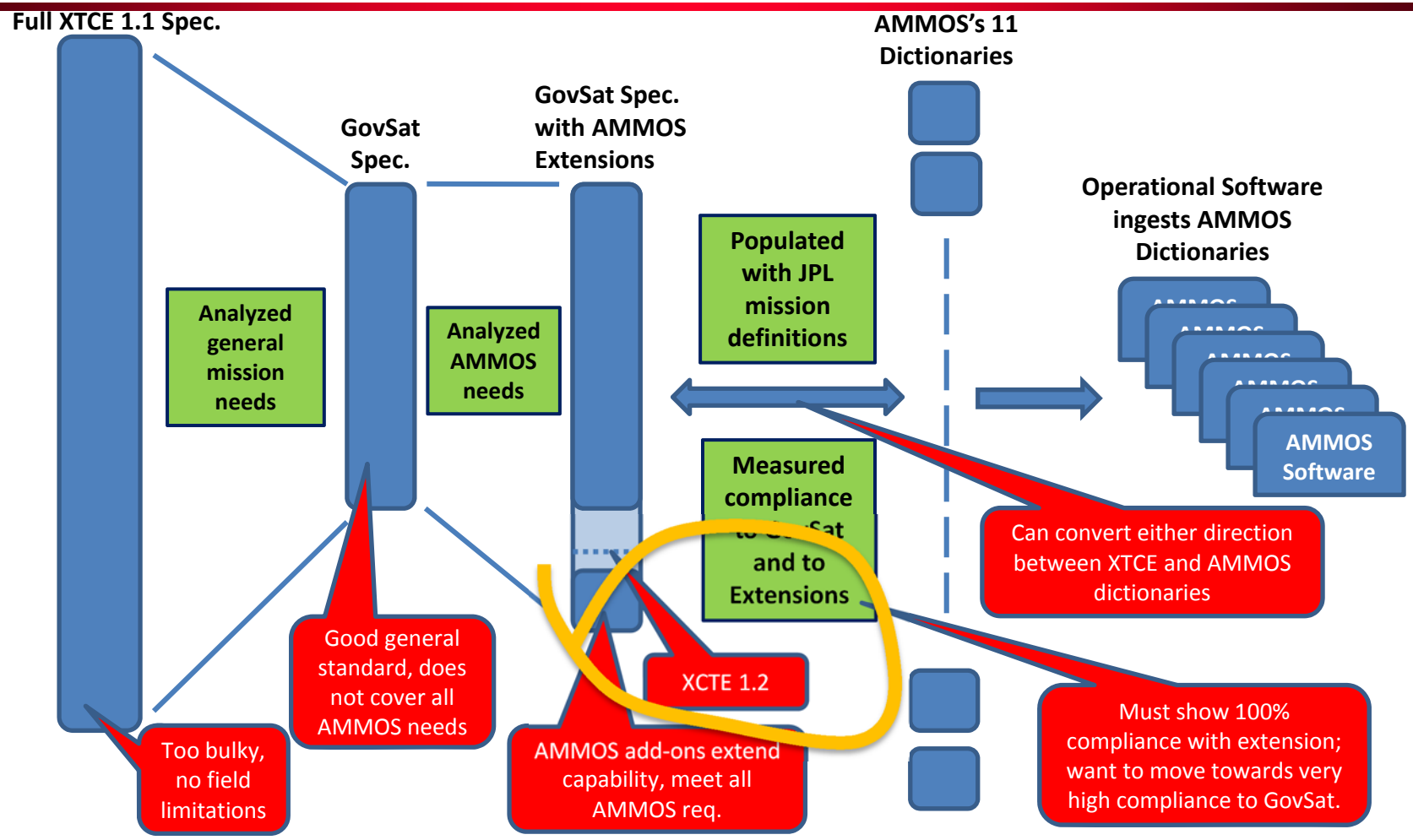
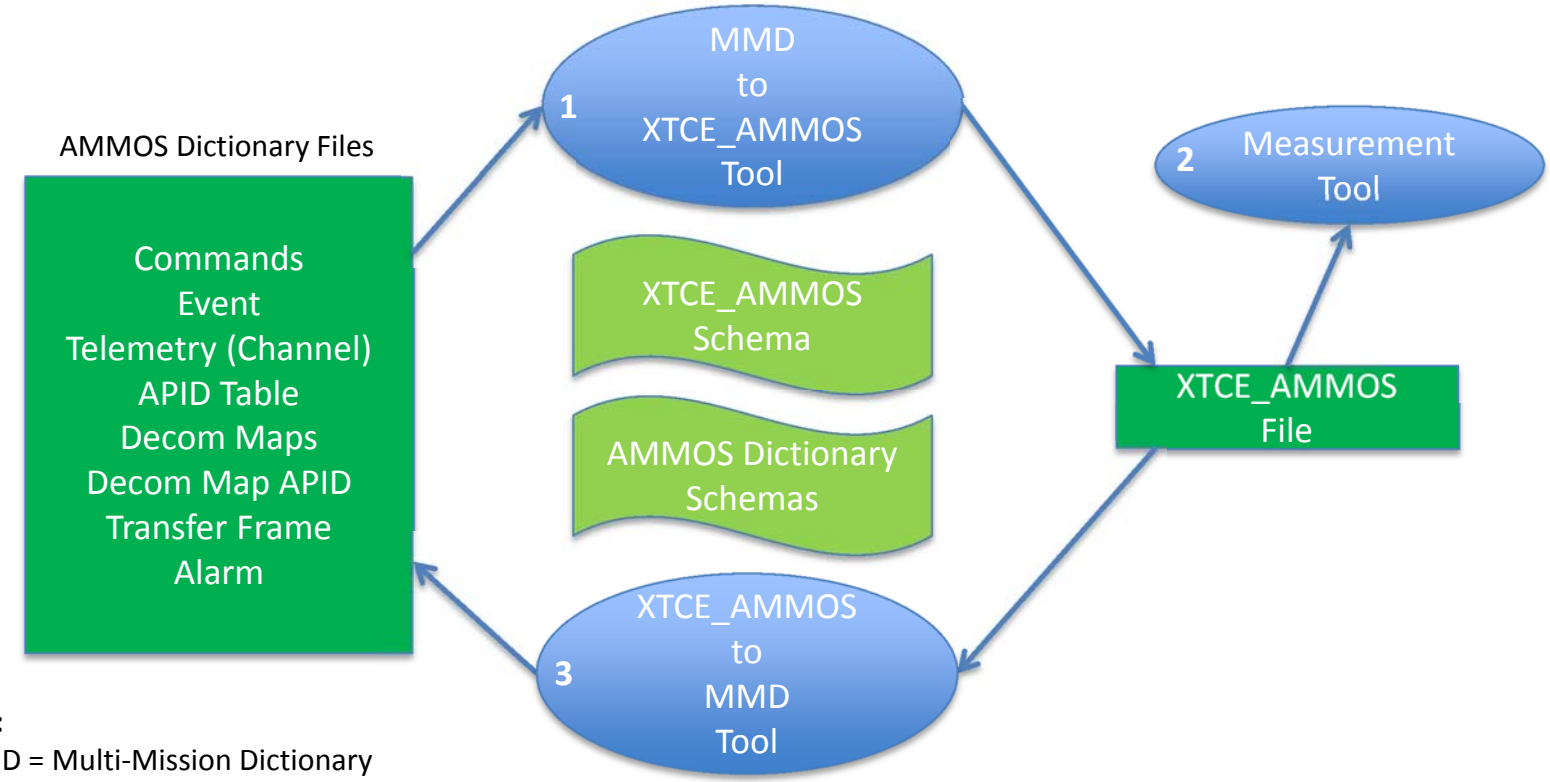
XTCE Specification to AMMOS Dictionaries Flow



With release of XTCE 1.2 more items covered by standard and less by extensions

MMD to XTCE Conversion Round-Trip



Key:
MMD = Multi-Mission Dictionary

Goal - demonstrate "Round Trip" of MMD conversion to XTCE and back without loss of content

JPL's XTCE Method

- Then we did a metric analysis to see how well we did:
  - We wanted to know how much of XTCE we used vs extensions per database
  - We followed a rigorous process to obtain the metrics

Metrics from MMD to XTCE Conversion

Input	Output	Measurement
Odyssey Mission Dictionaries - Apid (apid table) - Channel (telemetry) - Command - Generic_decom_by_apid - decom map (1 packet file) - Transfer frame (front end) - alarms - Evr (event)	Events : 225497 DataSource : 5662 DecomMap : 208 DecomMapApid : 168 XferFrame : 25 Alarms : 5279 Fill/Repeat : 190 CmdArg AbsTime : 10 CmdArg EnumRange : 19559 MaxLen Strings : 306	Item / Total / XTCE 1.1 / XTCE 1.2 XTCE+JPL extensions: 714,701 100.00% 100.00% XTCE: 356,166 49.83% 92.31% JPL Extensions: 358,535 ** 50.17% 7.69% ** High due to number of Events in MMD File. - XTCE 1.1 does NOT handle events - XTCE 1.2 WILL handle events
Juno Mission Channel Dictionaries - Apid (apid table) - Channel (telemetry) - Generic decom by apid - decom maps (13 packet files) - Transfer frame	DataSource :23682 DecomMap :8707 DecomMapApid :904 XferFrame :136	Item / Total / XTCE 1.1 / XTCE 1.2 XTCE+JPL extensions: 429,146 100.00% 100.00% XTCE: 395,717 92.21% 97.73% Extensions: 33,429 7.79% 2.27%

XTCE AMMOS completely supports the Odyssey MMDs and Juno Channel Dictionary

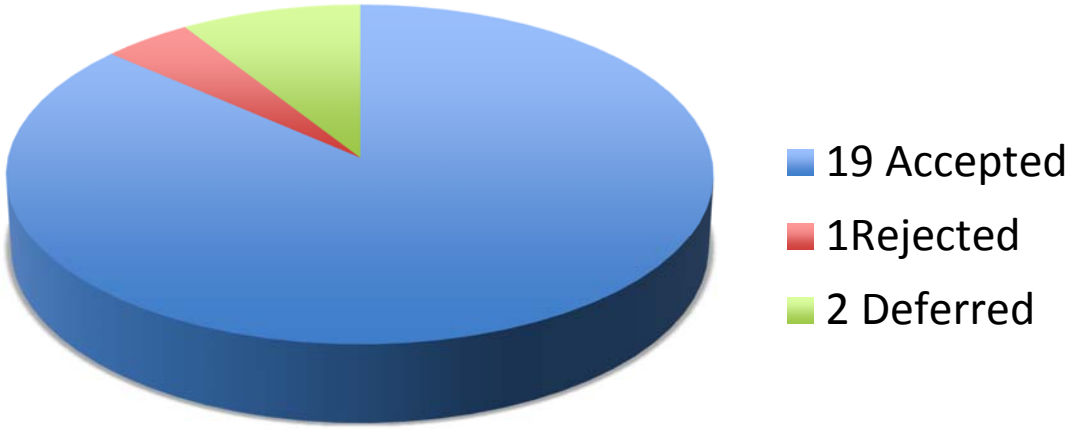
JPL's XTCE Method

- Brought JPL extensions to OMG/CCSDS standard community:
  - Discussed for inclusion into XTCE 1.2
    - Some were accepted, some deferred and some were rejected
  - Face-To-Face meetings with the OMG Space Domain Task Force
  - Final OMG meeting in Austin solidified all issues relevant to XTCE 1.2 and JPL
    - By participating our voice was heard, many of the extensions made it in
    - But a few will still be needed
- XTCE 1.2 soon to be published

JPL Items in XTCE 1.2 OMG Summary

- OMG accepted many suggested enhancements to XTCE in version 1.2, but chose to defer or reject some, which must be accommodated in JPL extensions to support AMMOS

- Update at the last OMG meeting:



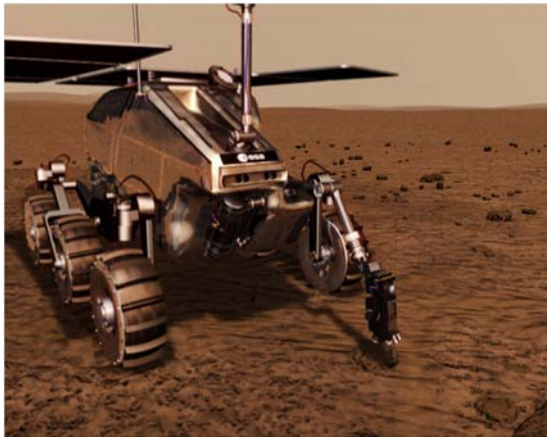
22 items in original JPL files not addressed in XTCE, change requests were then submitted

JPL Infusion Tasks

- Finally we moved to infusion at JPL:
  - FSW Core, Instrument Software, Ground Software, and Project System Engineering
  - Identified and worked with additional NASA missions and interfaces to incorporate standard
  - XTCE demonstration with the FSW Core and Europa Clipper mission
    - Potentially others, such as Mars 2020, INSPIRE CubeSat, JSC
  - Support implementation and use of standard across other NASA centers

JPL collaboration with ESA TGO Electra Instrument

- The Trace Gas Orbiter (TGO) will be a Mars telecommunications orbiter and atmospheric gas analyzer mission (launch 2016)
- It will deliver the ExoMars EDM lander and then proceed to map the sources of methane on Mars and select a landing site of the ExoMars Rover (launch 2018)
- NASA will provide an *Electra* telecommunications relay and navigation instrument to assure communications between probes and rovers on the surface of Mars and controllers on Earth (till 2022)



Conclusions

- XTCE can work for you -- Gaps can be handled 100% is critical: 98% is not good enough!
  - It is important to assess compliance between your existing systems and XTCE
  - as suggested by updates to the standard
  - as local extensions
- Benefits may come in several ways
  - Easier coordination across different existing or new tools
  - Simplified data exchange with external partners
  - More efficient operations
  - Reduce maintenance costs
    - Reduces variation among dictionaries (for different missions)
- Import XTCE from others: Big Savings
  - definitions of instruments
  - or even entire satellites developed by others in XTCE,
  - and automatically create the corresponding AMMOS dictionaries.
- Standards participation works!

Future plans

- Continue infusion process with NASA and ESA missions:
  - Collaboration towards a joint international standard (NASA/ESA tailoring)

- Or Use XTCE as AMMOS native dictionary:
  - Some up front cost, but would make sharing even easier/cheaper

Acknowledgments

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- **References:**

  - OMG XTCE: http://www.omg.org/space/xtce/
  - Juno mission: http://missionjuno.swri.edu/
  - Michela Munoz Fernandez. “Excellence in international collaboration: the Juno mission to Jupiter,” ISDC 2011.
  - ESA TGO: http://exploration.esa.int/mars/46475-trace-gas-orbiter/

Questions?

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JPL XTCE items

Issue #	Title	Disposition
19367	Bit Extract	Supported (XTCE 1.2)
19368	Alarm count in and out	Accept
19369	Re-architect XTCE alarm model.	Partially Accept
19371	Mask Alarm needed	Supported (XTCE 1.1, 1.2)
19372	Digital Alarm needed	Supported (XTCE 1.2)
19373	Change alarm	Supported (XTCE 1.1, 1.2)
19374	Combination alarm	Defer
19375	Off Alarm	Partially Supported (XTCE 1.1, 1.2)
19376	Elevate annotation specifying time string formats to an attribute	Accepted
19378	Expand Telemetry data source	Accepted
19379	Raw units	Defer
19380	Title	Supported (XTCE 1.1, 1.2)
19381	Categorization (Label Set)	Duplicate
19382	Variable in decom map	Partially Supported (XTCE 1.1, 1.2)
19383	width semantics	Partially Supported (XTCE 1.1, 1.2)
19384	Gap spacer in container	Supported (XTCE 1.1, 1.2)
19385	Switch in container	Partially Supported (XTCE 1.1, 1.2)
19386	Front-end Processing encodings	Reject - Possible New SpaceDTF Standard Specification
19387	Identifying List(s) -- APID to decom map	Supported (XTCE 1.1, 1.2)
19388	Events not supported	Accept
19403	Fill arguments	Supported (XTCE 1.1, 1.2)
19404	Repeat arguments	Supported (XTCE 1.2)