USDA NRCS RESPONSE TO EO 13095, REQUEST FOR INFORMATION, TO THE NIST

Purpose: The purpose of this document is to represent the uses of Positioning, Navigation, and Timing (PNT) within the USDA Natural Resources Conservation Service (NRCS), the adverse impacts of PNT disruption, the consequences to agency operations of PNT disruption, and current risk management protocols within the agency to mitigate PNT disruption.

Background: The employees of the USDA NRCS utilize Positioning, Navigation, and Timing (PNT) obtained from the Global Positioning System (GPS) and other Global Navigation Satellite Systems (GNSS) daily. Space Based PNT is utilized for timing of telemetry, navigation to features on the ground, performing inventory and inspection of engineering structures, ground survey for construction, as built documentation of built structures, inventory of soil, water, animal, plant, and air resources, layout of construction designs and conservation practices, and measurements for conservation practice certification.

Characterization of Space Based PNT disruption: The NRCS considers and plans for disruption of PNT services that occur in two principal categories: A) Denial of signal reception due to natural or technological means, and B) Manipulation of data encoded within the signals from space.

Risk Management and Mitigation: Risk management takes place at the NRCS National, State, and Local level. NRCS employees are briefed on disruption to PNT services and indicators of disruption. NRCS policy establishes a reporting chain for reporting disturbances. State and national level geospatial leads are aware of the reporting chain and will refer suspected cases to the NRCS National PNT Leader, who will in turn report suspected cases to the Coast Guard Navigation Center (NAVCEN).

Variability of Risk Management and Mitigation within NRCS: The NRCS is a large federal agency that employs over 9,000 personnel in the 50 U.S. states as well as Puerto Rico, Virgin Islands, Samoa, Guam, and cooperating Pacific island nations. National level briefing and training programs and curricula have not been created. State level coordinators have received briefings as have selected field personnel in other agency disciplines. Direction is provided in the agency policy guide, the General Manual. NRCS has utilized PNT tools and services since 1991 but most service center offices have not relinquished manual tools such as measuring wheels, total stations, levels, and chains. Reversion to use of these tools is expected if disruption is sustained or frequent.

See Profiles next page.

Prepared by Gary Hallbauer, National PNT Leader, USDA NRCS *National Geospatial Center of Excellence*, Fort Worth, Texas.
Gary.Hallbauer@usda.gov

NRCS PNT Profiles

Activity or Business Area and Description	PNT Service	Disruption Impact	Business Consequences	Agency Risk Management
I. Snow Survey Program (SNOTEL/SCAN) telemetry transmission and reception to over 600 monitoring sites. SNOTEL is the source of critical water supply forecasts for the Western United States. The Soil Climate Analysis Network provides data to support natural resource assessments and conservation planning.	Timing for monitoring sites, control stations, data collection and aggregation. Coordinate meteor burst, satellite, and cellular telemetry from the networks. Provide timing to servers based at the Water & Climate Center.	Severe – coordinated data transmission and reception is disrupted. Timing of servers, master control stations, and control stations are disrupted. Ability for monitoring sites to transmit data is disrupted. Data are missing or corrupted.	The availability, reliability, and integrity of data from SNOTEL/SCAN is diminished. Critical water supply forecasts are delayed and less accurate. Disrupted server timing could result in loss of historical and current data.	SNOTEL/SCAN engineers and technicians monitor the system and are alerted when timing is disrupted. Log files are generated periodically and can be analyzed for sources and causes of disruption. Crews are dispatched to control stations and monitoring sites to perform trouble shooting. Satellite and cellular telemetry provides communicate disruption cases to the Water & Climate Center.

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II. Navigation to and recovery of soil, water, and resources inventory sample sites and instruments over ground. Soil Scientists recover typical soil sample sites to obtain samples and perform additional characterization. Resources Inventory Specialists recover historic sample points and characteristic soils, forbs, and woody plants. Data are placed into server-based database systems for analysis, trending, and reporting.	Positioning and Navigation – use of current position and vector navigation to achieve closest point of approach in order to physically locate the sample site or instrument.	Severe – current position and vector direction, speed over ground, and navigation quality can't be determined or has gross error. More time is required – and some risk – to physically locate the site or instrument.	Inability to perform task or excessive time spent to perform task. Faulty navigation data and inattention to situational awareness could lead to accidental injury or death for the employee performing the task. Incorrect data would be collected because of the location error. Vital clues to composition of plants and soils would be lost or would be misinterpreted leading to error.	Users of PNT navigation services are instructed on how to detect, monitor, and report disruptions or disturbances to space based PNT signals. Policy is in place to ensure that quality data are collected and an evaluation of PNT signal quality is included in assessments. Users are taught to distinguish between static and mobile disturbances and how to perform rough localization. Users also correlate PNT disruption with disruption of other spectrum use such as smart phone and cellular data.

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III. Maritime navigation. NRCS soil scientists perform investigations along some of the nation's coasts assessing the composition and condition of subaqueous soils. Boats are used to travel to sites offshore, record data on site and return to port.	Navigation and Positioning to obtain boat location relative to the shoreline and to avoid hidden obstructions. Navigation to prior work sites or new designated work sites.	Moderate to severe – degradation of current position can cause data collection inaccuracies that can cause mispositioning of features. Loss of navigation can cause boats to collide with submerged features. Modern maritime navigation systems sound proximity alarms but mispositioning will affect the accuracy of the alarms	Mispositioning in offshore underwater data is not something easily fixed. Surveys are often done using bottom sampling tools that can't be seen from above the surface. Data must be re-collected which incurs extra time and expense. Mispositioning and interference with navigation service can cause the boat to collide with electronically charted submerged features. Collisions can result in injury or death.	Agency PNT users are advised of military exercises that may degrade maritime navigation and positioning through Coast Guard Navigation Center advisories. Users of PNT navigation services are instructed on how to detect, monitor, and report disruptions or disturbances to space based PNT signals. Policy is in place to ensure that quality data are collected and an evaluation of PNT signal quality is included in assessments.

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IV. Vehicle navigation is performed by most NRCS personnel to travel to work sites, sample sites, or inspection sites. Workloads are often planned to maximize the number of sites or visits that take place during a field day.	Navigation: Site coordinates are loaded into vehicle GPS or GNSS devices. The employee will follow the turn by turn directions of the navigation device. Use of this service is especially valuable for new employees or employees working in unfamiliar areas.	If navigation service is disrupted the turn by turn directions will be inaccurate. If the disruption is severe enough the inaccuracy could result in missed turns that force employees to double back and attempt to find the correct direction. In areas of small land holdings, the employee may report to the wrong address.	Loss of time while the employee attempts to overcome the issue with the navigation device or stops to ask for directions. Loss of professional credibility may occur. NRCS is a voluntary and cooperative conservation agency that relies on the trust of the clients and the professionalism of employees. Prolonged disruption or frequent disruption can erode the efforts of NRCS to increase conservation on the landscape.	Alternative means of navigation such as county highway maps are available in every Service Center Office. Employees that operate handheld GPS/GNSS devices for data collection are briefed on techniques to detect disruption of navigation service and to utilize maps and other means of navigation reference.

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V. Small UAS use of location and navigation for acquisition of digital imagery and elevation data: Small UAS are being utilized in more NRCS activities such as inspections and small area imagery and elevation data acquisitions. NRCS is not currently authorized to own, operate, or fly sUAS and must rely on cooperating partners and contractors to fulfill requirements.	Positioning and Navigation of sUAS aircraft is core to an acquisition mission. The sUAS must be able to establish a home position in case of low battery or loss of ground guidance. The sUAS must also be able to navigate and follow pre-planned flight lines that ensure data collection that meets national standards for resolution and coverage overlap.	Severe impact can result from even minor disruption. Loss of positioning and navigation can cause an sUAS to not be able to return home. Flight line navigation will be affected as will the quality of positions within the collected imagery or elevation data.	Loss of ability to position and navigate home can result in loss of aircraft and possible injury or death to person's below. Sustained disruption can cause the aircraft to ground itself resulting in loss of valuable mission time and lost opportunity to collect data. Ability for approved Part 107 pilots to operate near airports and other sensitive or restricted sites is very dependent on high quality PNT signals from space. The NRCS assists clients near these type of facilities – sometimes even on the facilities – and disruption of PNT services will force NRCS to use less efficient tools.	Agency sUAS operators fly aircraft that meet guidelines for responding to loss of controller signal and PNT signals from space. Remote pilots have PNT quality indicators displayed on the aircraft control smart device tethered to the controller. The aircraft control app displays PNT status (GNSS status). Alerts are built into the sUAS to communicate to the controller and remote pilot that PNT disruption is occurring. If disruption becomes too severe and sustained – the aircraft internal processor grounds the aircraft. The controller app sustains the information from the last known position and enables recovery of the aircraft.

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VI. Aircraft use of location and navigation for acquisition of digital imagery and elevation data. USDA and NRCS are users of digital aerial photography flown by the National Aerial Imagery Program as well as products flown under contract by local units of government and other federal agencies. Aerial photographic imagery is used in nearly every NRCS conservation line from conservation plan mapping to engineering design to long term monitoring and trend analysis. Ad hoc aerial imagery data collection is also utilized after natural disasters to assess impact to resources and clients and to monitor recovery. NRCS is a partner in the interagency 3D Elevation Program. Elevation data, specifically LiDAR, is utilized for multiple	Positioning and Navigation Services are utilized to locate the position of the photo or LiDAR aircraft and provision precision flight line navigation. Precision navigation of flight lines reduces cost of acquisition and allows for acquisition of larger areas at reasonable price. Newer acquisitions encode positional coordinates – either within reference points within the aerial images or within the elevation data record (X,Y, and Z).	Disruptions that are either brief or sustained have an immediate impact on the operation of a photo or LiDAR aircraft moving at over 200 mph. The slightest deviation in course can cause systemic error all the way down the flight line. Avionics deployed in data acquisition aircraft are designed to maintain precise flight lines at constant altitudes. Disruptions in PNT services also affect the encoding of time and position into aerial imagery and LiDAR data.	Disruptions Positioning and Navigation services reduces the precision of flight lines and results in more flying time to cover the same area. The result is higher cost to acquire the data. The position coordinate accuracy for encoded data within the LiDAR or aerial imagery product will be reduced. In cases where the coordinate accuracy does not meet National Program Specifications for NAIP and LiDAR the data must be re-acquired. Reacquiring data is expensive for the vendor and causes project deadline slippage. The NRCS is not able to use such data except for the most basic of planning activities. Data would no longer be useful in engineering design or water management activities. Imagery data could be salvaged by	On the client side: Data products undergo multiple tiers of Quality Assurance inspections. Error standards are tested and reported back to the agency contracting officials. On the vendor side: The aircraft flying aerial imagery and LiDAR acquisition utilize aviation GNSS avionics that warn pilots of disruptions and errors. Pilots can overcome disruption by reverting to backup navigation systems. In the worst cases of disruption pilots would be forced to abandon and reschedule the mission with an increase in overall costs. Contractual requirements buffer the agency from increases within a single flying season but frequent or sustained disruption over time will increase costs in the longer term.

conservation and engineering business lines.			using georeferencing and photogrammetric techniques to create orthometric products, but the result would add cost to an acquisition project.	
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VII. Agency personnel use location for recording resource concerns and other landscape information for conservation planning by connecting the planning data to a conservation plan map. More than 7,000 agency personnel augmented by hundreds of contractors and Soil and Water Conservation District partners incorporate location into all aspects of conservation planning. Many of the GPS/GNSS devices, including smart phones, used to record data are equipped with geotagging digital cameras.	Positioning services provided by GPS and GNSS signals in space have enabled NRCS personnel to perform more work, with more accuracy, in a shorter amount of time. Resource issues are noted by position and type. Concerns are then input into Conservation Plan maps that assist the client with decision making and conservation implementation. Programmatic requirements drive the types and quantities of data collected for conservation planning. Legislative mandates including NEPA are also requirements drivers.	Disruption to positioning services provided by GPS/GNSS would not shut down NRCS conservation planning activities but would lengthen the time to collect data and nullify gains in productivity the agency has enjoyed since GPS was made fully operational. Personnel would have to utilize manual methods to record data. Data would be recorded onto paper forms, topo maps, and paper plan maps in the field. Data would have to be manually input into agency digital planning tools.	The collections of paper topo and plan maps that have been cleaned out of many Service Centers would have to reconstituted. Much more time would be required to input data onto forms and sketches and then manually enter that into the agency GIS based digital planning tools. Costs to obtain a conservation plan – either through an agency employee or through a contractor or partner – would escalate because of the extra time involved. Multiply impact by 2,300 Service Centers to get an insight into agency impacts.	Agency employees in the Service Centers have been reluctant to recycle paper base reference materials and forms but these can be recreated and distributed. Most Service Centers have retained analog methods to capture data. Agency employees in the Service Centers know how to initiate an interference report if disruption is suspected. The reporting chain is documented in agency policy known as the General Manual. Employees are aware of what indicators to look for during periods of suspected disruption and are trained to utilize manual tools.

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VIII. Agency personnel use location for measuring installed conservation practices for certification of financial assistance. Inspection and certification are required under the Federal Acquisition Rules (FAR) and other Federal laws, and Departmental regulations. Allowable deviation from contract performance is pre-documented and discrepancies in the field are noted and sent to a state level officials.	Navigation and positioning services are used to find practices that have been downloaded to GPS/GNSS devices from GIS data bases. Personnel utilize positioning best practices to measure lengths and areas on a client field. Results are recorded and entered into agency contracting applications that permit or deny payment based on the results of the measurements.	Severe impact can be expected from disruption of PNT services used for measurements. Infrequent disruptions can introduce error into measurements while sustained disruption of PNT services may force a change of technology to complete the certification and permit payment to the client.	As GPS PNT has improved and more PNT services have been provided by other GNSS the ability to measure accurately and precisely has increased dramatically. What used to take a 2 or 3-person crew to accomplish with manual tools such as chains is now performed by one person – and in much time. The possibility PNT services disruption threatens the integrity of the certification process and will create a substantial loss of efficiency for NRCS personnel.	Agency employees in the Service Centers know how to initiate a disruption report if disruption is suspected. The reporting chain is documented in agency policy known as the General Manual. Employees are aware of what indicators to look for during periods of suspected disruption and are trained to utilize manual tools.

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IX. Agency personnel use location for inspection of engineering structures and agricultural easements: Agency personnel perform periodic inspections on over 10,000 PL-566 Small Watershed Dam structures in more than 20 states. Agency also perform ground inspections on more than 10,000 agricultural easements to ensure compliance with contractual requirements and program law.	Positioning for geolocation of issues and deficiencies as well as measurements to ensure easement contract compliance. Navigation services to directly move to issue points or areas discovered through remote sensing. Positioning services to delineate changes in boundary or denote encroachment.	Inspection of dams, many of which are classified as high hazard because of age, is a high priority for NRCS. Denoting issues using GPS/GNSS PNT or sUAS LiDAR or imagery is a powerful tool to reveal issues in dam surfaces as well as secondary structures such as spillways and channels. Many of the dams are over 40 years old and require more time to inspect. PNT services provide a way for inspectors quickly and safely inspect dams that have issues – some of which could be hidden.	Engineering inspectors would need to use manual sketching and traverse a substantially greater amount of the site to locate and document issues. The ability to return to issues and monitor those over time would be lost with sustained PNT disruption. Inspectors would incur greater risk because of the extended on-ground time on higher risk dams. Inspections of agricultural easements would take longer and be less efficient. Manual methods would have to be used for navigation, mensuration, and documentation of issues. In either inspection case – issues could be missed without the use of PNT services on sUAS.	Agency employees in the Service Centers know how to initiate a disruption report if disruption is suspected. The reporting chain is documented in agency policy known as the General Manual. Employees are aware of what indicators to look for during periods of suspected disruption and are trained to utilize manual tools.

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X. Agency personnel use PNT location for survey work as input to engineering design of structures and water management systems. Use of survey methods date back to the earliest days of NRCS with topographic surveying for construction of field water conveyance channels, terraces, and small structures being the primary utilization. Use of manual methods such as theodolite, chaining, and plane table were replaced by positioning services provide by space based PNT in the 1990's. NRCS engineers have utilized Real Time Kinematic (RTK) surveying for more than 20 years and have moved to use of cellular RTK corrections.	Positioning services are vital to successful use of modern survey instruments within the NRCS. Space based PNT is utilized every day by one or more offices and multiple personnel each day. Measurements from PNT services are used to plan irrigated pipeline installation, channel placement and design, land forming to improve drainage and reduce erosion, and design and construct larger structures such as PL-566 Small Watershed Dams.	Disruption of PNT services for survey work would at the minimum be a nuisance for infrequent disruptions to creating real data quality and workflow issues for more frequent and sustained disruptions. Direct impact to work in progress and project management milestones would become quickly apparent. Loss of efficiency as personnel revert to manual methods would occur. Use of less efficient methods would slow the pace of rehabilitation of high hazard dams and installation of conservation water management structures.	The NRCS will not be hiring more personnel to make up for increased use of less efficient methods. Loss of efficiency means that less engineering conservation practices would be installed. Field work would take longer, and employee performance would suffer over a long term.	The engineering community in NRCS are very well versed in PNT services disruption. The equipment in use can flag subthreshold performance but indicating a reason for the issue something that needs to be investigated. RTK methods are known to be vulnerable to disruption but the tolerance level for equipment purchased recently is unknown. Engineers are aware of the reporting chain for PNT disruption. Field personnel report to the State Conservation Engineer then pass up the chain to the Coast Guard Navigation Center.