REVISION RECORD

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-	Initial Release	5/1/07	

APPROVAL RECORD

Function	Name	Signature	Date
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1. Introduction

The INMS Flight software effort at the University of Michigan Space Physics Research Laboratory (SPRL) spanned a time period from September 2001 through December 2006. At the start of the effort, INMS was still powered off on the Cassini spacecraft and efforts focused on developing ground operations software and procedures and software for operating the INMS Engineering Model (EM) and Prototype for testing purposes. It eventually became clear that SPRL would need full control over the Flight Software and a significant effort to port the software, enhance it and to diagnose an unpredictable reset problem, was undertaken.

Other efforts during this time period included the rebuilding of the INMS prototype, programming and hardware setup for the INMS Operations Network (ION), development of numerous data processing and diagnostic programs, and training operations team members on the use of the Engineering Model and Prototype for testing.

2. Ground Software

Several programs were developed during this period for the INMS Operations Network (ION) and for support of the Flight Software Development effort.

The largest of these programs was the DataManager. This program allows network connections between the ION database and multiple data sources such as the INMS Engineering Model or Prototype (connected to the PPCRTIU), and the SOPC for downlinked data. This program has undergone many revisions over the years as requirements changed and bugs were found. It runs continuously on the ION servers.

Significant ground software was also developed in support of the new Flight Software Velocity Compensation mode. A Matlab program was developed to translate the linear energy equations, usually provided by Wayne Kasprzak at the Goddard Spaceflight Center (GSFC) into table constants usable by the flight software. Additional programs were developed to generate test sequences for the INMS Prototype to test these constants.

Additional software was developed in support of the INMS Unexpected Reset investigation. Once the tracing feature was in place in the Flight Software, a program was developed to decode the downlinked trace and present it in a readable fashion to aid diagnosis.

Many other small programs were developed over the years to process or generate various files in support of operations.

3. INMS EM and Prototype

The INMS Engineering Model and Prototype are invaluable tools for testing operational sequences prior to uplinking them to the spacecraft as well as for testing the Flight Software, itself. It had been many years since anyone on the INMS team had used these instruments, however, and a significant effort was undertaken to re-learn the operations of them. This included interfacing them to the newly developed PPCRTIU, a spacecraft simulator provided by JPL. Additionally, the prototype was not built in a very robust way, and it eventually failed. A successful effort was undertaken to rebuild the prototype from scratch in a much more reliable way.

The DataLogger was developed to verify the low-level operations of the INMS Prototype when sequences were run. This is particularly helpful testing the actual operation of Operations Tables uploaded to INMS. In addition, the DataLogger was invaluable for developing and testing the INMS Velocity Compensation algorithms and tables.

4. Flight Software Development

It became clear by early 2003, that use of the built-in INMS PROM software would not be adequate for operations during the entire tour, so an effort was undertaken to port the software to the JPL supported TLD Ada compiler. The result of this effort was INMS Flight Software Version 7. While this effort was ongoing, it was also discovered that INMS exhibited a problem eventually termed the 'Unexpected Reset Anomaly'. During early operations at Saturn, INMS would occasionally reset itself. Virtually no information as to the cause was available for diagnosis and several efforts to correlate the problem with other spacecraft operations failed to find anything. Additionally, every effort to reproduce the problem with the EM or the Prototype failed, even when tested in the JPL Instrument Test Laboratory (ITL).

Prior to the Version 7 uplink, several small flight software builds were released and uplinked to try and narrow down the cause of the unexpected reset. The first of these was very simple and was intended to verify that the INMS CPU could operate without resetting. This test ran for about 16 days and was declared successful (i.e. no reset was produced). The second upload added a fair amount of Ada code including simple BIU spacecraft interface functionality and Ada tasking. This test produced a reset. At this point in the investigation, the focus shifted to the BIU as the likely culprit for the reset, however, this proved to be a false lead as so much additional Ada code had been added to support the BIU.

After Version 7 was uplinked in early 2004, the flight software effort continued due to some known problems discovered during testing and in flight and to try and further diagnose the unexpected reset problem, which continued to occur. Two interim versions were built and tested but the next version to be uplinked was version 9.1. This version contained some significant diagnostic code which would essentially trace the flight software as it executed. Each function in the flight software would record a code when it was called, including interrupt service routines. INMS had enough spare storage for about 0.5 seconds of these codes, so when the unexpected reset occurred, the last half-second of execution would be preserved for download at the next opportunity.

Several real-time patches were uplinked to modify V9.1 as additional resets were experienced to try and refine the way in which the trace information was recorded. Eventually, the 5th patch in this series indicated that the unexpected reset was due to a missed interrupt from the Timer B, internal to the CPU. This was eventually contributed to a flaw in the Revision H Marconi 1750 used by INMS when an errata sheet was provided by Dynex, the current owners of the processor technology. Patch 6 was uplinked in late 2005 and in November, 2005 and unexpected reset event occurred. Patch 6 detected the event – the missed interrupt – and corrected the problem and kept INMS operating normally. A counter in the housekeeping packet indicated the event occurred.

Early 2006 was spent developing INMS Flight Software Version 10. This version incorporated all the Version 9.1 patches including the patch that corrected the unexpected reset problem. This version was uplinked to INMS on Cassini in the Fall of 2006 and has been operating successfully ever since.