

## Vita

### **T.S. Kelso**

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#### **Education**

Doctor of Philosophy in Mechanical Engineering (Operations Research), The University of Texas at Austin, August 1988. Dissertation: *Temporal Clustering in the Multi-Target Tracking Environment*.

Master of Science in Space Operations, Air Force Institute of Technology, December 1982. Distinguished Graduate. Thesis: *An Investigation of Spin-Orbit Resonance Effects About the Geosynchronous Orbit*.

Master of Business Administration in Quantitative Methods, University of Missouri-Columbia, August 1979.

Bachelor of Science in Physics and Mathematics, United States Air Force Academy, June 1976. Honor Graduate.

#### **Professional Military Education**

Air War College, September 1997.

Air Command and Staff College, July 1985.

Squadron Officer School, November 1979.

#### **Professional History**

2004–Present Senior Research Astrodynamist, Analytical Graphics, Inc. (AGI), Center for Space Standards & Innovation, Colorado Springs, CO

Promotes optimum use of space assets to further enhance U.S. security and public awareness of space information; fosters innovation in space control, technology, commerce, and exploration; acts as a central resource for open, readily available, industry-wide standards to encourage interoperability; compiles and disseminates accurate industry information, including the most capable techniques, sources, practices, and tools for space and defense applications; supports high standards by advocating state-of-the-art advancements; and encourages young talent and creative

ideas to thrive in the aerospace field. STK certified.

- 2003 Chief, Space Analysis Division (HQ AFSPC/XPY), Air Force Space Command, Peterson AFB, CO
- Manages 40 analysts, scientists, and engineers to conduct analyses across all Air Force Space Command mission areas in support of requirements generation, planning & programming, acquisition, operations, and support by assessing military utility of space systems, improving operational space capabilities, quantifying space effects in exercises and wargames, and acting as a key analysis focal point for collaboration within the national security space community.
- 2001–2003 Director, Air Force Space Command Space Analysis Center (ASAC), Air Force Space Command, Peterson AFB, CO
- Manages 40 analysts, scientists, and engineers to conduct analyses across all Air Force Space Command mission areas in support of requirements generation, planning & programming, acquisition, operations, and support by assessing military utility of space systems, improving operational space capabilities, quantifying space effects in exercises and wargames, and acting as a key analysis focal point for collaboration within the national security space community.
- 2001 Commandant, Air Force Institute of Technology (AFIT/CC), Wright-Patterson AFB, OH
- Manages 521 military and civilian faculty and staff, over 500 resident graduate students, 19,000 nonresident graduate and continuing education students, three schools, a major research laboratory, and an \$80 million annual budget.
- 1999–2001 Vice Commandant, Air Force Institute of Technology (AFIT/CV), Wright-Patterson AFB, OH
- Together with the AFIT Commandant, manages 521 military and civilian faculty and staff, over 500 resident graduate students, 19,000 nonresident graduate and continuing education students, three schools, a major research laboratory, and an \$80 million annual budget. Directs the Institute's Mission Support staff, International Affairs Office, Public Affairs Office, Protocol Office, Resources Directorate, and Information Resources Management Board. Responsible for day-to-day operations and long-range planning for the Institute.

- 1998–1999 Associate Dean, Graduate School of Engineering, Air Force Institute of Technology (AFIT/EN), Wright-Patterson AFB, OH
- Principal advisor to the Dean for the strategic planning and execution of all facets of the School's mission. Directed interactions with key customers, such as the Air Force Research Laboratory, Air Force Materiel Command, and both US and Air Force Space Command. The School's senior military officer, responsible for career development of 50 military faculty and academic progress of 300 graduate officer students. In the absence of the Dean, supervised 100 graduate faculty and 60 laboratory and administrative employees in six academic departments and five research laboratories. Served as chair of the School's Information Resources Committee (IRC) and Chief Information Officer (CIO).
- 1997–1998 Associate Director for Research, Airpower Research Institute, College of Aerospace Doctrine, Research, and Education (CADRE/AR), Maxwell AFB, AL
- Same duties as Deputy Director, Air University Research Coordinator Office (below).
- 1994–1997 Deputy Director, Air University Research Coordinator Office (AU/RCO), Maxwell AFB, AL
- Led a team of researchers and technologists chartered by the Air University Commander to facilitate and enhance research collaboration internal and external to Air University and the US Air Force via electronic media, creating and maintaining databases containing faculty expertise, as well as ongoing and completed research, and upgrading educational technology systems for Air University. Developed the Air University World Wide Web home pages and led AU network security accreditation effort. Developed research collaboration system that was subsequently adopted by the Joint Chiefs of Staff for all Department of Defense schools.
- 1994–1996 Director of Research Plans and Programs, Air Command and Staff College (ACSC/DR), Maxwell AFB, AL
- Directed research program at Air Command and Staff College for 110 faculty and 600 students to produce over 100 quality research products a year, impacting every aspect of US Air Force operations. Developed model research program which was subsequently adopted at Air War College. Responsible for developing research template and style guide for use throughout Air University, which have also been adopted by many other professional military educational institutions in the US.

- 1993–1994 Deputy Chief, SPACECAST 2020 Technology Team, Air Force Institute of Technology (AFIT/ENX), Wright-Patterson AFB, OH
- Led a team of AFIT technology experts supporting an Air Force Chief of Staff–commissioned study at Air University to identify high-leverage, innovative space technologies and systems that will best support the warfighter in the 21<sup>st</sup> century. Team assisted in the space-related education of the 150-member AWC and ACSC study teams, conducted first worldwide electronic data call, and provided technical assessments of systems concepts.
- 1990–1993 Deputy Director (1990-1991) and Director (1991-1993), Graduate Space Operations Program, Department of Operational Sciences, Air Force Institute of Technology (AFIT/ENS), Wright-Patterson AFB, OH
- Led a staff of three faculty to develop and manage academic policies and procedures for the Graduate Space Operations (GSO) program consisting of more than 35 USAF, USA, Canadian, and Australian officers. Represented the Institute in space operations education and research discussions with other Air Force organizations, DOD agencies, and international allies.
- 1988–1994 Assistant Professor of Space Operations, Department of Operational Sciences, Air Force Institute of Technology (AFIT/ENS), Wright-Patterson AFB, OH
- Developed academic curriculum, taught courses, and supervised student research within the GSO program. Conducted advanced research to fulfill critical Air Force needs.
- 1984–1985 Chief, GPS Spacecraft Operations Team, Headquarters Air Force Satellite Control Facility (HQ AFSCF/VOD), Sunnyvale AFS, CA
- Responsible for overseeing the day-to-day operations supporting a constellation of eight Block I Global Positioning System (GPS) satellites. Led three officers and a Mission Control Force (MCF) of more than 40 contractor personnel in planning, evaluating, and maintaining GPS satellite state-of-health. Supported the launch and early-orbit operations of one Block I GPS and one Defense Support Program (DSP) satellite. Developed plans to support the launch of an additional Block I vehicle, transition to the Data Systems Modernization program, and the deployment of 28 Block II satellites using the Space Transportation System (space shuttle). Developed initial study showing correlation between increased geomagnetic activity as a result of solar storms and satellite on-orbit anomalies—resulted in improved design of Block II satellites. Developed new computer scheduling techniques to support launch of GPS Block II satellites—increased launch rate from one launch per year to nine launches per year.

- 1982–1984 Chief, Training Plans Branch, Air Force Satellite Control Network Activation Directorate, Headquarters Air Force Satellite Control Facility (HQ AFSCF/VXTX), Sunnyvale AFS, CA
- Responsible for the concept definition and preliminary design of \$157 million integrated training program for the activation of the Air Force Satellite Control Network. Developed plans and schedules for the implementation of training for the Satellite Operations Complex. Integrated training for the Shuttle Operations and Planning Complex into the overall training program for the Consolidated Space Operations Center (now Schriever AFB). Oversaw planning for the development of simulation and computer-aided/managed instruction capabilities.
- 1980–1981 ICBM Operations Instructor, 4315<sup>th</sup> Combat Crew Training Squadron, Vandenberg AFB, CA
- Competitively selected by HQ SAC for Combat Crew Training Squadron duty. One of only 25 Air Force officers qualified and responsible for instruction of Minuteman Modernized Improved Launch Control System (ILCS) Initial Qualification Training (IQT) for future Strategic Air Command (SAC) missile combat crews. Upgraded to classroom instructor in record time.
- 1979–1980 Instructor Missile Combat Crew Commander, 351<sup>st</sup> Strategic Missile Wing, Whiteman AFB, MO
- Conducted comprehensive missile combat crew training to establish and maintain fully qualified, mission-ready crews. Performed Wing Alternate Command Post and Emergency Rocket Communications Systems (ERCS) duties.
- 1977–1979 Deputy Missile Combat Crew Commander (1977-1978) and Missile Combat Crew Commander (1978-1979), 509<sup>th</sup> Strategic Missile Squadron, 351<sup>st</sup> Strategic Missile Wing, Whiteman AFB, MO
- Exercised primary responsibility for the operational condition, security, safety, and maintenance of 10 nuclear ICBMs. As Wing Alternate Command Post commander, directly responsible to HQ SAC for positive control and execution of 150 nuclear ICBMs and direction of 15 missile combat crews. Managed alert status for wing and coordinated with HQ SAC and Airborne Launch Control Center.

## Scholarly Activities

### *Teaching*

SP94	OPER 412	Space Intelligence Seminar
WI94	OPER 411	Space Intelligence Seminar
WI94, WI93, WI92, WI91, WI90, WI89	OPER 592	Space Operations Planning
SP93, SP92	OPER 572	Stochastic Methods in Operations Research
SU92, SU91	OPER 637	Analysis and Modeling of Spatial-Temporal Information
SU92, SU91, SU90, SU89, WI89	OPER 511	Introduction to Space Systems and Operations
SP92	AERO 698	Design and Systems Seminar
WI92, SP91, SP90, SP89	OPER 666	Military Systems Simulation
SP91, SP90	OPER 398	Research Methods
WI91	OPER 402	Operations Research Seminar
SU90, WI89	OPER 562	Introduction to Management Science
WI90	OPER 525	Analysis of Logistics Systems
SU89	OPER 561	Management Science for Systems Managers
FA88	OPER 526	Quantitative Decision Making

Developed OPER 511—Introduction to Space Systems and Operations

Developed OPER 411, 412, 413, and 414—the Space Intelligence Seminar—for the Graduate Space Operations program. This seminar covers space intelligence issues at the TS/SCI level and was the first such course developed at AFIT. Planning involved developing the curriculum, coordinating the justification for both faculty and student TS/SCI billets, and coordinating the list of presentations through both AFIT/CC and NAIC/CC. The seminar has been running continuously since January 1994.

Restructured OPER 592—Space Operations Planning—for WI90 quarter.

Advisor for 26 master's theses (including one Commandant's Award winner and two nominees); reader for 20 additional master's theses (including one at the Naval Postgraduate School).

Advisor for the following master's theses:

1. Davey, "Ground-Based Deep-Space LADAR for Satellite Detection: A Parametric Study," (**Commandant's Award winner**) December 1989.
2. Gallagher, "Numeric Model of a CO<sub>2</sub> Laser Amplifier," December 1989.
3. King, "Kinetic Studies of Dissociation in Oxygen-Iodine Lasers," (**Commandant's Award nominee**) December 1989.
4. Kogler, "Modeling the Effects of the Use of GPS Derived Altitude Indication in the C-17A Airdrop System," December 1989.
5. Larcomb, "Spatial Registration of TIROS-N Weather Satellite Data," December 1989.
6. Maust, "The Air Force Satellite Control Network: A Discrete Stochastic Loading Analysis," December 1989.
7. Melancon, "A Model of Temperature Effects in Pulsed and Continuous Wave CO<sub>2</sub> Lasers and Optimization Using Response Surface Methodology," December 1989.
8. Sandys, "Evaluation of Platinum Silicide and Indium Antimonide as Detector Materials for Space-Based Remote Sensing in the 3.0-to-5.0 Micrometer Wavelength Band," December 1989.
9. Vasta, "An Analysis of the Relationship Between a Passive Microwave Sensor Data Set and Soil Moisture Content," December 1989.
10. Ahmed, "A Procedure for Performance Assessment of Drugs Hypothesized to be Effective in Controlling Motion Sickness," December 1990.
11. Mehlberg, "Development of an Image Registration Technique for Polar-Orbiting Satellites," December 1990.
12. Remillard, "Debris Production in Hypervelocity Impact ASAT Engagements," December 1990.
13. Severance, "Proposed Design of a Tactical Reconnaissance Satellite System," December 1990.
14. Szczur, "Technological Impacts on the Effectiveness of a Conceptual Space-Based RF Weapon System," December 1990.
15. Horn, "A Cost-Benefit Analysis on the Deletion of the Inertial Upper Stage Factory Acceptance Testing Versus a Decrease in Mission Reliability," September 1991.
16. Anton, "A Dynamic Computer Graphics Model of Satellite Orbits for Use in Instruction and Analysis," December 1991.
17. Cooper, "Verification and Validation of the Comprehensive Operational Support Evaluation Model for Space," December 1991.

18. Howard, "Analysis of Orbital Elements and Atmospheric Activity to Ascertain Possible Presence of an Ion Propulsion Capability Aboard Salyut 7/Cosmos 1686," December 1991.
19. Lefebvre, "An Analysis of Tracking and Impact Predictions," December 1991.
20. Martin, "Separation of Cloud/No-Cloud Regions in Satellite Imagery Using a Variation of Hierarchical Clustering Analysis," December 1991.
21. McGee, "The Application of Statistical Kriging to Improve Satellite Imagery Resolution," (**Commandant's Award nominee**) December 1991.
22. O'Brien, "Preliminary Design of a Model to Assess the Effect of Space Surveillance Network (SSN) Sensor Upgrades on Orbit Prediction Accuracies to the U.S. Anti-Satellite (ASAT) Mission," December 1991.
23. Blaufuss, "Analysis of Kriging Applied to Resolution Enhancement of Digital Satellite Imagery," December 1992.
24. Boltz and Kather, "Analysis of Whole-Sky Imager Data to Determine the Validity of PCFLOS Models," December 1992.
25. Berger, Moles, and Wilsey, "An Analysis of USSPACECOM's Space Surveillance Network (SSN) Sensor Tasking Methodology," December 1992.
26. Wasson, "Data Reduction With Least Squares Differential Correction Using Equinoctial Elements," December 1992.

Reader on the following master's theses:

27. Rooney, "The Manned Military Space Vehicle in Support of Grand Strategy Requirements," December 1988.
28. Simmons, "Analysis of Space-Based LIDAR for Aircraft Tracking," December 1988.
29. Elliott, "Decision-Analytic Approach to Rule-Based Expert System Development Using GPS as the Model," December 1989.
30. Thompson, "An Exploratory Analysis of Motion Sickness Data: A Time Series Approach," December 1989.
31. Banducci, "An Analysis of the Effects of Phenytoin in Treating Motion Sickness and the Effects of Motion Sickness on the Human Electroencephalogram," December 1990.
32. Forgues, "The Optimal Location of GEODSS Sensors in Canada," March 1991.
33. Reed, "Binary Programming Models of Spatial Pattern Recognition: Applications in Remote Sensing Image Analysis," December 1991.
34. Vogen, "A Topographical Analysis of the Human Electroencephalogram for Patterns in the Development of Motion Sickness," December 1991.
35. Barber, "Space Systems Analysis and Design," Naval Postgraduate School, September 1992.

36. Roblyer, "A Toposcopic Investigation of Brain Electrical Activity Induced by Motion Sickness," December 1992.
37. Claunch, "Identifying Targets Detected by Tactical Warning Satellites in Real Time Using an Artificial Neural Network (U)," March 1993.
38. Fournier, "Design Analysis of a Combined Optical/LADAR Deep-Space Surveillance Satellite," December 1993.
39. Hogan, "Performance Impacts of Actuator Misalignments and Actuator Failures in Large-Aperture Adaptive Optic Telescopes," December 1993.
40. Kunz, "A Virtual Environment for Satellite Modeling and Orbital Analysis in a Distributed Interactive Simulation," December 1993.
41. Page, "System Design Analysis of a Lightweight Laser Satellite Terminal," December 1993.
42. Sovaiko, "A Methodology to Assess the Impact of the Global Positioning System on Air Combat Operations," December 1993.
43. Brown, "The Quota Allocation Model: The Linear Optimization of a Markov Decision Process," March 1999.
44. Olsen, "Issues in Modeling Military Space," March 2002.
45. Sumter, "Optimal Replacement Policies for Satellite Constellations," March 2003.
46. Loftis, "The Air Warrior's Value of National Security Space," March 2003.

### *Research*

Conducted research sponsored by 1 Command and Control Squadron (1 CACS) commander to develop a model to efficiently task the sensors of the Space Surveillance Network (SSN) for daily observations of the on-orbit satellite population in support of catalog maintenance. A need exists to determine the optimum number and spacing of observations for each of 8,500+ objects on orbit to reduce the load on the network in the face of an increasing orbital population and reduced network resources. Development of this tool will permit not only a much more efficient way to assign daily taskings but allow analyses to be performed to assess the benefit of proposed network upgrades and the impact of network changes on operations. Goals of the model were to reduce requirements while maintaining operational effectiveness and to provide a capability to perform normal scheduling, respond to contingency scheduling, and perform COEA analyses of system upgrades or closings. This study realized an immediate cost savings of several hundred thousand dollars and potential savings of millions of dollars.

Conducted research sponsored by HQ AFSPACECOM/XP to develop a model for assessing system effectiveness of the Air Force Satellite Control Network (AFSCN). The goals of this model were similar to those of the model developed for 1 CACS/CC, that is, to reduce the workload on the AFSCN while maintaining

operational effectiveness and develop a means for assessing the impact of system upgrades or closings.

Conducted independent research to develop low-cost, transportable weather stations with sophisticated applications software for tactical use. Commercially-built versions of these stations—based upon this research—were deployed for use in Desert Storm by CINC AFSPACECOM to replace ‘airlift-intensive’ DMSP terminals.

Conducted independent research to assess the validity of various theories pertaining to hypervelocity impacts such as those involved in the employment of an anti-satellite (ASAT) weapon. Numerous conflicting theories existed and no effort had been made to attempt to apply the results of US ASAT tests to determine which models were correct. Orbital data from the 1985 September 13 air-launched ASAT attack on the Solwind satellite were analyzed to assess the validity of competing theories. The results of this analysis are being employed to determine ways to reduce the potential of fratricide in an ASAT conflict.

Conducted research sponsored by the NASP Joint Program Office to analyze ballistic ascent trajectories to be used by a future National AeroSpace Plane (NASP) derived vehicle for satellite deployment. Use of these trajectories should increase the payload capacity of such vehicles. This research saved at least \$50,000 over a proposed contract for the same research. The employment of these techniques should work to significantly reduce the overall cost of launched DOD payloads to earth orbit.

Conducted research sponsored by the National Air Intelligence Center (NAIC) to apply statistical kriging techniques to improve satellite imagery resolution. Kriging was demonstrated to be at least as good as current image enhancement techniques and in some cases considerably better. The application of this technique to image interpretation holds the potential for revolutionizing existing methods, thereby greatly enhancing the value of our existing space-based imaging systems and extensive image databases. It also holds the potential for greatly reducing the amount of data transmitted to the ground for high-resolution imaging systems, thereby considerably reducing system costs.

Conducted research to study the human electroencephalogram (EEG) for patterns in the development of motion sickness, research key to developing effective treatments for space adaptation syndrome—or space sickness—a malady inflicting many astronauts and costing the National Aeronautics and Space Administration (NASA) \$10 million per space shuttle mission in lost productivity. Due to the resulting impaired crew performance, both the crew and the space shuttle orbiter are in jeopardy should a situation develop which requires return to earth during periods of space sickness. New ways were found to visualize the EEG and a possible pattern for electrical activity during the development of motion sickness was discovered which is consistent with the current understanding of how the human brain works. Through this research effort, it should be possible to develop treatments which allow NASA to significantly reduce the mission risk to both

crew and orbiter. Similar benefits exist for the application of these results to aircrew motion sickness.

Conducted research sponsored by the Director, SDI Logistics at Space Systems Division to perform an independent verification and validation (IV&V) of the Comprehensive Operational Support Evaluation Model for Space (COSEMS). This model shows the best way of logistically supporting proposed SDI constellations and the IV&V resulted in cost savings of several hundred thousand dollars to the Air Force.

Conducted research sponsored by Air Force Phillips Laboratory to develop and validate temporal-spatial models for predicting cloud cover. These models can be used in a wide range of applications, such as laser targeting of satellites or planning for optimum attack times based on target signatures.

Conducted research sponsored by the US Navy to develop a high-precision satellite tracking program for the Naval Satellite Operations Center for use in validating system performance of their new S-Band antenna at Point Mugu, CA.

Conducted research sponsored by the Wright-Patterson Weather Detachment and the B-2 SPO to develop system for forecasting contrail-formation conditions. This work is paramount to successful low-observable missions to prevent otherwise undetectable aircraft from being spotted by creating contrails. Consulting on satellite systems to use and equipment needed to develop a database for forecasting. Sponsor funds used to install satellite weather terminal at AFIT.

### *Professional Practice*

US Air Force representative to the Near-Earth Object Science Definition Team chartered by NASA to study the feasibility of extending the search for near-Earth objects to smaller limiting diameters.

Analysis lead for the DOD Columbia Investigation Support Team (DCIST) responsible for conducting and coordinating all DOD analysis in support of the Columbia accident investigation. Established DOD data repository and classified web portal to archive all DOD data relevant to the investigation.

Consulted with USSPACECOM/J3SOS on validating the use of a new orbital prediction model (GOBS) which will reduce the number observations required by the Space Surveillance Network in support of geosynchronous spacecraft.

Regularly worked to support the Advanced Ranging and Instrumentation Aircraft (ARIA) missions by supplying technical advice on satellite tracking and current orbital elements. This support resulted in the successful launches of the Galileo probe to Jupiter, the Magellan probe to Venus, and the Pegasus air-launched booster carrying MACSAT (which was used to support troops in the Persian Gulf during Operations Desert Shield/Desert Storm), and the Mars Observer.

Consulted for the Space Test Program at Space Systems Division to develop a method of scheduling payloads onto available launch vehicles.

Consulted for NAIC on a number of joint-interest topics involving ways to improve the quality of satellite imagery and to develop a library of orbital mechanics tools to facilitate rapid development of software for analysis.

Consulted for NAIC and NORAD to develop historical database for two-line orbital element sets for all artificial satellites launched since 1957. Current NORAD archives are in disrepair and NAIC's data was inadvertently wiped out in 1993. Worked to structure data and determine gaps. This work is key to successful analysis for past, present, and future space operations.

Consulted for Phillips Laboratory to provide information on orbital models and provide data in support of their work with the Navy Transit satellites to develop an Ionospheric Tomography System.

Consulted for Phillips Laboratory to develop initial design concepts for a space-based space surveillance network to augment/replace the current SSN. Specific tools and measures of effectiveness have already been developed to assess relative performance. Proposed system developed a low-cost constellation capable of at least doubling current SSN performance.

Consulted for the Naval Postgraduate School and Navy TENCAP on developing a catalogue of earth-orbiting UHF systems.

Consulted for US Naval Academy on NORAD orbital models and providing orbital data for their research with the DARPA Microsats.

Consulted for the US Army to provide information on NORAD orbital models and orbital data in support of TERRA SCOUT.

Consulted for the US Army Space Institute at Fort Leavenworth on various tactical weather systems for combat operations.

Consulted for the Naval Postgraduate School to develop an experiment for STS-51 which was the first to evaluate the suitability of GPS for navigation in near-earth orbit.

Consulted for NASA researchers at Goddard Space Flight Center to prepare the Shuttle Solar Backscatter Ultraviolet (SSBUV) experiment for STS-34.

Consulted for Mission Specialist Ron Parise to prepare the Shuttle Amateur Radio Experiment (SAREX) used on STS-35. This experiment was conducted with schools around the world during the STS-35 mission and resulted in the first attempted communication between the US Space Shuttle and the Soviet Mir space station.

Consulted for the National Solar Observatory (NSO) (under the National Oceanographic and Atmospheric Administration (NOAA)) to set up the first system to capture and display weather data from polar-orbiting satellites at the South Pole. The system is now operating year-round. The NSO is using software developed through AFIT theses to support their work.

Consulted for the Meteorological Group at the South Pole to upgrade their existing satellite weather capabilities and provide satellite communications via medium-inclination geosynchronous satellites.

Provided two-line orbital element sets on key geosynchronous satellites along with technical support to the South Pole to support vital satellite communications with the United States. Support was instrumental in supporting several critical humanitarian rescue operations.

Consulting for the National Oceanographic and Atmospheric Administration's Direct Readout User Services to provide users of NOAA polar-orbiting and GOES geostationary weather satellites with orbital data.

Consulted for the National Radio Astronomy Observatory at Kitt Peak to develop methods for tracking asteroids. Work focused on providing information on high-precision orbital models for tracking earth-orbiting satellites to characterize near-field operating characteristics of their telescopes.

Consulting for NASA/Marshall Space Flight Center to provide satellite tracking documentation and orbital element sets for their Spacelink BBS.

Consulted for NASA/Goddard Space Flight Center on ways to disseminate orbital elements via electronic media.

Consulted for the Aerospace Corporation to validate NORAD orbital models for use in their Satellite Orbital Analysis Program (SOAP) for PCs and Sun workstations.

Consulted for the Lick Observatory on developing a means of using geosynchronous satellites to calibrate the telescope pointing mechanisms of the telescopes supervised by the University of California. This procedure was applied in the activation of the Keck 10-meter telescope in Hawaii, the largest telescope in the world.

Consulted for the Massachusetts Institute of Technology to provide improved orbital models/software in support of their research with the Hubble Space Telescope.

Consulted for the Pakistani Space Agency (SUPARCO) on satellite tracking models and software.

Consulting for the Yokohama Science Center in Japan to provide information on satellite tracking and current orbital elements.

Consulted for the South African Astronomical Observatory on the visual tracking of artificial satellites for their educational programs.

Consulted for the University of Oulu in Finland on orbital tracking models for use in the research on monitoring the aurora.

## Publications

### Book Chapters and Edited Publications

1. Kelso, T.S. "Space-Based Platforms and Sensors," *Manual of Remote Sensing, Volume 1.1: Earth Observing Platforms & Sensors*, ed. Mark W. Jackson. Bethesda, MD: American Society for Photogrammetry and Remote Sensing, 2009 (3<sup>rd</sup> Edition), pp. 291–319.
2. Stokes, Grant H. et al. *Study to Determine the Feasibility of Extending the Search for Near-Earth Objects to Smaller Limiting Diameters*, Report of the Near-Earth Object Science Definition Team, 8 August 2003.
3. Howell, Kathleen C., David A. Cicci, John E. Cochran Jr., and Thomas S. Kelso, eds. *Spaceflight Mechanics 1997*. 2 vols. San Diego: Univelt, Inc., 1997.
4. Air University. *Student and Faculty Research: Academic Year 1996*. CD-ROM. Maxwell AFB, AL: Air University Research Office, December 1996.
5. Air University. *Style Guide for Writers & Editors*. Maxwell AFB, AL: Air University Press, September 1996.
6. Air University. *Student and Faculty Research: Academic Year 1995*. CD-ROM. Maxwell AFB, AL: Air University Research Coordinator Office, December 1995.
7. Kelso, T.S. et al., "Unconventional Spacelift," *SPACECAST 2020 Final Report, Volume I*, June 1994.

### Refereed Journals

8. Senior, A., F. Honary, P. J. Chapman, M.T. Rietveld, T.S. Kelso, and M.J. Kosch. "High-frequency magnetospheric sounding at EISCAT: Some trials and their implications." *Radio Science*, 43, RS4009 (August 2008).
9. Hamill, J. Todd, Richard F. Deckro, Jack M. Kloeber, Jr., T.S. Kelso. "The Value of Information and Risk Management in a Defense Computer System." *Military Operations Research*, 7, no. 2 (2002): 61–81.
10. Parnell, Gregory S., Thomas S. Kelso, Roger C. Burk, and Stephen F. Sovaiko. "A Methodology to Assess the Contribution of the Global Positioning System to Air Combat Outcomes." *Journal of Air Force Operational Test and Evaluation*, 6, no. 1 (July 1996): 12–26.
11. Kelso, T.S., C.H. Ohms, R.L. Swedenburg, and J.J. Armstrong, "Determination of Optimum Gas Mixture for CO<sub>2</sub> Laser." *The Journal of the Colorado-Wyoming Academy of Sciences*, VII, no. 6 (May 1975).

## Magazine Articles

[*Satellite Times* articles were written as editor of *Computers & Satellites* column]

12. Kelso, T.S. "More on Geostationary Orbits." *Satellite Times*, 4, no. 9 (July 1998): 76–77.
13. Kelso, T.S. "Basics of the Geostationary Orbit." *Satellite Times*, 4, no. 7 (May 1998): 76–77.
14. Kelso, T.S. "More Frequently Asked Questions." *Satellite Times*, 4, no. 5 (March 1998): 76–77.
15. Kelso, T.S. "Frequently Asked Questions: Two-Line Element Set Format." *Satellite Times*, 4, no. 3 (January 1998): 52–54.
16. Kelso, T.S. "Space Surveillance." *Satellite Times*, 4, no. 1 (September/October 1997): 68–69.
17. Kelso, T.S. "Software Review: Micro Orbiter 3.0." *Satellite Times*, 3, no. 6 (July/August 1997): 68–69.
18. Kelso, T.S. "Sunrise . . . Sunset." *Satellite Times*, 3, no. 4 (March/April 1997): 66–67.
19. Kelso, T.S. "Tracking the Sun and Moon." *Satellite Times*, 3, no. 3 (January/February 1997): 66–67.
20. Kelso, T.S. "Real-World Benchmarking." *Satellite Times*, 3, no. 2 (November/December 1996): 80–82.
21. Kelso, T.S. "Visually Observing Earth Satellites." *Satellite Times*, 3, no. 1 (September/October 1996): 80–82.
22. Kelso, T.S. "Orbital Data on the WWW." *Satellite Times*, 2, no. 5 (May/June 1996): 80–81.
23. Kelso, T.S. "System Benchmarking." *Satellite Times*, 2, no. 4 (March/April 1996): 80–81.
24. Kelso, T.S. "Orbital Coordinate Systems, Part III." *Satellite Times*, 2, no. 3 (January/February 1996): 78–79.
25. Kelso, T.S. "Orbital Coordinate Systems, Part II." *Satellite Times*, 2, no. 2 (November/December 1995): 78–79.
26. Kelso, T.S. "Orbital Coordinate Systems, Part I." *Satellite Times*, 2, no. 1 (September/October 1995): 80–81.
27. Kelso, T.S. "Orbit Determination." *Satellite Times*, 1, no. 6 (July/August 1995): 80–81.
28. Kelso, T.S. "Orbital Estimation." *Satellite Times*, 1, no. 5 (May/June 1995): 80–81.

29. Kelso, T.S. "Orbital Propagation, Part II." *Satellite Times*, 1, no. 4 (March/April 1995): 80–81.
30. Kelso, T.S. "Orbital Propagation, Part I." *Satellite Times*, 1, no. 1 (September/October 1994): 70–71.
31. Kelso, T.S. "Astronomical Computing Benchmarks." *Sky & Telescope*, March 1986.

#### WWW Publishing

32. Kelso, T.S., ed. *CelesTrak*. On-line. Internet, 1998 July 24. Available from <http://celestrak.com>. [System has over 258,000 unique visitors per month, as of 2007 August.]

#### *Invited Presentations*

1. Kelso, T.S., "Analysis of the Iridium 33-Cosmos 2251 Collision," presented at the 10<sup>th</sup> Advanced Maui Optical and Space Surveillance Technologies Conference, Maui, HI, 2009 September 2.
2. Kelso, T.S. "Analysis of the Iridium 33-Cosmos 2251 Collision," presented at the 19<sup>th</sup> AIAA/AAS Astrodynamics Specialist Conference, Pittsburgh, PA, 2009 August 11.
3. Kelso, T.S., David A. Vallado, Joseph Chan, and Bjorn Buckwalter, "Improved Conjunction Analysis via Collaborative Space Situational Awareness," presented at the 5<sup>th</sup> European Conference on Space Debris, Darmstadt, Germany, 2009 April 2.
4. Kelso, T.S., David A. Vallado, Joseph Chan, and Bjorn Buckwalter, "Improved Conjunction Analysis via Collaborative Space Situational Awareness," presented at the 3<sup>rd</sup> International Association for the Advancement of Space Safety Conference, Rome, Italy, 2008 October 22.
5. Kelso, T.S., David A. Vallado, Joseph Chan, and Bjorn Buckwalter, "Improved Conjunction Analysis via Collaborative Space Situational Awareness," presented at the 9<sup>th</sup> Advanced Maui Optical and Space Surveillance Technologies Conference, Maui, HI, 2008 September 19.
6. Kelso, T.S., "Analysis of the 2007 Chinese ASAT Test and the Impact of its Debris on the Space Environment," presented at the 8<sup>th</sup> Advanced Maui Optical and Space Surveillance Technologies Conference, Maui, HI, 2007 September 14.
7. Kelso, T.S., "Validation of SGP4 and IS-GPS-200D Against GPS Precision Ephemerides," presented at the 17th AAS/AIAA Space Flight Mechanics Conference, Sedona, AZ, 2007 January 29.

8. Vallado, David A., Paul Crawford, Richard Hujsak, and T.S. Kelso, "Revisiting Spacetrack Report #3," presented at the AIAA/AAS Astrodynamics Specialist Conference, Keystone, CO, 2006 August 21–24.
9. Kelso, T.S. and S. Alfano, "Satellite Orbital Conjunction Reports Assessing Threatening Encounters in Space (SOCRATES)," presented at the Defense and Security Symposium 2006 (Modeling, Simulation, and Verification of Space-Based Systems III Conference), Orlando, FL, 2006 April 17.
10. Vallado, D.A. and T.S. Kelso, "Using EOP and Space Weather Data for Satellite Operations," presented at the 6<sup>th</sup> US-Russian Space Surveillance Workshop, St. Petersburg, Russia, 2005 August 26.
11. Kelso, T.S. and S. Alfano, "Satellite Orbital Conjunction Reports Assessing Threatening Encounters in Space (SOCRATES)," presented at the 6<sup>th</sup> US-Russian Space Surveillance Workshop, St. Petersburg, Russia, 2005 August 22.
12. Vallado, D.A. and T.S. Kelso, "Using EOP and Space Weather Data for Satellite Operations," presented at the 15<sup>th</sup> AIAA/AAS Astrodynamics Specialist Conference, Lake Tahoe, CA, 2005 August 11.
13. Kelso, T.S. and S. Alfano, "Satellite Orbital Conjunction Reports Assessing Threatening Encounters in Space (SOCRATES)," presented at the Fourth European Conference on Space Debris, Darmstadt, Germany, 2005 April 18–20.
14. Kelso, T.S. and S. Alfano, "Satellite Orbital Conjunction Reports Assessing Threatening Encounters in Space (SOCRATES)," presented at the 2005 AAS/AIAA Space Flight Mechanics Conference, Copper Mountain, CO, 2005 January 24.
15. Kelso, T.S., R.F. Morris, G.T. DeVere, J.C. Randolph, B.R. Bowman, R.A. Racca, N.L. Ericson, and R.G. Thurston, "How Space Surveillance Contributed to the STS 107 Accident Investigation," presented at the 72<sup>nd</sup> Military Operations Research Society Symposium, Monterey, CA, 2004 June 22.
16. Kelso, T.S., R.F. Morris, G.T. DeVere, J.C. Randolph, B.R. Bowman, R.A. Racca, N.L. Ericson, and R.G. Thurston, "Space Surveillance Contributions to the STS 107 Accident Investigation," presented at the 2004 AAS/AIAA Space Flight Mechanics Conference, Maui, HI, 2004 February 9.
17. Kelso, T.S., R.F. Morris, G.T. DeVere, J.C. Randolph, B.R. Bowman, R.A. Racca, N.L. Ericson, and R.G. Thurston, "Modeling and Simulation Support to the STS 107 Accident Investigation," presented at the 2003 Core Technologies for Space Systems Conference, Colorado Springs, CO, 2003 November 6.
18. "Operationally Responsive Spacelift Military Utility Analysis: A Capabilities-Based Approach," presented at the 2003 Air Force Operations Research Symposium, Hanscom AFB, MA, 2003 October 23.
19. Kelso, T.S., R.F. Morris, G.T. DeVere, J.C. Randolph, B.R. Bowman, R.A. Racca, N.L. Ericson, and R.G. Thurston, "Space Surveillance Contributions to the STS 107 Accident Investigation," presented at the Fifth US-Russian Space

- Surveillance Workshop, Pulkovo Observatory, St. Petersburg, Russia, 2003 September 24.
20. "Initiatives of the AFSPC Space Analysis Center," presented at the 70<sup>th</sup> Military Operations Research Society Symposium, Fort Leavenworth, KS, 2002 June 20.
  21. "Engaging the Adult Learner through Research and Technology," presented at the Convention of the National Communication Association 2000, Seattle, WA, 2000 November 9.
  22. Capt J. Todd Hamill, Dr. Richard F. Deckro, LTC Jack M. Kloeber, Jr., and Col. T. S. Kelso, "The Value of Information in a Defense System", presented at AFORS 2000, Air Force Operations Research Symposium, Colorado Springs, CO, September 2000.
  23. "Curso de Simulación Orbital (Orbital Simulation Course)," a ten-part series on orbital mechanics, presented at the II Encuentro de Ingeniería Aeroespacial (2<sup>nd</sup> Aerospace Engineering Conference), La Academia Politécnica Aeronáutica, Santiago, Chile, 2000 July 24–28.
  24. "WWW Operations: Getting Your Web Pages on the Internet," presented at the Civilian Personnel School, Ira C. Eaker College of Professional Development, Maxwell AFB, AL, 1998 May 29.
  25. "WWW Operations: Getting Your Web Pages on the Internet," presented at the Civilian Personnel School, Ira C. Eaker College of Professional Development, Maxwell AFB, AL, 1998 May 21.
  26. "Electronic Publishing for Professional Military Education," presented at DTIC '97 Annual Users Meeting and Training Conference, Arlington, VA, 1997 November 3–6.
  27. "Electronic Publishing Process," presented at Military Education Coordinating Conference, National Defense University, Fort McNair, VA, 1997 October 15–16.
  28. "AU Research Publishing Process," presented at Defense Technical Information Center, Fort Belvoir, VA, 1997 July 22–23.
  29. "Electronic Opportunities for Collaborative Research," presented at TABES '97, Huntsville, AL, 1997 May 12–14.
  30. "AU Research Publishing Process," presented at Air Force Institute of Technology, Wright-Patterson AFB, OH, 1997 April 20–23.
  31. "WWW Operations: Getting Your Web Pages on the Internet," presented at the Civilian Personnel School, Ira C. Eaker College of Professional Development, Maxwell AFB, AL, 1997 March 5.
  32. "Writing Research Reports," presented at Air Command and Staff College, Maxwell AFB, AL, 1996 November 26.

33. "Research Collaboration and Technology Insertion," presented at the Military Education Coordinating Conference, National Defense University, Fort McNair, VA, 1996 November 19–20.
34. "Satellite Tracking Software," presented at Grove Expo, Atlanta, GA, 1996 October 18–20.
35. "Visually Observing Earth Satellites," presented at Grove Expo, Atlanta, GA, 1996 October 18–20.
36. "Sister Service Schools' Research Directors Meeting at Naval War College," presented at Naval War College, Providence, RI, 1996 October 3–5.
37. "Air Command and Staff College Research Program '97," presented at Naval War College, Providence, RI, 1996 October 3–5.
38. "Electronic Opportunities for Collaborative Research," presented at 20<sup>th</sup> Annual Interservice Correspondence Exchange Conference, Montgomery, AL, 1996 September 17–19.
39. "Guidelines for Systems Responsibilities," presented at the Air Force Institute of Technology, Wright-Patterson AFB, OH, 1996 January 26.
40. "Electronic Opportunities for Collaborative Research," presented at Quality Air Force Symposium, 1995 October 2.
41. "Internet: Roles and Responsibilities," presented at Air Command and Staff College, 1995 September 26.
42. Selected to brief *SPACECAST 2020* "Unconventional Spacelift" study to the Secretary of the Air Force, May 1994.
43. Selected to brief "Tactical Satellite Weather Stations" to Air University commander, AFIT commandant, and a visiting delegation of Russian general officers, June 1993.
44. "Low-Cost Satellite Weather Stations," presented to the Amateur Satellite Forum, Dayton Amateur Radio Convention (Hamvention), 1993 April 23–25.
45. "Space-Based Space Surveillance," presented to Air Force Phillips Laboratory (PL/SXS), Kirtland AFB, NM, 1993 March 25.
46. "Space Systems Design: A Case Study," presented at Canadian Defence Force's School of Aerospace Studies, Winnipeg, Manitoba, Canada, 1993 March 5.
47. "Russian Space Program," presented at Canadian Defence Force's School of Aerospace Studies, Winnipeg, Manitoba, Canada, May 1992.
48. "Satellite Imagery and Image Processing," presented to the Amateur Satellite Forum, Dayton Amateur Radio Convention (Hamvention), 1992 April 24–26.
49. "Space Systems Design: A Case Study," presented at Canadian Defence Force's School of Aerospace Studies, Winnipeg, Manitoba, Canada, 1992 February 27.

50. "Real-Time Processing of Satellite Weather Imagery on a Personal Computer," presented at the 59th MORS Symposium, West Point, NY, 1991 June 11–13.
51. "An Analysis of Spatial Registration of TIROS-N Weather Imagery," presented at the 59th MORS Symposium, West Point, NY, 1991 June 11–13.
52. "Low-Cost Satellite Weather Stations," presented to the Amateur Satellite Forum, Dayton Amateur Radio Convention (Hamvention), April 1991.
53. Balakrishnan, S.N., M.M. Crawford, T.S. Kelso, S. Lee, J.B. Lundberg, and B.D. Tapley, "Application of Clustering Techniques for the Detection, Classification, and Estimation of Multiple Targets in Space," *Proceedings of the 26<sup>th</sup> AIAA Aerospace Sciences Meeting*, Reno, NV, January 1988.

## **Honors and Awards**

### *Military*

Perfect 5.0 Highly Qualified Rating on Minuteman ICBM Standardization Evaluations: December 1976, May 1977, September 1978, April 1979, August 1979, December 1979.

509<sup>th</sup> Strategic Missile Squadron Crew of the Month: August 1978, April 1979

509<sup>th</sup> Strategic Missile Squadron Company Grade Officer of the Quarter, Fourth Quarter 1978

Eighth Air Force Crew Member Excellence Award, September 1979

Combat Readiness Medal, January 1980

Air Force Commendation Medal, February 1980

Alternate, Manned Spaceflight Engineer Program, September 1982

Air Force Achievement Medal, November 1983

Air Force Meritorious Service Medal, December 1993

Air Force Commendation Medal (1<sup>st</sup> Oak Leaf Cluster), September 1994

Air Force Meritorious Service Medal (1<sup>st</sup> Oak Leaf Cluster), August 1998

Legion of Merit, October 2002

Legion of Merit (1<sup>st</sup> Oak Leaf Cluster), December 2003

### *Academic*

4315<sup>th</sup> Combat Crew Training Squadron Instructor of the Quarter, First Quarter 1981

Alpha Iota Delta (national honor society of the Decision Sciences Institute), 1982

Omega Rho (international honor society of Operations Research), 1985

AFIT Outstanding Instructor, Summer 1989

Friend of Education, Kettering Classroom Teachers Association, 1991

Kettering City Schools' Community Service Award, October 1991

Gen Bernard A. Schriever Award, Wright Memorial Chapter, Air Force Association, Air Force Institute of Technology, 1994. For advancing aerospace power, technology, Air Force doctrine, or the military as a profession.

Selected as Eminent Engineer by Tau Beta Pi, June 2000.

Selected for *Who's Who in Science and Engineering*, 2000–2001.

### *Other*

Invited by the governments of the Russian Federation and the Republic of Kazakhstan to view the launch of the Soyuz-TM 14 mission to the Mir space station and to tour facilities at the Baikonur Cosmodrome—the first US official to do so after the collapse of the Soviet Union.

### **Service**

#### *Institute (AFIT)*

Academic Standards Committee, Member, 1990–1992

Program Director, Graduate Space Operations Program, 1991–1993

Deputy Program Director, Graduate Space Operations Program, 1990–1991

AFIT Representative to the Ohio Space Grant Consortium, 1989–1993

Associate Dean, Graduate School of Engineering, 1998–1999

Vice Commandant, 1999–2001

Commandant, 2001

Adjunct Assistant Professor of Space Operations, 2001–Present

#### *External*

American Institute of Aeronautics and Astronautics (AIAA), Member, 1992–1994; Senior Member, 1994–2000; Associate Fellow, 2000–Present

American Astronautical Society (AAS), Member, 1995–2008; Fellow, 2008–Present

AAS Space Flight Mechanics Technical Committee, Member, 2005–Present

AAS Space Flight Mechanics Technical Committee, Chair, 2007–Present

AIAA Astrodynamics Standards Committee, Member, 2004–Present

Conference Co-Chair, Modeling, Simulation, and Verification of Space-based Systems III, 2006 Defense and Security Symposium, Orlando, FL, 2006 April 17

Session Chair, Surveillance and Space Debris, 2006 AAS/AIAA Space Flight Mechanics Conference, Copper Mountain, CO, 2005 January 23–27

Session Chair, Tethers II, 2005 AAS/AIAA Space Flight Mechanics Conference, Copper Mountain, CO, 2005 January 23–27

AIAA Astrodynamics Technical Committee, Member, 1993–1997; Secretary, 1993–1996

Facility Coordinator, 61<sup>st</sup> Military Operations Research Society (MORS) Symposium, Wright-Patterson AFB, OH, 1993 June 22–24

Session Chair, AIAA/AAS Astrodynamics Conference, San Diego, CA, 1996 July 29–31

AIAA General Co-Chair, AAS/AIAA Spaceflight Mechanics Conference, Huntsville, AL, 1997 February 10–12

AIAA Space Logistics Technical Committee, Member, 1997–1999

Leader, JCS Military Education Coordinating Conference (MECC) Research Collaboration Team, 1995–1998

Workshop Chair, Military Operations Research Society Workshop: Tackling the Space Community's Analytical Challenges, 2002 February 26–28

Working Group Chair, Working Group 5: Operational Contributions of Space Systems, 71<sup>st</sup> Military Operations Research Society Symposium, Quantico, VA, 2003 June 10–12

Working Group Chair, Working Group 5: Operational Contributions of Space Systems, 72<sup>nd</sup> Military Operations Research Society Symposium, Monterey, CA, 2004 June 22–24

Session Chair, Fifth US-Russian Space Surveillance Workshop, Pulkovo Observatory, St. Petersburg, Russia, 2003 September 24–27

Technical Chair, 2003 Core Technologies for Space Systems Conference, Colorado Springs, CO, 2003 November 4–6

Sponsor/Exhibits Chair, 2004 Core Technologies for Space Systems Conference, Colorado Springs, CO, 2004 November 8–9

Session Chair (Optical Systems and Observations), Sixth US-Russian Space Surveillance Workshop, Pulkovo Observatory, St. Petersburg, Russia, 2005 August 22–26

Recognized worldwide as an expert in the area of satellite tracking and orbit determination. Regularly sought out for advice and counsel by NASA, European Space Agency (ESA), Russian Space Institute, US and AF Space Command, and many universities and commercial space organizations. Author of software library

used in many commercial satellite tracking packages, including software used at the South Pole and on the Mir space station.

Actively supported the Dayton Public School System in encouraging young students' interest in science and engineering. Conducted sessions on the use of microcomputers to capture and display weather imagery from polar-orbiting satellites at the 1989, 1990, and 1991 Space Symposia. Handled scheduling of all instructors, demonstrators, and students at the 1990 and 1991 Space Symposia.

Worked with Kettering Junior High School to set up a microcomputer-based station for capturing and displaying weather imagery from polar-orbiting satellites.