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OVERVIEW

Statement of Work:

The products and services Kucera International Inc. will provide for this contract will include new (2005) aerial photography, ground and airborne control surveying, aerial LiDAR surveying, film scanning, aerotriangulation, digital elevation/terrain model (DEM/DTM) acquisition, digital orthophoto production at 1”=400’ scale/2’ pixel resolution or 1”=100’ scale/0.5’ pixel resolution, and digital 2’ contour topography production covering designated areas of the quad cities/bi-state Illinois-Iowa region. The aerial photography will be taken and digital orthophotography will be produced in black and white, natural color, and/or color infrared.

Project Standards/Accuracy:

The project work will be accomplished in full accordance with the Bi-State Commission’s 2005 Aerial Mapping Services RFP Section 2 – Project Scope, including conformance with the following accuracy standards/tolerances for the various map product deliverables:

Map Product	***Accuracy Tolerance***
1”=400’ scale orthophotography	12’ horizontal @ 95% confidence
1”=100’ scale orthophotography	3’ horizontal @ 95% confidence
DTM/2’ contour	1’ vertical @ 95% confidence
1”=100’ scale ortho DEM outside MAGIC area	2’ vertical @ 95% confidence
1”=100’ scale MAGIC area ortho DEM	5’ vertical @ 95% confidence
1”=400’ scale ortho DEM	8’ vertical @ 95% confidence

The accuracy conformance will be internally verified through review of aerotriangulation results and comparison of image/map coordinates for targeted project ground checkpoints against their corresponding field/GPS-surveyed values. For the latter, a minimum of 40 ground survey points spread throughout the region (10 points per county) will be checked and the results provided to the Commission in a project summary/accuracy verification report.

Approach:

In order to complete the work in a timely, organized, and cost-effective manner while maintaining a high level of quality and accuracy, Kucera will utilize a systematic, phased approach incorporating the most advanced available, proven photogrammetric, remote sensing, surveying, imaging, and GIS conversion technologies and procedures. The major phases of the approach in general order of performance will be as follows:

1. **Project Initiation –** Finalize scope of work and document in project procedure manual.

2. **Ground Control Targeting/Surveying** – Select, recover/establish, and target ground-based control and check points as needed for georeferencing/aerotriangulation of the aerial photography and quality control of the airborne GPS, aerotriangulation, and mapping.

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3. **Aerial Photography/Airborne GPS-IMU Survey –** Perform aerial flyover/photography of the project area using aerial camera interfaced with airborne GPS/IMU system while simultaneously operating GPS base station receivers on the ground. Process and check the aerial film and airborne GPS/IMU results.

4. **Aerial LiDAR Survey and DEM Production –** Perform aerial LiDAR flyover/survey of the designated project areas to acquire a new digital elevation model (DEM) supporting the orthoimage rectification and serving as the mass point component of a digital terrain model (DTM) supporting contour topography generation where required.

5. **Aerial Film Scanning –** Directly scan the aerial film while still in pristine condition to create high quality digital photographic imagery for use in digital orthophoto generation and other softcopy photogrammetric processes.

6. **Pilot Project** – Aerotriangulate aerial photography covering designated pilot areas and generate sample final orthophotography and topography for review and approval/selection by the Commission and/or relevant entities.

7. **Aerotriangulation –** Use a softcopy or analytical aerotriangulation process to check and refine the airborne GPS/IMU control survey and finalize the georeferencing of the aerial photography**.**

8. **Digital Stereocompilation –** Use a digital stereocompilation process to photogrammetrically acquire/compile DEM as needed for the orthoimage rectification and augment the LiDAR mass points to create a DTM supporting contour topography generation for designated city areas.

9. **Digital Orthophoto Production** – Orient digital photo imagery using aerotriangulation results and rectify to the project DEM. Batch and manually process rectified imagery into final ortho-photography.

10. **Topographic/Contour Mapping –** For designated city areas, generate 2' contour topography from photogrammetrically augmented LiDAR DTM and batch and manually edit. Convert to and perform final quality control check in ArcGIS environment.

11. **Project Wrap-Up/Summary Report** - Produce project summary report documenting procedures used and results achieved in each project phase, including products delivered, quality and accuracy assessment, source materials retained, etc.

The work phases will be performed concurrently to the maximum extent possible to maximize efficiency and accelerate turnaround/completion times.

Descriptions of the procedures, technologies, and deliverables for the various phases of the project are provided in the subsequent subsections of this proposed approach, followed by a summary of project deliverables and project equipment commitment summary.

Kucera is also offering an alternative approach involving the aerial image acquisition with a Leica ADS40 large-format digital camera system and providing the digital orthophotography in color, color infrared, and black and white. This alternative is described at the back of this proposal section.

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1. PROJECT INITIATION

1.1 Project Review/Startup:

Immediately upon notice of award, Kucera's Project Manager will convene members of the project management team to review the scope of work, specifications, deliverables, schedule, and administrative requirements. At this project review meeting the Project Manager will solicit questions and recommendations to be presented to the Commission.

The Project Manager will subsequently schedule a "kickoff" meeting or phone conference with the Commission and Consortium entities as needed to establish lines of communication, review the scope of work, and address any outstanding questions/issues related to the project.

1.2 Procedural Plan:

Following the kickoff meeting/conference the Project Manager will prepare a comprehensive job write-up and project procedural plan for the Commission and members of the project management team. The procedural plan will include the following, as needed:

1. Summary of project procedures and deliverables
2. Work flowchart indicating phases, milestones, points of acceptance
3. Equipment calibration reports
4. Flight and control network diagrams
5. Master sheet tile/index
6. Quality control plan/acceptance criteria
7. GIS database design (for topographic mapping as needed)

The plan will be revised/updated as needed over the course of the project to reflect approved procedural changes and additional procedures/information as required.

1.3 Sheet/Tile Schemes:

The sheet/tile schemes used for production and delivery of the 1"=100' and 1"=400' scale orthophotography and mapping will be based on the specified NAD83 state plane coordinate grid-defined 1500' x 1500' and 6000' x 6000' modular tile unit, respectively, with the exception of the City of Davenport mapping, which will be delivered in the specified quarter-section coverage tiles. As part of the project initiation phase, Kucera will review the various tile layouts with the Commission and various jurisdictions and make adjustments as needed, with corresponding adjustments to the project flight and control plans. Kucera will furnish ArcView shapefile digital versions of the finalized tile schemes to the Commission and jurisdictions as needed. The digital tile schemes will be used to graphically report the work phase status over the course of the project.

1.4 Source Material Review:

As part of the project initiation process, Kucera will research and perform an evaluation of source materials available for the project, including the following:

- Existing DEM/DTM data for use in orthoimage rectification
- Records/descriptions of existing ground-based control for recovery/targeting
- Existing planimetric/topographic feature mapping if available for use in quality control checking the newly produced orthophotography

The evaluation will include the applicability of the data to the project in terms of its age, accuracy, completeness, format, etc. A report/summary of the source data available and potential use will be furnished to the Commission and included in the procedure plan.

As described in following subsections of this proposed approach, Kucera is proposing to produce wholly new DEM/DTM data via aerial LiDAR survey and/or stereocompilation for all orthophoto and contour mapping work as opposed to using existing DEM/DTM data. The new DEM data will meet all Commission-specified vertical accuracy requirements. If existing DEM/DTM data meeting the project accuracy requirements and supporting the specified mapping is found to be available for significant areas of coverage, Kucera can photogrammetrically update and use this data with a resulting cost savings to the Commission or relevant jurisdiction.

2. GROUND CONTROL TARGETING/SURVEYING

2.1 Ground Point Network:

The flight/control diagram provided at the back of this proposal section shows Kucera's proposed network of targeted ground points in relation to the aerial photography flight lines and designated mapping area.

The project control will consist of the targeted ground points combined with accurate photo-center coordinates and orientations determined through the airborne GPS/IMU survey. The combined ground and airborne control data will support the production of the project mapping to the project accuracy standards with accuracy verification of the same. The ground network will include at least 40 redundant targeted points (10 points/county) which will be withheld from the subsequent photogrammetric processes and used as independent quality control checkpoints. The ground-based control and checkpoints will generally be spread uniformly around the periphery and through the interior of the project area to prevent control extrapolation and, where possible, will be located so as to fall in the sidelap area between flight lines to strengthen the ties between lines in the aerotriangulation process.

The project ground network will consist primarily of recovered and targeted existing points from the various county and city control networks, with new control stations being established as needed in critical locations where existing control is lacking. The project network will be subject to geometric strength analysis and revised as needed during/following the project initiation phase and control recovery work, with a final control plan being presented to the Commission and jurisdictions as needed and included in the procedure manual.

2.2 Survey Conduct:

The ground control survey/recovery and targeting work will be overseen by an experienced geodesist and licensed surveyor, and will be conducted in a manner ensuring maximum safety and minimal disruption of traffic, disturbance of private property, etc. Survey vehicles will be clearly marked and at all times the survey crews will carry proper identification and an official letter of authorization from Kucera, the Commission, and/or appropriate jurisdiction. The survey crews will report to the appropriate jurisdiction offices as needed for briefing and data as needed before going into the field.

2.3 Existing Control Reconnaissance/Recovery:

The existing ground points used for the project network will be appropriate (i.e., first/second order horizontal, third order vertical) points from the various jurisdiction control networks and will be recovered using to-reach descriptions obtained from the jurisdictions. Suitable existing control from other sources such as the US NGS will be researched, recovered, and used if required, and converted as needed for datum compatibility with the project control network. Recovery condition reports of the existing points searched for and used will be furnished in the project control report. Existing control stations which are found to be disturbed, destroyed, or otherwise not usable will be reported to the appropriate jurisdiction.

2.4 Control Marking:

Any newly established ground control stations will be marked in the field with Pk nails, capped iron pins, or other semi-permanent monumentation. Selected new ground stations can be alternatively set with more permanent (e.g., NGS Class "C") type monumentation at the individual jurisdiction's option. The stations will generally be set at locations which offer a high degree of permanence, stability, access, satellite reception, and intervisibility as required for future surveys and azimuth marks. For each new point set, to-reach descriptions and recovery sketches will be prepared and included in the control survey report.

2.5 Target Parameters and Maintenance:

The ground network points will be targeted prior to the aerial flyover using crosses, tees, or chevrons with legs 12" to 18" wide and 6' to 12' long, with larger targets being used for smaller scale photography/mapping areas. Targets on unpaved areas will be durable vinyl properly affixed to the ground, while targets on paved areas will be painted if permitted. The targeting work will be performed so as to assure maximum possible visibility and pointing accuracy on the aerial photography, with target color being white on darker surfaces (e.g., grass, asphalt, older pavement) and black on lighter surfaces (e.g., sand, new pavement). Any traffic control measures which need to be taken for the target placement will be reviewed with the appropriate jurisdictions. The shape of the target used for each control station will be recorded for reference in the aerotriangulation and mapping work.

The targets will be monitored until the aerial photography and any necessary reflights are completed for the season. The targets will be removed by Kucera within two weeks of the completed flyover. The jurisdictions will be notified of any target locations which are observed to be susceptible to destruction due to activities such as construction, mowing, etc. so that appropriate action can be taken to protect the targets until the aerial flyover is completed.

2.6 Alternative Photo-Identifiable Control:

New project ground control or checkpoints can be surveyed coordinates for photo-identifiable feature points selected on prints of the completed aerial photography as an alternative to (in the event of delayed authorization to proceed) or replacement for (in the case of being destroyed or otherwise not visible in the imagery) the targeted points. The points will be selected at distinct, occupiable locations (e.g., sidewalk corner intersections, ends of paint stripes on roads) and will have detailed survey descriptions prepared to ensure their accurate use.

2.7 Survey Technology/Receiver Calibration:

All new ground control/checkpoint coordinates and elevations will be surveyed using geodetic-grade, dual-frequency Trimble 5700 Series GPS receivers. The receivers will be calibrated and checked on site if possible by observing vectors between available HARN or first-order control stations. The vectors observed between the stations will verify that the instruments meet or exceed the accuracy required for a first-order (10 ppm) survey.

2.8 Control Accuracy/Datum:

All ground control/checkpoints will have coordinates established on the NAD83(96) IA or NAD83(97) IL HARN state plane coordinate systems and elevations established on the NAVD88 vertical datum. The coordinates will be surveyed to at least second order Class 1 (1:50,000) accuracy and elevations will be surveyed to at least third order, 3 cm-equivalent accuracy. All survey measurements will be in US survey feet.

2.9 GPS Field Procedures:

The ground GPS survey work for new point establishment will be conducted using static differential carrier phase techniques, which are least susceptible to error sources such as multi-path and unmodeled geoidal undulation. The carrier phase will be measured and recorded at 15-second intervals for a period of not less than 20 minutes with a four or more satellite simultaneous observation. Between 30% and 50% of the new stations will be occupied two or more times.

A direct connection will be made between points whenever the distance between them is less than 20% of the distance between those points traced along new or existing connections. Repeat measurements, approximately equal in the north-south and east-west directions, will be taken on at least 5% of the baselines.

When a control station is occupied during two or more back-to-back GPS sessions, the antenna/tripods will be reset and replumbed between sessions to meet criteria for an independent occupation. A measurement will be made in meters and in feet at the beginning and end of each station occupation. Rubbings or photographs of the station marks will be taken. The accuracy of the optical plummet will be checked with a plumb bob once during each station occupation. Meteorological data will be recorded at a representative station for each session.

Quality control of the vertical GPS readings will be achieved by double occupations for a number of points and by tying them to a number of existing benchmarks within/around the area. The published/computed elevations of the area's existing benchmarks will be compared with those derived from the GPS to determine if all new points meet the accuracy specifications.

Loop closures and differences in repeat baseline measurements will be computed to check for blunders and to obtain initial estimates for the internal consistency of the GPS network. No more than 10 baselines will be included in each loop, and the length of any loop will not exceed 100 km. Maximum loop closure will not exceed 10 ppm (1:100,000).

After performing loop closures, the data will be input to the FGCS-certified, three-dimensional least squares TRIMNET Plus program. Three adjustments will be made:

- A correctly weighted, minimally constrained "free" adjustment, which will indicate the internal network consistency and accuracy
- A constrained adjustment on the NAD83 datum, which will account for the orientation and scale differences between the satellite and network control datums, geoid-ellipsoid relationships, and distortions and/or reliability in the network control
- A final, fully constrained adjustment on the NAD83 datum holding all available vertical as well as horizontal control

The results will be shown in latitude, longitude, height, state plane coordinates, meters, US survey feet, convergence angle and combined scale factors.

In the vertical control GPS reduction process, the undulation of the geoid as predicted using the NGS GEOID99 program will be applied. A specific project area geoid model will be derived as a residual model of the combination of NGS GEOID99 and the large number of existing benchmarks which are occupied. The residual model is applied to all vertical control points, resulting in elevations with 3 cm or better accuracy.

2.10 Ground Survey Report:

At the completion of the recovery/targeting/ground survey work Kucera will provide the Commission and jurisdictions with a comprehensive ground survey report containing a summary of the survey procedures and technologies used, final control listing, project network diagram, target parameters, new control description sheets, existing control recovery sheets, GPS observation and reduction data, and other relevant survey documentation as required.

3. AERIAL PHOTOGRAPHY / AIRBORNE GPS

3.1 Season/Environmental Conditions:

The project aerial photography will be performed on a first-priority basis in the late winter/spring 2004 flight season (March 15 - April 15) before the emergence of vegetation and as soon after flight plan approval and target placement as weather (clear, no excessive cross winds) and ground (no smoke, fog, flooding) conditions permit. The photography will only be taken during the time of day (approximately 10 a.m. to 2 p.m.) when the sun angle is greater than 30º to minimize shadows. For the airborne GPS/IMU work, the aerial photography will be taken only at times when at least five satellites are observable with a PDOP of less than 3 and the cutoff angle/elevation mask is greater than 15°.

Weather conditions will be monitored via direct observation and weather forecasts obtained through computer access to the National Weather Bureau, the Weather Channel, and local flight service centers. The Project Manager will maintain regular contact with the Commission throughout the aerial photography period to report on flight conditions and completed flying. Computer printouts of weather sequences will be maintained as a record of photography conditions.

3.2 Flight Commitment/Base of Flight Operations:

The aerial photography flyover will require up to 145 flight lines and 2500 flight line miles. Kucera will be committing at least two of its three twin-engine aircraft and latest generation aerial camera systems to the project, and with these aircraft will be able to complete the project flyover for any option in four or less sessions covering contiguous sections of the project areas.

Kucera's aircraft will be based on site throughout the flyover period to ensure that the flyover is completed at the first possible opportunity and in the shortest possible timeframe or minimum possible flight sessions with consistent ground and lighting conditions. The aircraft will be available for inspection, media coverage, etc. while based on-site and when not performing the project flyover work.

3.3 Restricted Airspace:

Kucera's flight crews have considerable experience in performing aerial flyovers in military, commercial/industrial, and other types of restricted airspace and will coordinate with the proper air traffic control authorities to obtain flight access to any restricted areas within the region. Copies of airspace clearance documentation will be maintained and furnished to the Commission as needed.

3.4 Flight Altitude/Photo Scale, Flight Plan, and Sidelap:

The flight/control diagram provided at the back of this proposal section shows Kucera's proposed flight pattern for the aerial photography in relation to the project mapping areas and proposed ground control network.

The aerial photo scales used for the production of the 1"=100' and 1"=400' scale orthophotography will be 1"=700' (flight altitude 4200' above mean terrain) and 1"=2000' (flight altitude 12,000' AMT), respectively, as specified. The aerial flight lines will be oriented in a north-south or east-west direction for efficiency of coverage and will be spaced apart so as to have a side overlap of 30% between adjacent flight lines of the same-scale photography. Over center city and/or other identified tall-structure areas, additional feature-centered flight lines with 50% to 60% side overlap will be used to facilitate the development of "true" or near "true" orthophotography (no or minimized feature lean) covering these area. All flight lines will be extended so as to provide two-photo-center coverage beyond the corresponding mapping areas, achieve stereo coverage of peripheral control points, and ensure that orthophotos at the area peripheries can be prepared as full (versus partial) coverage tiles at the specified scale.

The 1"=700' scale aerial photography will also be used to photogrammetrically augment the LiDAR DEM for the production of DTMs and 2' contour topography covering the designated contour mapping areas.

3.5 Flight Diagram:

Before proceeding with any aerial photography work, flight maps will be prepared on 1:24,000 and/or 1:100,000 USGS quadrangles and reviewed with the Commission and jurisdictions for approval. Upon approval/finalization of the flight diagram, flight line latitude/longitude or endpoint coordinates will be read for GPS-based navigation. The quad maps will be used for visual reference/check to the automated navigation when performing the aerial photography and as an aid for in-house inspection of the completed photography.

3.6 Endlap:

The aerial photography will be taken with standard 60% stereo photo coverage endlap between exposures in the line of flight. The on-board GPS navigation/flight management system will be used to automatically fire the camera with the proper endlap.

3.7 Aircraft:

The aerial flyover will be performed from Kucera's twin-engine Piper Navajo Chieftain (no. 3547G) and Cessna 310 (no. 76KA) aircraft. These are FAA airworthiness-certified, low-wing, turbo-charged aircraft with a cruise speed of 180 to 200 knots, fuel capacity for six hours of continuous flight, and IFR weather instrumentation. The aircraft are equipped with the Genisys ACCUPHOTO GPS flight management and navigational systems and have Novatel dual-frequency antennas mounted above the camera port for airborne GPS. A third Piper Navajo Chieftain twin-engine aircraft will be available as backup.

3.8 Aerial Camera:

The aerial cameras used to take the aerial photography will be Kucera's two latest-generation Zeiss RMK TOP 15 cameras having built-in motion compensation (FMC) and optical/geometric/functional characteristics meeting the USGS NAPP specifications as determined by recent US Geological Survey calibrations. The cameras gyro-stabilized during the aerial photography acquisition using Zeiss TAS gyro-stabilizing camera mounts and have AWAR resolution ratings of over 100, putting them in the highest achievable resolution range and yielding photography optimal for producing high-image-quality digital orthophotography. **Calibration reports for the cameras to be used are provided at the back of this proposal section.**

3.9 Crab and Tilt Control:

Average camera tilt and crab will be limited to not more than 1º and 3º, respectively, as required. Tilt correction is accomplished through the use of the gyro-stabilized mount and manual leveling as required. Crab correction is accomplished visually by the photographer monitoring the camera viewing system by making sure the camera is angled such that the top and bottom of each exposure progressing across the view is coinciding with the flight line location as shown on the project flight maps. Crab correction is also accomplished through coordination between the aircraft pilot and photographer. The pilot uses the aircraft's GPS navigation system together with aircraft instrumentation to determine the aircraft's actual bearing in degrees, which is reported to the photographer who makes the crab angle correction. The camera angle can be changed by a remote control device interfaced with our camera mounts or by manually swinging the camera.

3.10 Aerial Film:

The aerial photography will be taken using one or more of the following aerial film types for production of the aerial imagery:

Imagery	*Film Type*
Black and white	AGFA PAN80 black and white negative
Natural color	AGFA X100 color negative
Color IR	Kodak Aerochrome III 1443 positive

All of these are latest generation aerial films designed for high quality digital image production and having superior resolution (125 lp/mm) and shadow and highlight detail. AGFA X100 has high natural color saturation and is not susceptible to buckling during scanning and resultant Newton ring development in the imagery as can be the case with other latest generation color films. AGFA PAN80 is a fine-grain panchromatic film designed for photography taken from altitudes of 3000' and higher and which has extended red wavelength sensitivity for increased shadow detail. Kodak 1443 has infrared spectrum sensitivity to 900 nm with superior haze penetration, increased resolution, and reduced contrast for greater exposure latitude.

The aerial photography will be taken using the f-stop and shutter speed which are optimal for the terrain/lighting conditions, film type, and end products to be generated. One type of film will be used for the entire flyover to ensure consistency. Before and after exposure and processing, the aerial film is stored at Kucera's facility under manufacturer-specified optimal climate conditions. For quality control purposes, samples from each roll of film to be used will be checked for acceptable levels of base fog and density before the film is used. The emulsion number for each new roll is noted on the film so that any film deficiencies can be traced. As a standard camera check procedure, four to ten run-in exposures of film are shot off before beginning each new day's photography.

3.11 Photographic Parameters/Film Processing and Handling:

Completed photography will be processed within 24 hours using Kodak Versamat automatic film processors operating under strict sensitometric and densitometric quality control monitoring. As a quality control measure a sensitometry test/report for each roll of completed photography will be prepared.

The film will be exposed and processed in a manner which maximizes the amount of detail which can be extracted in the image scanning and reproduction processes. During and at all times following the film processing, the film will be handled with maximum care to prevent any scratching/marking of the film surface which could appear in the digital imagery.

3.12 Film Checking/Reflights:

Once processed, the aerial photography will be immediately checked for acceptable exposure, resolution, contrast, overlap, crab and tilt level, absence of foreign markings, etc. For each roll of film, two consecutive stereomodels will be analyzed on a stereoplotter to verify that there was no residual parallax due to vacuum loss in the camera magazine during the aerial photography. An image quality report will be prepared documenting the film inspection results. All rejected photography will be reflown at the first possible opportunity using the same camera as used for the balance of the photography. Reflights will be made in the same flight pattern as the accepted photography and will overlap into the accepted photography as necessary to provide continuous photographic coverage. Copies of the film inspection reports and flight logs indicating exposures taken, photographic parameters/ conditions, etc., will be maintained by Kucera and provided to the Commission for flight documentation as needed.

3.13 Film Labeling/Titling:

Each frame of the aerial photography will be directly labeled by the aerial camera at the time of exposure. The labeling will be located in the camera data chamber margin between the frames and will include the time and date of exposure, film type, camera aperture and shutter speed, camera serial number and focal length, FMC use, flight crew, counter/exposure number, project number, and project name.

The photography will also be ink-titled on the leading edge of the exposures using a Max Cadliner CD-950 computerized Leroy-type (non-thermal) film titler. The title information will include the date, scale, city/county name, and flight line and exposure number as specified. Flight lines will be numbered sequentially without repetition starting with the northernmost or westernmost flight line. Exposures will be numbered from west to east or north to south within each flight line in consecutive fashion starting with exposure number 1. Samples of the film titling will be provided for the Commission's review and approval.

3.14 Contact Prints/Diapositives:

The Commission and/or jurisdictions can be furnished with one or more full sets of unmarked color or black and white contact prints of completed aerial photography as a deliverable. The prints will be exposed from the titled aerial film on Kucera's LogE Mark V auto-dodge contact printer and printed emulsion "up" on Kodak Supra color or AGFA Rapitone tone-graded black and white photographic paper. The printing will be accomplished using computer-controlled dodging and neutral density filters to even out tones and bring out detail in shadow areas. Once exposed the prints will be processed in-house on Kucera's Colex color or Versamat black and white print processor. The prints will be trimmed or untrimmed as specified and will be delivered in labeled sleeves organized by flight line.

Note that for quality control purposes it is Kucera's preference to scan the aerial photography before any photographic contact prints/diapositives are made, while the aerial film is still in a relatively pristine condition. This procedure helps eliminate the appearance of dust particles, micro-scratches, etc., which can occur on the film in the course of handling, and which would need to be edited from the digital imagery.

As a cost-saving alternative to photographic contact prints, Kucera can furnish color or black and white "Scanprints" – high resolution inkjet plots of the individual scanned digital photo images produced on an HP desktop color laser plotter. The Scanprints can be produced on glossy or matte bond paper media and bound in a flight-line-tabbed notebook for delivery.

3.15 Flight/Photo Index:

In lieu of or in addition to contact prints, the Commission can be provided with a combined digital vector and raster index to the aerial photography in the form of Kucera's "Scandex" product. The vector data will include photo center point locations (derived from the airborne GPS/IMU survey) on a digital road network background of the project for reference. The photo center locations are attributed with the roll, flight line, and frame numbers, and can optionally be "hot-linked" to low resolution raster images of the corresponding scanned photo exposures for full image display. The Scandex flight index will have appropriate title information/metadata and will be furnished with the aerial photography report in ArcView/ArcInfo, AutoCAD, and/or other specified GIS/CAD format.

3.16 Film Storage:

During the course of the project and for any desired length of time beyond, the exposed aerial negatives will be stored in a climate-controlled film vault at Kucera's headquarters photo lab facilities at no cost to the Commission or jurisdictions. The negatives will be owned by the Commission and upon request will be forwarded to the Commission along with corresponding flight logs containing flight data, crew member, camera/lens serial number, etc. The film will be stored and shipped in appropriately labeled 250' or 400' plastic roll film containers. While in Kucera's possession the negatives will be covered by Kucera's valuable papers insurance. No photographic/map products will be sold from photography without the Commission's permission.

3.17 Airborne GPS/IMU Technology and Procedures:

The aerial photo mission will be performed with advanced airborne GPS/IMU technology to accurately measure the principal point coordinates/elevation and the camera orientation angles for each frame of photography at the instant of exposure. Kucera is one of the few companies which has combined airborne GPS (AGPS) and inertial measuring unit (IMU) technology, and has completed over 70 county/citywide and hundreds of other mapping projects using AGPS/IMU with excellent results.

The in-flight system used for the AGPS/IMU survey will be an Applanix 510 position and orientation recording system for airborne vehicles (POS/AV). The Applanix system consists of a high accuracy (20 arc second) "strap down" (attached to the aerial camera) inertial sensor unit linked to a Novatel dual-frequency GPS receiver. The system accurately measures both the camera center position and the camera exterior orientation at the instant of each exposure, thus determining all of the unknowns previously solved for through the aerotriangulation process. Use of the Applanix technology theoretically eliminates the need for aerotriangulating the aerial photography, although Kucera maintains the aerotriangulation process as needed for quality control checking, with the "checkpoints" being the targeted ground control network points.

Note that Kucera uses the Model 510 of the Applanix AGPS/IMU systems, which is the highest accuracy (i.e., "geodetic-grade") in the Applanix model line (i.e., 310, 410, 510).

The field work for the GPS/IMU survey will involve the continuous operation of two or more static base station GPS receivers on the ground for the duration of each flight session. The base station receivers will be first-order-certified Trimble 5700 series dual-frequency systems set up over selected newly established and/or existing HARN/1st order stations in the flyover area. Where possible, the base stations will be placed at higher elevation points to maximize satellite signal reception.

The base stations will be positioned so as to be within approximately 50 km of the roving (aircraft) receiver during each flight session, being moved as necessary to keep within this distance before starting the next flight session. The use of multiple base stations will ensure data quality and provide redundancy in the event of equipment malfunction. Data from all base stations will be processed so that the camera position at the time of exposure can be calculated independently for each station and compared. As a quality control check, the AGPS/IMU data will be processed with recordings from the closest continuously operating reference stations (CORS) and the results compared with those obtained by processing the GPS/IMU data with the on-site base stations.

The airborne and base station GPS receivers will make observations at one second (1 Hz), or one-half second epochs (2 Hz), with post-processing of the data being performed using on-the-fly (OTF) kinematic techniques and yielding a positional accuracy 10 cm or better for the camera perspective center. Camera positions will separately processed from at least two base stations, with results being compared for quality control. Camera station coordinates and elevations will be transformed to the NAD83 coordinate system and local vertical datum, respectively, and will be fully compatible with the coordinates/elevations of the targeted ground control points.

Note that the electrical phase center of the aircraft antenna is located in relation to the centroid of the camera by using two base station receivers and the aircraft receiver to establish a baseline on the ground while the aircraft is parked. A three-dimensional triangle is then found by the phase center of the aircraft antenna and the two baseline points. A coaxial total station then occupies the baseline and locates the centroid of the aerial camera by repetitive angles, distance, and statistical analysis.

The aerial photography will be taken in multiple flight sessions, each covering a “block” of contiguous flight lines. At the start and completion of each flight session, the roving (Applanix system) receiver will be initialized by being operated for approximately 10 minutes in the aircraft while it is parked stationary at a local airport. The AGPS/IMU data sets will be initialized using the fixed baseline method, with one base station being placed in close proximity to the airport initialization location so as to facilitate the AGPS data reduction process by providing a short baseline vector solution.

Throughout each flight session, the base station receivers will be continuously operated for observations, with radio contact being maintained between the flight and ground (base station monitoring) crews. During the flight mission the aircraft turns will be performed with flat/shallow banks to avoid cycle slips. Following each flight session the observation data will be immediately downloaded for extraction by the flight crew using the POSpac set of software modules provided by Applanix/Waypoint Inc., to ensure successful data recording and coverage. The data is processed with at least a coarse reduction result being determined before the next flight session is performed to detect any significant problems requiring a reflight.

During the AGPS post-processing, a very robust KAR - kinematic ambiguity resolution (fixed integer solution) - is implemented, along with an analysis of the days’, satellite configuration and PDOP, satellite signal standard deviations, atmospheric interferences, and forward/reverse plots to attain the most accurate GPS solution available. Subsequently, the solution’s relative accuracy is assessed – an assessment that combines the final processing results with any loss of accuracy introduced by baseline distances from aircraft to base station. The GPS and IMU data are processed together, with the IMU data being used to fill in and adjust the GPS results as needed and the GPS data being used to minimize the effects of aircraft “drift” in the IMU measurements. The data is smoothed and corrected using both “forward and backward” processing with the resultant photo-center coordinates and orientation angles extracted and output into the proper datum. The result is a GPS solution that is even more refined than the initial processing (the inherent drift is also removed) along with a highly accurate set of orientation angles for each exposure (a

Smoothed Best Estimate of Trajectory). The AGPS/IMU reduction results are thoroughly analyzed to ensure proper IMU behavior and accuracy with the data graphs also being used to ensure that the proper flying parameters are followed for each mission. For any area in which the AGPS/IMU results and/or flying appear suspect, the flight session will be re-accomplished.

The AGPS/IMU processing software used by Kucera allows simultaneous implementation of multiple base stations as a function of post processing. Therefore, it is not a prerequisite that one base station is chosen over another.

An experienced AGPS/IMU technician will manipulate the software according to evaluations of the processing and standard GPS knowledge to automatically determine which of the multiple base stations yields the best results for each particular epoch. In this way the best results of both receivers can be included in the final AGPS processing. Kucera will provide a report detailing the rationale and an explanation of the settings used to include a multiple base station solution, if applicable.

3.18 AGPS/IMU Report:

At the completion of the AGPS/IMU data processing Kucera will provide the Commission with an AGPS/IMU report containing a summary of procedures used, base station locations processed, georeferencing accuracies achieved, etc., along with copies of data reduction and daily PDOP reports.

4. AERIAL LIDAR SURVEY AND DEM PRODUCTION

4.1 Overview:

For the designated 1”=100’ scale mapping areas, Kucera is proposing to perform a new aerial LiDAR survey to acquire digital terrain surface (DEM/DTM) data supporting the 1”=100’ scale orthophoto image rectification and production of 2’ contour topography where specified. The advantages of LiDAR over a conventional photogrammetric stereocompilation process to produce the DEM/DTM data are as follows:

- The LiDAR survey produces a significantly denser terrain point spacing (10’ to 20’) than can cost effectively be achieved using conventional stereocompilation (35’ to 50’ spacing) and typically provides greater penetration/terrain surface data in wooded areas – thus providing faster and more accurate orthophoto and contour topography production.
- The LiDAR survey can be performed in significantly less time and at less cost than required for traditional compilation, given the automated nature of the terrain point collection/processing and the fact that the LiDAR survey can be performed at the same time as the aerial photo flyover (as opposed to after the flyover as required for conventional compilation). The LiDAR DEM and bald-earth mass point data will be available for use in orthorectification and contour-grade DTM augmentation much sooner than corresponding stereocompiled data.
- The aerial LiDAR survey data can be processed/augmented to yield supplemental products, including the raw “point cloud” and a digital surface model (DSM) of structures, tree canopy, etc.

4.2 LiDAR Survey Technology and Procedures:

The LiDAR survey will be accomplished using Kucera's in-house Leica ALS50 LiDAR system operated from one of Kucera's twin-engine aircraft. The ALS50 is the latest in Leica's line of aerial LiDAR technology and the most advanced LiDAR technology currently available. Features of Kucera's ALS50 system that make it superior to earlier-generation LiDAR systems include:

- A laser pulse rate of up to 87 kHz and increased pulse rate at any flying height – resulting in ability to achieve dense point collection rate from higher flight altitudes.

- Maximum system parameter flexibility – the Leica system has no limitation on pulse rate settings up to 85 kHz and has a full flight altitude range of 200 m to 4000 m – allowing system settings to be adjusted optimally for job-specific flight and mapping requirements.

- Automated roll stabilization – the Leica ALS50 laser scan is adjusted with the roll of the aircraft to maintain the proper scan swath width, which increases flight efficiency and reduces survey cost.

- Up to four returns per laser pulse, with one return always being the last or latest return, thus maximizing the potential that a ground-based point will be recorded.

The flight parameters proposed for the aerial LiDAR survey and associated resulting DEM vertical accuracies are as follows:

	100 Scale Ortho DEM and 2' Contours (1' vertical accuracy)	100 Scale Ortho DEM (2'-5' vertical accuracy)
• Flight altitude	4800'	10,170'
• Aircraft speed	140 knots	150 knots
• Scan FOV	45º	60º
• Scan rate/pulse rate	33 Hz / 60.3 kHz	15 Hz / 33.4 kHz
• Sidelap/flight line spacing	23% / 3060'	10% / 10,520'
• Swath width	3980'	11,740'
• Post spacing	7'	16'
• Flight direction	E-W	E-W

The LiDAR flyover will be performed in the same flight period (March 15 – April 15) as the aerial photography flyover to maximize ground return (i.e., during leaf-off conditions), consistency between surveys, and efficiency of ground GPS base station and ground control use. The LiDAR flyover is typically completed in advance of the aerial photography acquisition, since the LiDAR flyover can be performed at all times of the day and night and under cloud cover while the aerial photography can only be taken during periods of sufficient sun angle on clear days. Like Kucera's aerial cameras, the ALS50 LiDAR system is integrated with an Applanix 510 POS/AV airborne GPS/IMU system for in-flight georeferencing, performed in the same fashion as described for the aerial photo flyover work. The LiDAR flight lines will be oriented in an east-west direction for efficiency of coverage of the area.

Before or after every LiDAR survey project, Kucera performs a LiDAR flyover of a preset calibration site to precisely model the positional relationship (i.e., "boresighting") between the ALS50 laser scanner head and the Applanix IMU for entry in the post-processing software, and to monitor the behavior characteristics of the system over time. The flyover covers a carefully designed calibration pattern consisting of four crossing flight lines at low and high altitudes to precisely measure the roll, pitch, and heading correction parameters. Kucera's main calibration site, Lost Nation Airport in Willoughby, Ohio, has been carefully surveyed to locate highly accurate control points for determination of the LiDAR data elevation offset value during calibration.

During each LiDAR flight session, the LiDAR operator closely monitors the system to ensure proper operation of the laser scanner, IMU, and GPS signal lock and acceptable PDOP. Four data returns and corresponding intensities will be measured for each pulse, including the last/latest return with greatest probability of representing the "bare-earth" location. Post-mission data is compared to ground-surveyed checkpoints in the project area as a final system calibration and data accuracy check.

4.4 Data Processing and Quality Control:

Immediately following each day's flying, the flight crews perform initial processing of the LiDAR and airborne GPS/IMU data to generate trace/route logs which are checked for proper system operation and data capture coverage. Areas having data gaps or anomalies are flagged for reflight in the next flyover session.

Office processing of the multi-return LiDAR data is performed using Terrasolid's Terramodeler and Terrascan software with in-house customizations. The raw data "point cloud" is filtered to remove structures and vegetation and produce the digital elevation model (DEM) to be used for the digital orthophoto image rectification. The DEM will include points on elevated bridge decks and overpasses as well as the underlying terrain to ensure proper rectification of both features. The LiDAR DEM will have a point spacing of approximately 15'.

The LiDAR DEM will be further refined/processed by removing points on bridges, overpasses, and other smaller, non-surface features to create the "bald-earth" mass point component of a digital terrain model (DTM) supporting 2' contour topography generation for the designated mapping areas. The 1"=700' scale project aerial photography will in this case be used to photogrammetrically check the LiDAR point grid and add breakline (e.g., road centerlines/edge, hydrography) and spot elevation features to produce the final contour-grade DTM as described in Subsection 8 (Digital Stereocompilation) of this proposed approach.

Other deliverables from the aerial LiDAR survey will include the "first-return" digital surface model (DSM) delineating ground and above-ground features (e.g., buildings, bridge decks, tree canopy) suitable for 3D modeling, biomass calculation, and other applications and the raw LiDAR point cloud as needed.

The in-house post processing of the GPS/IMU and LiDAR data is thoroughly QC checked through all processing stages. The GPS/IMU data is checked to ensure all satellites used in the solution were operating within acceptable ranges during data collection and that GPS signal lock was maintained and PDOP values were acceptable.

While much of the LiDAR data post-processing is necessarily automated due to the large size of the datasets, a skilled data processing technician monitors and corrects the processing parameters as needed. A completely "black box" process is never used by Kucera. The LiDAR data is viewed from various perspectives to verify that the instrument calibration is still within specification. Mis-calibration of the instrument will be manifested as an elevation offset in areas where flight lines overlap. These offsets are modeled and corrected in the post-processing routine. The post-processed data is then compared to the project ground-based control to ensure the data is within project accuracy specifications. An accuracy report is generated during post-processing with the elevation error for each control point and the LiDAR surface and also an average error for all control and the LiDAR surface. When stereophoto coverage is available, the LiDAR data is viewed in a softcopy compilation environment as a further check of accuracy. Should uncertainty arise as to the correct classification of the LiDAR data points, the data is viewed as an overlay with either the installed webcam imagery and/or aerial photography to resolve the classification issue.

4.5 Optional/Alternative Regionwide 100 Scale Ortho-Grade LiDAR DEM:

As described in Subsection 8 (Digital Stereocompilation), Kucera will be photogrammetrically stereocompiling the DEM data required for the rectification of the 1"=400' scale regionwide orthophotography. As an alternative/optional approach Kucera can perform a regionwide aerial LiDAR survey to create a DEM supporting regionwide 1"=100' scale orthorectification. The flight parameters for the regionwide LiDAR survey would be the same as previously noted for the 1"=100' scale ortho-grade DEM.

The advantage to this approach is that the Commission will have DEM data supporting 1"=100' scale orthophoto production anywhere in the region for future expansion of 1"=100' scale coverage.

4.6 LiDAR DEM Deliverable:

The new ortho-grade LiDAR DEM will be furnished as a project deliverable on CD or DVD in generic ASCII, DWG, ArcInfo, shapefile, and/or other specified CAD/GIS formats. The data will be delivered by individual tile or in larger coverage blocks as specified. The augmented contour-grade LiDAR DTM will also be furnished as a deliverable as described in Subsection 8 (Digital Stereocompilation).

5. AERIAL FILM SCANNING

5.1 Procedures and Technology:

The digital photo imagery used for the project digital orthophotography and softcopy photogrammetric processes will be produced by scanning the aerial film directly on Kucera's two Z/I Imaging PhotoScan 2002 photogrammetric scanning systems. The scanning aperture used will be 14 microns (1800 dpi), yielding raw pixel resolutions of 0.39' and 1.1' for the 1"=700' and 1"=2000' scale aerial photography, respectively. The imagery will be resampled to the specified 0.5' or 2' pixel resolution as part of the orthoimage rectification process as described in Subsection 9 (Digital Orthophoto Production).

SCOPE OF SERVICES / APPROACH TO PROJECT

The Z/I PhotoScan systems are among the most advanced scanners currently in operation. The systems are powered by Pentium III Xeon NT workstations and are certified first-order instruments which have two-micron precision and accuracy and can be independently calibrated to a grid plate. The PhotoScan is one of the few scanners which features one-pass as opposed to three-pass color and black and white scanning to minimize scan times and maximize image quality. The PhotoScan scanner also features a diffuse (as opposed to direct) light source to minimize light scattering and maintain high image sharpness. The scanners are outfitted with Kodak CCD heads which employ a lower power light source than less advanced CCDs and offer a higher level of color/tone sensitivity and stability.

Every exposure of the aerial photography will be scanned to ensure maximum ability to produce the digital orthophotography from the most central portions of the photo exposures. The scanning of each exposure will cover the entire frame, including fiducials. The imagery is initially rasterized with 1024 density levels per channel, which are remapped to 256 density levels using a project-specified “lookup table” (LUT) based on the film type, photographic characteristics, and desired image characteristics. For production of color orthoimagery, the LUT process is superior to the more rudimentary gamma/curve histogram adjustment in that it provides for specific level-to-level density/color assignment and thus permits very fine adjustments of the color balance at the scanning stage.

Note that Kucera’s digital orthophoto imagery is tone/color balanced <u>after</u> image rectification including "hot spot" removal and overall block area balancing. This procedure is superior to "pre-balancing" at the scanning stage because the balancing is based only upon the portions of the aerial imagery which are used to produce the final orthophoto tiles. With a pre-balancing approach, the balancing is based on the full extent of the aerial exposures, including the outer edges, which are generally not used in the rectification and the development of the orthophoto tiles. The balancing in this case is not necessarily optimal for the tone/color range used for the delivered orthophotography. The post-rectification balancing process is optimal in that it is limited strictly to the tone/color range of the imagery used in the orthophoto production.

A geometric stage, geometric camera, and radiometric calibration of the scanning system is performed weekly and the scanning system calibration is reviewed daily before starting the scanning work. When scanning color photography, the scanner is renormalized every two hours of operation to ensure proper color distribution.

The scan quantization factor (Q-factor) for JPEG-compressed TIFF imagery is typically set at 3 for production scans in the Z/I PhotoScan system software, but can be set to 1 or to scan as an uncompressed TIFF image as required/preferred.

The interior orientation parameters of each scanned photographic exposure will be automatically computed during the scanning phase using the PhotoScan system’s AutoIO utility. The AutoIO utility uses raster templates of the camera fiducials to automatically compute an interior orientation for each image that is generated while in progress. Complete interior orientations are performed within scan jobs. These measurements are saved to each image and to a separate database to be used for QC as well as relevant processes later (softcopy aerotriangulation, compilation, orthophoto generation). If the RMS error of the fiducial measurements exceeds tolerance, then the negative is scanned again and checked for any anomalies such as geometric accuracy, etc.

5.2 Scan Environment and Film Handling:

Kucera's PhotoScan system is housed in a fully enclosed, environmentally controlled, "clean room" type environment to ensure optimal system performance and help prevent dust contamination of the film surface prior to scanning. Once the aerial film has been inspected it is immediately moved to the scanning room in our headquarters photo lab and stored here until it is scanned. Prior to scanning, the film is run through a dedicated film cleaning device and brushed with static brushes to remove foreign surface particles. The scanner operators wear gloves, lab coats, and hair nets to further prevent dust contamination.

6. PILOT PROJECT

6.1 Pilot Project Procedures:

Following the initial data acquisition phases of the project (aerial photography, LiDAR survey, control survey, scanning), Kucera will produce samples of the finalized orthophotography, DEM/DTM, topography, and metadata covering the designated four square-mile area for the 400 scale orthophotography and two square-mile urban area for the 100 scale orthophotography. The pilot project will be used to validate all procedures and verify that the project deliverables meet specifications and the Commission's approval. The pilot project deliverables will include samples of the orthophotography at various grades of color/contrast for review and selection of the preferred radiometry. Note that generally the same radiometry will need to be used for each jurisdiction to best achieve consistency across the region.

Note that it is Kucera's plan to complete the pilot project after the aerial scanning phase is completed and before the aerotriangulation is fully completed. Concerning the scanning, the preference is to get all of the photography scanned as soon as possible while the aerial film is still in a relatively "pristine" condition, in order to obtain the best quality digital photo imagery. Concerning the aerotriangulation, the plan is to perform this work in a small block sufficiently covering the pilot area to allow the mapping work to proceed on this area while continuing with completion of the aerotriangulation.

7. AEROTRIANGULATION

7.1 Procedures and Technology:

Softcopy or analytical aerotriangulation of the aerial photography will be used to densify and check the project control and generate orientation parameters as required for the image rectification and mapping work to be performed. The initial input to the triangulation process will include the ground-based control points and the photo-center coordinate and orientation data from the airborne GPS/IMU survey, which together will allow the process to rapidly and accurately converge to a final solution with a minimal number of iterations being required.

For the softcopy process, an Inpho MATCH AT softcopy aerotriangulation workstation will use image correlation technology to join digital stereo photo image pairs and computer coordinates/elevations for manually selected and/or automatically generated triangulation points for each image-correlated stereopair. The points are run through a preliminary triangulation adjustment with a limited number of measured control points to determine the point residuals, with points having greater than a 7-micron residual being filtered out. The final triangulation is performed with the accepted points and all control points being subject to thorough manual review and adjustment as needed to achieve the optimal point location and distribution.

For the analytical method, the positions of all control, orientation, and triangulation pass points (nine points per photo) and orthophoto orientation points (five points per photo) will be manually selected on a set of contact prints and pugged into a set of triangulation diapositives using a currently calibrated, one-micron accuracy Kern CPM1 point marking and transfer device equipped with 60-micron diamond tip drills. A currently calibrated Zeiss C100 Planicomp analytical stereoplotter with one-micron pointing accuracy interfaced with a Softmap data collection station will be utilized for recording photo coordinates of the pugged points and fiducials, with the Softmap system performing a preliminary triangulation adjustment during the point reading to identify point reading/pugging blunders in real time.

Kucera generally prefers to use softcopy aerotriangulation where possible due to its higher degree of redundancy and its faster automated triangulation pass point generation. Kucera recognizes that the softcopy triangulation process can be degraded where the terrain and/or coverage of the individual photographic exposures does not allow for a sufficient distribution of auto-correlated triangulation points, such as over large expanses of wooded areas, swampland, and open water areas. Where such terrain is prevalent, the softcopy process may not be able to generate a good distribution of triangulation points in the photo coverage, thus the choice for analytical procedures with fully manual triangulation point determination.

As part of the pilot project Kucera will review the completed aerial photography and run tests to confirm that a softcopy aerotriangulation process is optimal or if fully analytical procedures are required. In either case (analytical or softcopy), Kucera will triangulate each scale of photography directly to the project control without the use of control transfers, and will perform the triangulation in single large blocks of same-scale photographs, rigorously tied as needed through triangulation of common flight lines to maximize triangulation accuracy/consistency throughout the project.

7.2 Triangulation Programs:

The triangulation programs used will be Inpho PATB block and bundle refinement adjustment programs run on dedicated workstations. The PATB triangulation software accepts ground and/or airborne GPS control data and softcopy and/or analytical triangulation pass point input, produces a rigorous simultaneous polynomial solution with output of RMS residual values, and has a full suite of error-checking and correcting support programs.

In the point measurement phase of the analytical adjustment, the triangulation software applies corrections for systematic errors resulting from the comparator/reading instrument using instrument calibration data, film deformation and lens distortion using camera calibration data, and atmospheric refraction based on the flight height and ground level.

7.3 Error Tolerances/Check Points:

The triangulation will support mapping meeting the project accuracy standards, with the following individual point and RMS horizontal and vertical accuracy residual tolerances being observed relative to the corresponding map products:

Map Product	*Photo Scale/ Flight Height*	*Individual Point Residual Tolerance (1:6000 Flight Height)*	*RMS Residual Tolerance (1:10,000 Flight Height)*
1"=100' scale orthophotography, 2' contours	1"=700' / 4200'	0.70'	0.42'
1"=400' scale orthophotography	1"=2000' / 12,000'	2'	1.2'

Note that Kucera will be using the aerotriangulation process to maintain a high vertical as well as horizontal image georeferencing accuracy. In this way the triangulated aerial 1"=700' scale photography can be used directly for contour-grade DTM augmentation/compilation as required throughout the 1"=100' scale mapping area.

Designated redundant targeted control stations will be used as check points in the aerotriangulation process. These points will have triangulated coordinates determined for them, which will be compared against the actual coordinates for the points with the expectation of RMS errors not exceeding the specified tolerances. The checkpoint triangulation sessions will be re-run until results are satisfactory.

7.4 Triangulation Report:

For each scale of photography a triangulation report will be prepared and furnished as a deliverable in digital and hardcopy form. The triangulation reports will contain summaries of the procedures used and results achieved, printouts of the triangulation input and output, including control points and weighting factors, adjustment iterations, exposure orientations, and triangulation point listings and residuals. The report will also contain diagrams showing the control distribution in relation to the project area and exposure locations as needed.

8. DIGITAL STEREOCOMPILATION

8.1 Overview/General Procedures and Technologies:

In the stereocompilation phase of the project Kucera will photogrammetrically stereocompile the DEM needed for the 1"=400' scale orthorectification and augment the LiDAR DEM covering the designated 2' contour mapping areas as needed to support the contour topography production.

The stereocompilation work will be accomplished on Kucera's Z/I Imaging SSK and Cardinal Systems VR2 softcopy stereocompilation systems, which allow existing and newly compiled feature data to be viewed in three dimensions on top of the corresponding digital stereomodels of the new triangulated aerial photography. Kucera's softcopy stereoplotters are operated by experienced (> 4 years) stereocompilers and provide a variety of automated and semi-automated compilation features which allow the compilation work to be performed more efficiently and with greater thoroughness and accuracy. All data is captured in three dimensions from parallax-cleared stereomodels, and is compiled in intelligent, manual fashion.

8.2 DEM Compilation for 1"=400' Scale Mapping Areas:

SCOPE OF SERVICES / APPROACH TO PROJECT

Kucera recognizes that existing 10 m USGS DEM data exists for the region which may support 1”=400’ scale orthophoto image rectification, but this DEM has a reported vertical accuracy of 7 m, which is in excess of the specified vertical accuracy tolerance of 8’. In the absence of other suitable existing DEM, Kucera is therefore proposing to stereocompile a new DEM from the triangulated 1”=2000’ scale aerial photography which supports the 1”=400’ scale orthoimage rectification.

The 1”=400’ scale ortho-grade DEM will have a vertical accuracy on the order of 5’ and will consist of a grid of “mass points” at a 150’ to 200’ spacing and breaklines for any major breaks in grade (e.g., highways, elevated railroads, etc.) which would affect the 1”=400’ scale image rectification. The breakline data will include major bridge decks, overpasses, and other elevated features as well as the underlying terrain as needed to ensure proper rectification and depiction of the features in the orthophotography.

8.3 LiDAR DEM Augmentation/Upgrade to Contour DTM:

The LiDAR DEM upgrade work for the 2’ contour mapping areas will consist of adding stereocompiled 3D spot elevations, breaklines, and void/obscured areas as needed for accurate contour topography generation. The spot elevations will be compiled at all significant high and low points (peaks, troughs, saddles, etc.) missed in the LiDAR DEM. The breaklines would include hydrography (streams, rivers, ponds, etc.), major road edge breaks, major cliffs/bluffs/high walls, and other breaks in grade where distinct changes in contour topography occur and are not adequately represented by the LiDAR DEM points. Void/obscured areas will include water bodies and areas of dense vegetation where the DTM elements may inadequately represent the ground surface. The end product of the upgrade process will be a digital terrain model (DTM) supporting 2’ contour generation.

8.4 DEM/DTM Quality Control:

Following production and before being used in subsequent mapping processes, Kucera’s DEM/DTM data is subject to several quality control checks, which include:

- Direct digital review of the data as a 2D point file and as 3D visuals to check for anomalies such as data gaps or data spikes
- Generation of “check” contours from the data and review for proper formation
- Use of PROSA progressive sampling software technology identifying areas where the DEM/DTM may require densification based on a designated “curvature threshold”
- Use of Terrasolid Terrascan software to compare elevations of surveyed control and triangulation points to DTM surface and report displacement/vertical DTM accuracy over the project area

Where anomalies/inaccuracies in the DTM data are found, the data is reviewed and restructured/recompiled as needed.

The results of the DTM quality control testing/assessment are included in the project summary report.

8.5 DTM Data Deliverable:

The contour-grade DTM data files will be furnished as a deliverable in DWG, generic ASCII, ArcInfo, shapefile, or other specified formats on CD or DVD. The data will be in separate files/layers corresponding to mass point and breakline elements using the specified layering scheme and will be delivered by individual tile or in block area coverage.

9. DIGITAL ORTHOPHOTO PRODUCTION

9.1 Overview:

Kucera's digital orthophoto production is a three-stage process consisting of:

1. Initial image rectification and quality control review
2. Image mosaicking/tone balancing using advanced Inpho OrthoVista image processing technology
3. Final, thorough interactive/manual quality control inspection/mosaic/edit of individual image tiles

The process includes a full, manual quality control review and mosaic/edit as needed of each image tile. Kucera's numerous countywide orthophoto clients will readily attest to the superior quality/accuracy and low rejection rate of the orthophoto imagery generated by Kucera using this process.

9.2 Digital Image Rectification:

The digital orthophoto image rectification of the individual scanned photo exposures of the aerial photography to the project DEM data will be accomplished on Inpho OrthoMaster digital orthophoto systems running on dedicated workstations.

In performing the image rectification work, the scanned images to be rectified are subjected to an initial visual quality control review and the project DEM data is processed via Trimble Terramodel software to a TIN model and point grid supporting the rectification. The scanned exposures are oriented using camera fiducial readings (exterior orientation) and orientation parameters derived from the aerotriangulation process (interior orientation), with QC reports being produced and exterior orientation residuals being held to a 10-micron maximum tolerance. The oriented imagery is pixel-rectified to the processed point grid using a high-grade radiometric interpolation, with resampling to the target pixel resolutions being performed as needed using a cubic convolution resampling algorithm. For this project, the finished pixel resolutions will be 2' for the 1"=400' scale orthophotography and 0.5' for the 1"=100' scale orthophotography as specified.

Quality control of the rectification process includes:

- Visual inspection of imagery for observable distortions and other anomalies, with special attention given to DEM quality "indicator" features, such as railroads, highways, and bridge overpasses.

- Check geometric accuracy "fit" of imagery to project survey control and available existing planimetric feature data of equal or higher accuracy – expecting matching with specified tolerances.

- Check of ties with adjacent images within and between flight lines, expecting fit within specified tolerances.

- Selection of exposures with minimal "hot spots"/glare off of water bodies and other significant reflective surfaces.

Where rectification-related image deficiencies are found, the DEM data is reviewed and modified as necessary and the rectification is repeated. A rectification QC signoff report is generated for each rectified image and maintained by the orthophoto department manager.

9.3 Automated Image Processing – OrthoVista:

Following rectification, the imagery is tone balanced and processed into the final seamless image tiles using Zeiss OrthoVista, an automated orthophoto image processing program which performs optimized image tone adjustment, resampling, and tile formation in a batch mode. With the OrthoVista technology, image processing and tiling procedures which previously took weeks to accomplish and review manually are now carried out in a matter of hours or days with minimal need for operator interaction. Note that the OrthoVista program is among the most mature of its type and produces excellent results with virtually no image anomalies.

In performing the automated processing, sample images are run through the OrthoVista program and used to adjust the automated image dodging and seam removal intensity in relation to the tone of the imagery and the terrain being covered. With the parameters defined, a block of images are then batch processed to a seamless overall image representation, from which coordinate-defined tiles and/or resampled imagery is copied/extracted and output in the appropriate format. The seam lines are selected in specified/optimal image locations, with a "seam editor" feature being used for manual adjustment of seam lines where required. The OrthoVista software automatically selects areas of limited tone transition for seam line placement so as to avoid having seams placed through buildings and other areas where seams would be evident. Digital shapefiles of the OrthoVista seam line locations can be furnished to the Commission for quality review and accuracy checking. Kucera will also perform an internal quality control review of all seam line locations.

For this project Kucera will be using OrthoVista to produce the specified 6000' x 6000' coordinate grid-clipped tiles for delivery of the uncompressed 1"=400' scale orthophotography and 1500' x 1500' grid-clipped or quarter-section coverage (Davenport) tiles for delivery of the 1"=100' scale orthophotography. The Davenport quarter-section tiles will overlap as needed to ensure full coverage of the quarter section and to "square up" the image, but will still tie seamlessly (match perfectly) since they are being extracted by OrthoVista from the same master image mosaic. For all tiles, OrthoVista will "blend" the imagery at the transition between the different scales of photography/imagery to achieve a relatively seamless appearance, although there will be an inherent change in resolution/accuracy of the imagery due to the variation in flight height and map scale. Manual edit measures will also be used to minimize image "density shifts" at seam lines so that any effect is primarily non-observable.

OrthoVista will also be used to create resampled/retiled and/or block mosaic versions of the orthophoto imagery as needed for resampled data sets and/or compressed image mosaic files.

An example of "before" and "after" OrthoVista automated processing is provided at the back of this proposal section.

9.4 Bridges and Building Lean:

In areas where there are tall (> 50') bridges/overpasses, two sets of rectified imagery will be prepared, one rectified to the DEM representing the ground beneath the bridge as needed for proper representation of the same, and one rectified to DEM breakline data representing the bridge deck, again as needed for proper representation of the same. Using OrthoVista and manual image editing techniques, the images will be merged/mosaicked to produce the final proper image rendition.

For taller structure areas identified by the jurisdictions, feature lean effects will be minimized or eliminated ("true" orthophotography) using a semi-automated process involving piecing together portions of rectified imagery on which the individual tall structures are best centered and absent of lean. The editing work will be conducted by experienced image processing technicians who will make use of the OrthoVista technology's "QC" feature which automatically retrieves all available views for a particular feature for selection of the best view for subsequent mosaicking. The process will be facilitated as needed by the use of high sidelap (50%) and feature-centered aerial flight lines taken for tall structure areas. For buildings which are not tall but cover large areas (e.g., manufacturing plants, transfer facilities, etc.), a similar process will be used to ensure that the image coverage has minimal and consistent lean and that the appearance of the building is proper and not distorted due to image seams or differences in lean between sides.

9.5 Image Finalization:

The image tiles produced through OrthoVista will be thoroughly manually inspected individually and together, with a quality certification for each batch of images passing inspection. Elements of the final inspection and quality certification process will include:

Characteristic	***Acceptance Criteria***
Automated processing artifacts (e.g., image smears)	100% absent
Tone transition	< 10% variance
Image artifacts (e.g., dust, lint, etc.)	0% visible at target scale < 5 artifacts per tile
Control target image position offset (from survey coordinates)	< 12' offset at 1"=400' scale < 3' offset at 1"=100' scale
Seam line feature displacement	0% visible at target scale < 12' offset at 1"=400' scale < 3' offset at 1"=100' scale
DEM breakline/compiled feature image offset	< 12' offset at 1"=400' scale < 3' offset at 1"=100' scale
Elevated features (bridges, railroads, etc.)	No breaks/warping
Shadow/highlight areas	Good detail visible at target and magnified viewing scales

Characteristic	***Acceptance Criteria***
Color/contrast	Match with Commission-approved sample

In general, Kucera will process the imagery in contiguous blocks and expect these to have a seamless appearance throughout when viewed at the target and enlarged scales and have control/triangulation point displacement and seam mismatches/offsets within the designated project accuracy tolerances for various specified map scales. Correction of minor image imperfections and "spiffing" of tone will be performed as needed using Adobe Photoshop and Image Alchemy softwares as needed.

9.6 Data Delivery:

The final digital orthophoto image tiles will be furnished in georeferenced TIFF (.TIF with .TFW) or GeoTIFF format on USB and DVD media. The image file names will correspond to the specified geographic corner coordinate identifier, sequential number, or PLSS-quarter-section naming system. The delivery media and containers will have the Commission- or jurisdiction-specified labeling indicating the project/jurisdiction name, tiles contained, etc. Two sets of imagery will be furnished as specified, with the first set of images being delivered on USB drive for review/approval and the second set of images being delivered on DVD following full approval of the first set. Revised tiles from the first set of images based on the Commission's or jurisdictions' inspection will be posted on Kucera's FTP site or delivered on DVD. Note that each jurisdiction will receive a full set of tiles, with periphery tiles covering areas in multiple jurisdictions being duplicated as needed for each jurisdiction's set.

The file sizes for the individual uncompressed grid-based image tiles will be 9 MB if produced in black and white and 27 MB if produced in color. The individual quarter-section-based tiles for Davenport will be 28 MB in black and white and 84 MB in color.

9.7 Compressed Imagery:

Compressed jurisdiction-wide mosaic and/or individual tile version of the digital orthophotography will be provided in MrSID, ECW, JPEG 2000, or other desired compressed image format. Samples of imagery at various other compression factors (10x, 30x, 40x, etc.) will be provided for review and selection as requested. The compressed imagery will be produced using the highest available resolution orthophotography for any particular area in jurisdiction.

Kucera was one of the first companies to use Lizardtech MrSID and ER Mapper ECW compression softwares and has completed MrSID and ECW compressions for numerous large area digital orthophoto mapping projects. Both MrSID and ECW compression technologies provide significantly reduced file size/compression ability with minimal loss in digital image quality, fast regeneration time, stand-alone image viewing capability, and compatibility with ArcView and other GIS/CAD platforms. JPEG 2000 is a recently introduced compression format which has superior image quality and regeneration time and which can be used directly without special viewing software.

9.8 Optional Black and White Version of Color or Color IR Orthophotography:

A black and white version of the natural color or color infrared orthophotography can be produced and furnished for minimal added cost through an RGB (color)-to-grayscale (black and white) pixel mapping process accomplished in Adobe Photoshop. The RGB-to-grayscale pixel mapping process involves extraction of luminosity values from the red, blue, and green channels and assignment of grayscale values to the same, with no resulting image degradation. The use of a latest-generation, high resolution color aerial film and superior film scanning technology will also ensure that the black and white version of the imagery will be of high quality.

9.9 Metadata:

The digital orthophotography will be delivered with corresponding metadata files in FGDC-compliant format. FGDC-compliant orthophoto metadata is produced using the USGS program TKME v. 2.8.8. Metadata information is collected by both conventional and digital means, entered into the TKME program, then saved as an ASCII file to be converted to the client-specific file type, e.g., text-based HTML or XML.

9.10 Image Catalog/Viewing/QC Tracking Application:

To facilitate the Commission's retrieval, quality control review, and communication of inspection results for the orthophotography, Kucera will provide the ArcGIS-based Kucera KQ-View viewing and QC tracking utility program/application. The application allows orthophoto tiles to be displayed individually or through an input tile layout. Standard viewing tools such as zoom/pan and coordinates display, as well as custom tools which allow zooming to a specific tile, displaying all neighboring tile images, and the option of overlaying vectors on top of the image, are included.

The QC tracking tool resides within the application allowing operators to review the image and input the QC results (e.g., whether the image is accepted, reason for rejection if not accepted, etc.). Short descriptors or numerical coding can be used for identification of the edit/revision required (e.g., 1 = Edgematch, 2 = mosaic anomaly). The information is stored within the input tile layout as a project file which is updated and transferred to Kucera for each group of tiles reviewed.

Kucera recognizes that clients have varying areas of priority and levels of manpower for the quality control inspection process and can accommodate a variety of inspection and approval/rejection procedures. For larger projects involving progressive delivery of completed imagery over a period of time, the preference is to receive the QC inspection results progressively corresponding chronologically to shipments previously received (e.g., QC results follow client receipt by one month). For smaller projects or where manpower does not permit, QC results can be transferred and processed following all shipments. Minor image corrections/revisions are made within days or weeks of transmittal of inspection results (depending on numbers of images involved). Where major/high incidence revisions are sought, Kucera will immediately investigate the issue and submit a written report detailing the cause and proposed course of remedial action.

Note that where imagery is being delivered by DVD or CD in specific blocks/groups of tiles, a new CD or DVD is provided for the entire tile block which includes the revised images. Where imagery is being delivered on and downloaded from hard drive media, individual revised tiles are included with subsequent shipments of new tiles and can be uniquely named/identified for comparison with the previous version or can be delivered in duplicate file form for overwriting of the previously delivered tile. The procedures for coordinating the QC inspection and performing QC revisions are developed with the client in the project initiation process and documented in the quality control plan.

9.11 Optional ORTHOSCAPE® 3D Visualization:

As an optional service to the jurisdictions, Kucera can combine the newly produced digital orthophotography, LiDAR DEM data, and other available terrain feature source data to produce countywide or selected-area (e.g., downtown Davenport) 3D GIS visualizations using its proprietary ORTHOSCAPE® process. "Orthoscapes" are geometrically accurate, dynamic 3D fly-throughs/drive-throughs which are linked to the Commission's or jurisdiction's 2D orthophoto and/or vector GIS base mapping. Orthoscapes show actual building facades, road edges, and other major terrain features from the oblique portions of the aerial imagery and/or available terrestrial imagery and have accurately positioned and symbolized ground point/utility features. The views are an excellent visual reference and measuring tool for presentations and a variety of applications: emergency services, airport planning, urban development, etc. The ORTHOSCAPE® views are provided in executable file form which can be used independently or linked with all major GIS/CAD platforms.

9.12 Optional Latitude/Longitude Projection:

A latitude/longitude UTM projected version of the digital orthophotography can optionally be furnished to the Commission/jurisdictions for E911 software applications as needed.

9.13 Optional Softcopy Mask/Optional Hardcopy Plots:

Kucera can optionally furnish a GIS/CAD-compatible softcopy mask/digital sheet surround for each tile and plotting routine program for each jurisdiction's in-house use in producing hardcopy sheet plots of the orthophotography. The mask and plotting routine will be based on a jurisdiction's standard sheet format. As a further optional service Kucera can produce high resolution, non-fading, water-resistant color mosaic plots of countywide mosaics and/or selected areas using an AGFAJET 1440 dpi Grand Sherpa color plotting system. Sample final plots would be provided for review and approval before proceeding with deliveries and all plots would be thoroughly quality control inspected for image quality, title information, etc., before shipment.

9.14 Computer Infrastructure/Data Storage/Security:

Kucera's HQ office utilizes a Microsoft Windows 2000 Server / Microsoft Windows 2000 Professional / Microsoft Windows XP Active Directory (AD) software environment. This is a native Windows 2000 environment, with no down-level Windows 9x or NT 4.0 workstations. Forced logons / logoffs utilizing a public key infrastructure (PKI) and Kerberos Authentication are used. Group policies in place and security groups ensure that only those individuals working with the data have access to it. Standard procedures such as storing the enterprise root certificate offsite and onsite in a fireproof safe are taken.
An iSCSI Storage Area Network (SAN) back-end infrastructure using Linux iSCSI initiators and targets are in use for storage. The SAN uses Gigabit fiber switching in a full mesh fabric topology. All vector data (DEM / DTM / LIDAR / planimetrics) is stored on an iSCSI target using a RAID 1+0 array for a combination of speed and fault tolerance. All image scans, rectified imagery, and final mosaics are stored on 8 mm Mammoth tapes offsite, as well as on RAID Level 5 arrays for production use.

Kucera utilizes a secure firewall / DMZ configuration to secure against virus and Internet attacks. Event sinks on our e-mail server block potentially harmful scripts and attachments from reaching any workstation. In addition, Kucera uses Panda Antivirus software to scan for any potential virus.

If desired, file encryption can be used for sensitive data (such as the DEM / planimetrics / orthophotos) using encrypting file system on site, and SecureStar DriveCrypt for data delivery. This software utilizes 1344 Bit encryption for CD / hard disk delivery and either USB keys or Smartcard readers. Alternatively, a Layer 2 Tunneling Protocol (L2TP) Virtual Private Network (VPN) connection over IP can be used to deliver data from Kucera's T1 internet access point.

9.15 Optional Image Watermark:

Kucera can optionally employ Digimarc's ImageBridge software to digitally watermark the digital orthophotos. A Digimarc digital watermark is a special message embedded in an image, whether it is a photo, video or other digital content. Digimarc's software embeds these messages by making subtle changes to the data of the original digital content. These changes are so subtle that Digimarc digital watermarks are considered imperceptible. Optionally, an imagery monitoring service can be utilized that continuously scans the Internet. If any imagery is found having the same identification as the delivered orthophotos, the Commission will be informed and can take appropriate action.

The watermarks will be embedded in the imagery after the last QC checks of the imagery are complete. This will ensure that the watermark will be intact. A verify process of the watermarks will be performed at Kucera to ensure sufficient watermark strength in the imagery.

10. CONTOUR TOPOGRAPHY MAPPING

10.1 Overview:

In this phase of the project Kucera will generate the 2' contour topography for the designated urban areas from the augmented LiDAR DTM and perform a batch and manual edit/quality control review of this data. The edited data will be translated/converted to ArcGIS and AutoCAD formats and subject to final quality control review and edit directly in these formats.

10.2 Contour Generation:

The contour topography will be generated in continuous form from the DTM using Leica CIP, a modified TIN-based contour interpolation program which has an advanced "floating Z" contour-smoothing (splining) algorithm and residual output for a high degree of quality control. The CIP program has a number of features which make it superior to other TIN-based programs for the generation of contours which are smoothed and which require minimal post-generation editing for acceptable cartographic appearance. CIP uses horizontal and vertical splining in contour formation, as opposed to the more rudimentary horizontal, straight-line, point-to-point process, producing a smoother, more accurate contour representation.

10.3 Data Edit:

The new contour topography will be batch and manually edited initially on Zeiss CADMAP and/or Cardinal Systems VR1 dedicated editing workstations to produce a clean, seamless, layered feature database.

The editing process will include:

- Tagging/labeling of feature names from available source data;
- Snapping/joining of data compiled from adjacent stereomodels;
- Elimination of dangling nodes and undershoots/overshoots
- Tagging "hidden" contour lines at text breaks, under bridges, etc.
- Tagging of approximate contours within obscured area polygons
- Addition of spot elevations at high and low points of closed contours, intersections, saddles/troughs, water body centroids

- Review of layering assignment, cartographic appearance, compilation consistency;
- Review against corresponding digital orthophoto image backdrop for completeness (i.e., no features missed) and overlay accuracy (i.e., minimized displacement between image and vector feature location); and
- Creation of coordinate grid layer, sheet tiles, sheet index as needed

All batch edit functions performed are subject to manual review and edit as needed before proceeding with the data conversion.

10.4 Data Conversion:

The final data files will be converted to ArcGIS format in modular tile, block, or full area feature coverages. Before commencing with the data conversion work, translation tables will be developed based on the specified layering scheme/database design and reviewed with the Commission/jurisdictions for approval.

The conversion work from the CADMAP/VR1 format to ArcGIS will generally proceed as follows:

1. Use direct DXF (or other exchange format) translator to convert edited digital map sheet files to GIS-compatible exchange format, with conversion table based on specified database design file.
2. Import data to GIS and review directly in converted format for conversion problems/edits. Use GIS edit functions to correct and/or reconvert as necessary.
3. Perform batch edit and build topology as needed running CLEAN- and BUILD-type functions with specified dangle length and fuzzy tolerance parameters. Visually inspect after processing to ensure no errors introduced by CLEAN function.
4. Create attribute fields and populate as needed.
5. Perform final quality control review directly in ArcGIS platform before delivery of digital files.

The topological structure will be checked manually and using macro edit programs, with graphic data plots and attribute table reports being generated for further quality control review and documentation purposes. The final data will be furnished on CD or DVD along with a master sheet/coverage index file and metadata as needed.

To ensure the quality of the ArcInfo feature coverages, the following procedures will be performed:

Edgematch checking. Maps are edited in blocks of tiles at a time before they are cut using ARC command SPLIT. This ensures not only precise edgematching between these blocks of tiles, but also that the digital features will not go beyond their modular tile.

Creating linear and polygon topology in ArcEdit. Each block of tiles will first be checked for unnecessary pseudo- and dangling nodes which will be eliminated in ArcEdit. CLEAN will be run to create polygon topology for polygon coverages and intersections for line coverages.

Adding attribute item definitions and populating attribute values. Automated addition of attribute item definitions is accomplished via a simple AML to ensure consistency. Based on values of item DXF-LAYER created during import through DXF file format to ArcInfo, attribute values will be populated according to the database design. This will also be accomplished by another in-house AML program.

Assigning tolerance and projection. Automated assigning of tolerance and projection to coverages in

ARC will be accomplished as specified in the database design with a simple AML program.

Final checking. As a final quality check before delivery, an AML program will be run on all coverages to check for the following:

- Empty coverages
- Whether coverage is "cleaned"
- Fuzzy and dangle tolerance, coordinate precision
- Whether projection is defined
- Whether attribute tables have all required item definitions created

The AutoCAD data files will be produced directly from the ArcInfo coverage through the DXF exchange format to ensure full consistency of features between the datasets. The AutoCAD files will be thoroughly reviewed following the conversion and edited as needed for full conformance with the AutoCAD database design.

11. PROJECT WRAP-UP / SUMMARY REPORT

11.1 Overview/Procedures:

In the project wrap-up phase of the project Kucera will review the project transmittals/records and specifications to ensure that all deliverables were received by the jurisdictions. The jurisdictions will be asked to review their records as well to ensure all deliverables are accounted for. Project materials retained by Kucera (e.g., aerial film, raw image scans, backup DEM/DTM files, etc.) will be recorded and appropriately stored at Kucera's headquarters facility.

As a final deliverable Kucera will prepare a project summary report documenting the procedures used and results achieved in each phase of the work. The report will contain the results of accuracy testing along with other relevant project data, e.g., actual data and altitude/scale of aerial photography, camera focal length, project datum, accuracy statement, etc. A Microsoft Word digital and hardcopy version of the report will be provided to the Commission. The report will be signed/certified by the Project Manager.

PROJECT DELIVERABLES

The primary project deliverables by phase will as be as follows:

Project Initiation:

- Procedure plan, including:
  - Procedure/deliverable summary
  - Workflow chart/schedule
  - Camera calibration reports
  - Flight and control network plans
  - Sheet/tile index
  - Database design/layering scheme
  - Quality control plan

Aerial LiDAR Survey:

- Bald-earth ortho-grade digital elevation model (DEM) for the 1”=100’ scale mapping areas
- Digital surface model (DSM)
- Optional raw point cloud and intensity return data

Ground and Airborne Control Survey:

- Control survey report

Aerial Photography:

- Optional contact prints
- Digital flight index/Scandex
- Aerial film (delivered or stored by Kucera)

Aerotriangulation:

- Aerotriangulation reports

Pilot Project:

- Pilot area validation images/data files:
  - Digital orthophotography – uncompressed and compressed
  - LiDAR DEM/DTM and contour topography

Stereocompilation:

- Photogrammetrically compiled DEM for 1”=400’ scale mapping area
- Photogrammetrically augmented 2’ contour-grade LiDAR DTM for designated contour mapping areas
- DEM/DTM data furnished in ASCII, DWG, and shapefile format

SCOPE OF SERVICES / APPROACH TO PROJECT

Digital Orthophotography:

- Uncompressed digital orthophoto tiles in GeoTIFF or georeferenced TIFF format on USB and DVD:
  - 1"=400' scale/2' pixel and/or 1"=100' scale/0.5' pixel
  - Color, black and white, and/or color IR
- Areawide mosaic or individual tile compressed imagery in SID, ECW, or JPEG 2000
- KQ-View viewing/quality control tracking utility
- FGDC metadata
- Optional ORTHOSCAPE® 3D GIS
- Optional hardcopy image plots/plot files
- Optional digital watermark
- Optional lat-long projected orthophotography

Contour Topography Mapping:

- Contour topography in ArcGIS and AutoCAD formats
- FGDC metadata

Project Wrap-up

- Project summary report – hardcopy and Microsoft word

All project deliverables will be owned by the Commission.

PROJECT EQUIPMENT

Listings and descriptions of the equipment and software which will be committed to the project work by production phase/activity are provided below and on the following pages. All of the equipment and software listed is owned and operated by Kucera from/at Kucera's corporate headquarters production office in Willoughby, Ohio. All of the technologies are first-order, state-of-the-art systems which are currently calibrated and subject to regular preventive maintenance. Additional equipment at Kucera's headquarters and branch production offices will be assigned to the project work as needed to maintain the project specifications and schedule. A complete listing of Kucera equipment was provided in Kucera's previously submitted qualifications statement.

Control Surveying:

Ground-Based

- Four (4) Trimble 4000/5000 series geodetic-grade, dual-frequency GPS receivers
- Trimble Geomatics Office GPSurvey, Geolab Flykin data reduction software running on Pentium computer
- Two (2) Leica NA2 automatic levels
- Two (2) TOPCON ET2 total stations with data collectors

The Trimble receivers are used for surveying of ground-based control points and as base stations for airborne GPS surveys. The automatic levels and total stations are used for conventional surveying of control points as needed (e.g., not GPS-observable). Kucera has operated the conventional survey technology since the 1980s and GPS technology since the mid-1990s.

Airborne

- Two (2) Applanix Model 510 POS/AV first-order GPS/IMU systems (serial nos. 21 and 405179)
- Two (2) Novatel GPS 512C L1/L2 airborne GPS antennas
- Two (2) Genisys Accuphoto GPS-based flight management/navigation systems
- Two (2) Dell Latitude Pentium II notebook computers for in-flight or field-based GPS data recording
- Applanix POSPac data reduction software

Novatel dual-frequency GPS antennas are mounted on Kucera's aircraft for airborne GPS signal reception. The Genisys ACCUPHOTO systems are used for GPS-based navigation, camera control, and sub-meter camera position measurement. The Applanix POS/AV systems are mounted to the aerial cameras and provide high accuracy camera position and orientation measurements using inertial navigation technology, significantly reducing the time required for aerotriangulation of the aerial photography. Kucera has operated Applanix GPS/IMU technology since 2000.

Aerial LiDAR System:

- One (1) Leica ALS50 airborne LiDAR system with roll stabilization (serial no. 16)
- Leica TerraSolid Terramodeler and TerraScan LiDAR data processing software
- One (1) Applanix 510 POS/AV geodetic airborne GPS/IMU system (serial no. 42)
-

The Leica ALS50 system is the most advanced LiDAR technology currently in use and features a 200 – 4000 m altitude operating envelope, pulse rate up to 87 kHz, and superior laser scanning optics to maximize data return quality and quantity. Kucera has operated the ALS50 system since 2003.

SCOPE OF SERVICES / APPROACH TO PROJECT

Aircraft and Camera Systems:

- One (1) twin-engine Cessna 310 (no. 76KA) carrying Zeiss RMK TOP 15 6" focal length (f/l) aerial camera (serial no. 142832) with Zeiss TAS gyromount, FMC, 101 AWAR
- One (1) twin-engine Piper Navajo Chieftain (no. 3547G) carrying Zeiss RMK TOP 15 6" f/l aerial camera (serial no. 145860) with Zeiss TAS gyromount, FMC, 101 AWAR
- One (1) twin-engine Piper Navajo Chieftain (no. N350GB) carrying Leica ADS40 large-format, sweep-type digital aerial camera system (for alternative direct digital image acquisition)

Kucera operates a fleet of five aerial photography aircraft (three twin- and two single-engine) and three latest generation, high resolution aerial cameras. ***Calibration reports for the film-based cameras to be available are provided at the back of this section.*** *Kucera has operated the RMK TOP camera systems since the mid-1990s and recently acquired the Leica ADS40 digital camera system.*

Film Processing and Printing:

- One (1) Kodak Ektachrome RT 1411AM automatic film processor
- Two (2) MaxCADliner 950 Leroy film titlers
- Two (2) LogE Mark V computer-dodging contact printers
- One (1) Colex Colette Pro print processor

Kucera's photo lab and film processing units have been quality control-certified by Kodak. Kucera has in-house capability to produce black and white and color photographic prints/diapositives as needed using an in-house Colex color print processor. Kucera has operated the photo lab systems listed since the early 1990s.

Film Scanning:

- Two (2) Z/I Imaging PhotoScan 2002 2-micron precision/accuracy, first-order photogrammetric scanners with film autowinder

The Z/I PhotoScan is among the highest rated scanning systems, and features a diffuse light source to minimize light scattering, "one-pass" black and white or color scanning, and direct automatic roll film scanning. The scanner is housed in an environmentally controlled "clean room" type environment at Kucera's headquarters facility. Kucera has operated PhotoScan scanning systems since 1995.

Aerotriangulation Systems:

- Two (2) Inpho Match AT softcopy aerotriangulation stations
- Inpho PATB block/bundle adjustment aerotriangulation software
- One (1) Leica CPM2 point marking/transfer device
- Two (2) Zeiss C100 Planicomp analytical stereoplotters

Kucera has full in-house capability to complete the aerotriangulation adjustment work in either fully analytical or softcopy fashion. Kucera has operated the analytical aerotriangulation technology since the mid-1980s and the softcopy aerotriangulation technology since the mid-1990s.

SCOPE OF SERVICES / APPROACH TO PROJECT

Digital Stereocompilation Systems:

- Two (2) Z/I SSK Pro softcopy stereoplotters with Z/I CADMAP/DGN data collection system
- Two (2) Cardinal Systems VR2 softcopy stereoplotters
- One (1) BAE Systems SOCET SET softcopy stereoplotter

Kucera currently operates six softcopy and six analytical stereoplotters at its headquarters office facility. Kucera has operated the analytical stereoplotting systems since the mid-1980s and the softcopy stereoplotting systems since the mid-1990s.

Digital Orthophotography/Image Rectification Systems:

- Four (4) dual-Xeon workstations running:
  - Z/I Imaging OrthoPro (orthorectification)
  - Inpho Systems OrthoMaster (orthorectification)
  - Inpho Systems OrthoVista v. 4.0 (image mosaicking/processing)
  - Adobe PhotoShop v. 7 (image edit)
  - Lizardtech GeoExpress/MrSID v. 4.0.1 (image compression)
  - ER Mapper ECW Compressor v. 6.3 (image compression)
  - BAE Systems SOCET SET with Leica ADS40 camera sensor module and true ortho module (for optional digital aerial camera processing)

Kucera has a total of 12 systems dedicated to orthophoto image rectification and processing and has been operating these systems since the mid-1990s.

CAD/GIS Conversion:

- Four (4) Cardinal Systems VR1 dedicated editing workstations with orthophoto image backdrop
- Four (4) Pentium IV computers running:
  - ESRI ArcGIS v. 8.3
  - Autodesk AutoCAD 2002 w/AutoCAD MAP
  - Multigen Paradigm Vega Prime v. 1.2 (3D visualization)
  - Bentley Microstation v. 8 (as needed)
  - Intergraph GeoMedia v. 5 (as needed)

Kucera's GIS department runs current versions of all major CAD/GIS platforms and serves as an authorized ESRI Business Consultant. Kucera has operated ArcInfo in-house since 1991 and has been performing 3D GIS visualizations since 2003.

Hardcopy Image and Map Plotting Systems:

- One (1) HP 1050C 600 dpi color inkjet plotter
- One (1) AGFAJET Grand Sherpa high resolution (1440 dpi), large format (60") archivable color image plotter
- One (1) HP 755CM 600 dpi color inkjet plotter

The HP 1050C plotter is used to produce near-photo-quality mylar or paper image plots in black and white or color. The AGFAJET Grand Sherpa system is used to make large (up to 60" x 90") photo-quality, fully archivable color image plots. The plotting systems have been operated by Kucera since the *early 1990s.*

Computer Infrastructure:

- Forty (40) Windows NT/2000/XP workstations
- Eight (8) Linux iSCSI targets
- Two (2) Linux cluster iSCSI initiators
- Three (3) Windows 2000 AD domain controllers
- One (1) ISA server 2000
- One (1) Exchange server (bridgehead and backend)
- 3COM Layer3 gigabit Ethernet fiber switching

Kucera utilizes a Microsoft Windows 2000 Server / Microsoft Windows 2000 Professional / Microsoft Windows XP Active Directory (AD) software environment with an iSCSI Storage Area Network (SAN) back-end infrastructure using Linux iSCSI initiators and targets. The SAN uses gigabit fiber switching in a full mesh fabric topology.

Project Management:

- Microsoft Project 2003 Professional
- Microsoft Project 2003 Server

Microsoft Project is used for internal project tracking and web-based status reporting.

ALTERNATIVE APPROACH – AERIAL IMAGE ACQUISITION WITH LARGE-FORMAT DIGITAL AERIAL CAMERA – LEICA ADS40

Kucera recently acquired a Leica ADS40 large-format digital aerial camera system and can alternatively use this system for the Bi-State aerial image acquisition and associated digital orthophoto production and mapping work. The ADS40 employs continuous sweep/pushbroom line scanning technology for acquisition of the aerial imagery in continuous flight strips ("pixel carpets") as opposed to individual exposures. The ADS40 is superior to all frame-based digital camera systems and, in fact, is the only camera system which has been used successfully to date for aerial image acquisition for regionwide and other large-area projects. The advantages of the ADS40 over large-format, frame-based systems such as the Z/I DMC and Vexcel UltraCam systems include:

- The ADS40 provides much better ability to produce "true" orthophotography (no feature lean), since it automatically captures a true vertical view of each feature in the line of flight.

- The ADS40 simultaneously collects RGB and IR imagery directly at 0.5' pixel resolution – the RGB and IR imagery is <u>not</u> acquired at a lower resolution and "pan-sharpened" (mapped onto higher resolution panchromatic imagery) as is the case with the large-format frame cameras.

- The ADS40 imagery is more readily processed into orthophotography with modern computer/image processing technology since it is acquired directly in flight strips as opposed to individual exposures.

For this alternative, the flying heights used would be approximately 4000' and 12,000' above mean terrain yielding ground sample distance/pixel resolutions of 0.4' and 1.3', respectively. The swath width of each same-altitude flight line will be set to yield a 30% side overlap image coverage between flight lines.

The ADS40 system collects stereo panchromatic (black and white), RGB (natural color), and near infrared spectral bands in the 430 to 885 nm wavelength range, with a dynamic collection range of 12 bits per pixel and true 5 cm spatial resolution. The imagery is collected in continuous mode with forward, center, and backward line scanner arrays to provide stereo-coverage for subsequent photogrammetric processes. The imagery is initially georeferenced using Applanix AGPS/IMU technology and processed/triangulated to achieve final georeferencing using Leica G-Pro photogrammetric processing software run on Kucera's BAE SOCET SET photogrammetric workstations. The digital orthophotography will be rectified and produced from the processed digital camera imagery in the same fashion as described for the primary approach.

The deliverables for the digital camera alternative will be natural color and duplicate coverage color IR and black and white digital orthophotography at 1"=100' scale/0.5' pixel resolution and 1"=400' scale/2' pixel as specified.

Regarding ADS40 system calibration, a panel of experts commissioned by the USGS and the American Society of Photogrammetry and Remote Sensing (ASPRS) recognize the need for a new capability to calibrate digital cameras and the panel recommended that the USGS acquire a digital camera calibration capability to satisfy the growing national need. This activity is a task under the USGS Remote Sensing Characterization, Calibration, Verification, and Validation project known as Digital Camera Characterization Program. This activity will be used to help define USGS policy and procedures related to collection, calibration, and use of aerial digital imagery. The imagery will be acquired by various contractors and evaluated with respect to camera calibration parameter and product characterization processes using an in situ methodology.