The Hammers Company is a woman-owned small business; a software development company specializing in satellite ground systems, on-board flight software and spacecraft dynamic simulations. Hammers has been developing and maintaining software with and for NASA GSFC and other government and commercial enterprises in the US and abroad for 27 years, and in that time, we have participated in more than 50 flight projects.

Hammers was initially founded on flight software development for GSFC, and we continue to support flight software efforts at Goddard, NRL, universities and other customers. Hammers personnel perform guidance navigation & control (GN&C) analysis, develop GN&C and C&DH spacecraft flight software, and science instrument flight software. Our developers contributed significantly to the creation of NASA’s Core Flight System (CFS), and Hammers now is offering commercial training in CFS to the industry. Hammers also employs experienced flight software test engineers and an award-winning cadre of flight software sustainment engineers.

For its own products and in its role as a support services contractor with NASA, Hammers rigorously adheres to the requirements of NPR 7150.2 and the underlying CMMI level 2 practices it embodies. This adherence to high standards has been confirmed repeatedly in assessments performed by the NASA projects we support. Hammers personnel also routinely support GSFC’s Software Engineering Division in their periodic CMMI assessments.

Hammers provides systems engineering services for ground system development, simulations and for flight embedded development. Hammers ground systems support includes NASA, USGS, NRL, Canadian Space Agency, MIT Lincoln Labs, Universities and numerous commercial spacecraft programs from large observatories, constellations, cube-sat and balloon missions.
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Hammers has a robust practice in systems and network administration. Hammers played a key role in the developing the Distributed Virtual Environment for Secure Test & Operations (DVESTO), NASA’s IT Security plan, and in achieving authorization to operate under that plan for Goddard’s multi-mission Science and Planetary Operations Control Center (SPOCC). Hammers provided key System Administration support for many mission I&T efforts, most recently for TIRS and TIRS-2, DSCOVR, LCRD and OCI. Hammers Company is also responsible for the SA and network engineering for the Landsat-8 MOC and now designing the Landsat-9 MOC with plans to integrate operations of L-8 and L-9 operating on a single GALAXY system with automation and archiving/trending operations tools developed by the Hammers Company. Hammers has extensive experience in creating and maintaining virtualized and distributed computing environments, and in NASA IT security policies and practices.

Recognition:

- Hammers was the prime contractor for the LDCM (Landsat 8) Mission Operations Element (MOE). Under this contract, Hammers led the design, development, integration, testing, deployment, and sustainment of the mission operations software and systems for LDCM. The Hammers team provided systems for telemetry and command, mission planning, flight dynamics, trending and analysis, data management, and automation. Hammers received an overall score of 97 for technical performance of the contract. Following handover of the mission from NASA to USGS, the project produced an extensive “Landsat in Retrospect” document detailing lessons learned. Among the “Key Success Factors” that document cites for the MOE:
  - The MOE had a strong technical team. All software development teams had extensive experience and products with strong heritage. The MOE team was consistently willing and committed to do what needed to get done to satisfy the government customer. In particular, the MOE technical lead, was highly skilled in the C&T system, was open and honest, and was always cooperative and easy to work with.
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○ The establishment of the MOE IT&M lab at the Hammers facility was a key to the technical success of the MOE. The lab allowed a separate environment for MOE development, testing, and trouble-shooting without impacting the FOT’s use of the systems in the MOC. The benefits of this especially paid off during the last 18 months before launch, when MOC activities were very high and access to MOC systems was crucial in meeting the launch date.

○ As mentioned in the MOC I&T section, MOE team integration and test leads eventually migrated to the government team to support GRTS and MOC integration. The MOE team’s willingness to release these resources for the betterment of the project as a whole was a contributor to success and benefitted both the MOE team and the government in the end.

○ Ultimately, the MOE delivered a technically capable and reliable system. This was evidenced by the fact that the MOE team only received one off-shift call for technical support during the entire on-orbit commissioning phase. The capability and reliability of the system is an obvious key to the success of the MOE effort and the success of the LDCM mission.

● Awards

○ Hammers provided engineering support for the following projects under the SES contract: ELC, LRO, SDO, Fermi, GPM, ATLAS, Terra, Cassini, DSCOVR, MMS, THEMIS, and ARTEMIS. Our team received 3 NASA Group Achievement Awards for GPM and MMS and a Team Award for ELC. Members of our team also received the Robert H. Goddard Award for Exceptional Achievement for Science for work on SDO, and an individual Contractor Excellence Award for Innovation for work on GPM. Hammers has contributed to mission success in flight software development and/or sustaining engineering for many other Goddard missions over the past 27 years.

○ Hammers played key roles in the design, development, and sustainment of the Science and Planetary Operations Control Center (SPOCC) in building 32. The SPOCC hosts or has hosted science
operations for MAVEN, LADEE, NICER, GEDI, DSCOVR, and ATLAS (ICESat-2). The SPOCC team received the 2012 Robert H. Goddard Exceptional Achievement Award for Customer Service and the 2013 Software Engineering Division Excellence Group Award for Innovation, recognizing the SPOCC Team's innovation in creating a low-cost instrument operations facility to benefit many GSFC missions for years to come. Our people also received the 2014 Robert H. Goddard Exceptional Achievement Award for Engineering as part of the LADEE Mission Support Team in the SPOCC.

● Commendations
   - Hammers developed a Mission Training Simulator (MTS) for the MMS project. The MTS combined our VIRTUALSAT, mission-unique VIRTUALSAT components, the MMS flight software, and our GALAXY telemetry and command system to accurately simulate the 4-satellite MMS fleet. The mission systems engineer wrote the following commendation to Goddard’s Director of Engineering and Director of Flight Projects: “The MMS spacecraft, instrument, and ground team just completed a 6 day, 24 hour a day mission simulation that was absolutely outstanding. I'd like to take a moment to comment on the great [job] ... Jeff D’Agostino (Hammers) did to make it possible. Jeff was our lead at tHC. All I really need to say is that the simulator, which uses the flight code, is so good that the MOC team uses it to validate flight command loads - think about what that means! We sit down in the MOC and it is almost impossible to tell if we're working with a real spacecraft or the MTS - you really have to look hard to tell.”
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World class aerospace commercial products have supported Government and industry spacecraft missions from initial development, integration & test and on-going mission operations and sustaining engineering:

● **VIRTUALSat®** is a modular real-time spacecraft dynamic simulator which models the orbital mechanics and dynamics of a spacecraft.
  ○ **VIRTUALSat** provides models for GN&C sensors and actuators, star catalogs, earth/lunar ephemeris/mag-fields and models for spacecraft power and thermal subsystems. Coupled with flight software, it can support flight software testing and mission operator training. Hardware interfaces are available which allow VIRTUALSat to interface with a flight system in place of real sensors and actuators to provide hardware-in-the-loop simulations. **VIRTUALSat** also provides commanded failures which simulate realistic failure modes of flight components.

● **GALAXY®** is a telemetry and command system.
  ○ **GALAXY** is derived directly from the ITOS telemetry and command system developed and maintained by the Hammers Company for NASA/GSFC, and we have been delivering **GALAXY** commercially since 1999. Together, **GALAXY** and ITOS have been used on more than 40 flight projects.
  ○ **GALAXY** is designed for fleet control. It can accept telemetry from and send commands to multiple peers simultaneously, and those peers...
LEADING EDGE MULTI-SATELLITE DEVELOPMENT & OPERATIONS

can include multiple spacecraft, simulators, ground stations, and many other entities and combinations. GALAXY communicates over a wide variety of transports and protocols including TCP/IP networking, synchronous and asynchronous serial ports, SpaceWire, MIL-STD-1553, and the GMSEC message bus.

- GALAXY can be configured to be a spacecraft, instrument, or component simulator. In this scenario, GALAXY can exchange commands and telemetry with instruments or other components over any supported interface. By using a 1553 interface, for example, GALAXY can act as a bus controller, running the spacecraft 1553 bus schedule and interfacing with instruments or other spacecraft hardware; or it can act as one or more remote terminals.

- **MERCURY™** is a sophisticated automation application for delivering, tracking, and approving file-based mission data products.
  - MERCURY is a key tool in providing for autonomous mission operations, and reduces manpower requirements for managing volumes of data over the mission life; including spacecraft data, flight dynamics products, mission planning products, and any other data products. MERCURY will issue alerts if products are not produced or delivered as expected. It includes a web portal for viewing product tracking information, for requesting re-delivery of products, and for approving products. The product flow is user-defined.
  - MERCURY was developed initially as the Data Management System (DMS) for the NASA Lunar Reconnaissance Orbiter (LRO), and now is a key part of the automation capability providing autonomous operations for both LRO and Landsat-8. From the outset, the product was designed to be mission-neutral and reusable.

- **STARS™** is a system for long-term mission data storage, access, and analysis.
  - STARS is designed for use across multiple missions, and users can query across missions and observatories. With STARS, users can access spacecraft data from a cloud-based system or strictly within
the operations center, and they can quickly define data sets, time periods, and trending analyses of mission data.

○ **STARS** provides automatic ingest of raw telemetry archives for multiple missions and web-services-based access to archived telemetry. **STARS** is designed to store full mission life telemetry and it also computes and archives statistical data including min, max, mean, standard deviation, number of points, rate of change, and variance.

○ **STARS** provides a web portal and a web-services API to access to raw and statistical data.

● **tACT™** is a tool for coordinating the activities of a team against a timeline of external events.

○ The Team Activity Coordination Tool (tACT) is used by a project’s mission planners to develop, schedule, execute, and manage activities to be performed by the mission operations team, especially during periods of intense activity such as observatory commissioning and science campaigns. It ingests flight dynamics events, contact schedules, and other events generated by the flight dynamics and mission planning systems, and allows the planners to organize a sequence of activities along this integrated event timeline to create a coordinated plan. It includes a web-based user interface that provides easy-to-comprehend graphical timelines and intuitive tools for activity planning. Users can create any number of customized timeline views that show only events and activities of interest over a desired time range.

○ The tACT supports a paper-free capability to maintain real-time communication of the plan and plan updates among mission subsystems teams. Activity definitions can include complex constraints with respect to timeline events and/or other activities. Activities can be grouped into hierarchies to express parent-child relationships. Activities can be linked to events so they automatically move when an event time changes.
**XHz Timing Box** is a Hammers-developed signal generation tool used for generating several timing signals. It normally is used as part of a simulation to provide the timing pulse used to synchronize spacecraft components.