

## **University Partnering for Operational Support**

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### **Abstract**

The UPOS program is an initiative to link university research with operational support requirements within the Army and the Air Force. UPOS provides mechanisms for DoD warfighters to partner directly with university scientists to exploit near term science and technology to address operational problems. Initial products are focused in two functional areas, tropospheric and space weather. Current projects address improvements in fine scale numerical modeling including sensible weather effects, improving understanding of boundary layer interactions and exploring new data sources to improve user products. Prototype operational products are developed and tested in CINC exercises. UPOS also provides a method for young scientists to learn about DoD requirements and leverage their science research to solve national security problems.

### **Overview**

University Partnering for Operational Support (UPOS) is an initiative to link university research with operational support requirements within the Army and the Air Force. The Department of Defense is constantly searching for new methods to improve support to warfighter and strategic customers while reducing costs. Universities are coming under increasing pressure to show the utility of sponsored research. UPOS suggests a common solution to both problems in areas of atmospheric and space sciences.

The key players for testing this prototype effort are the Air Force and Army operational staffs, the Applied Physics Laboratory (APL) of Johns Hopkins University and the Geophysical Institute (GI) of the University of Alaska, Fairbanks. Both university partners are not-for-profit institutions chartered to provide solutions to problems of government agencies. Each laboratory is part of a national university with a long legacy of public service and each institution is committed to developing leaders in applied science and technology. APL is a Department of Defense University Affiliated Research Center, which enables direct task order contracting. The

Geophysical Institute was established by an Act of Congress in 1946 for the purpose of conducting arctic research.

UPOS provides a mechanism for DOD warfighters to partner directly with university scientists, exploit near term science and technology advances, and solve operational readiness problems. By working directly with the warfighter, university researchers will be able to understand operational requirements and focus research efforts to solve real world problems. Allowing the developers of the new technology solutions to work directly with users should shorten the cycle time for bringing new ideas to the field and provide an effective mechanism to fine tune the products. UPOS researchers will interact closely with Alaskan Command as they develop solutions to problems, which are within expertise that APL and GI possess.

A central part of UPOS consists of testing the deliverables in exercises to evaluate the utility of products. New products that offer promise to improving operational support often contain glitches that limit their utility. Exercise and operational testing will enable the customer and the scientists to fine-tune the deliverables before they move into the integration phase at operational facilities. This prototype approach should reduce cycle time by planning and designing software to accept plug-in upgrades, reducing the need to get it completely correct the first time. Getting a reliable 80-percent solution fielded quickly with improvements to follow is the goal of UPOS deliverables.

Products will be designed to serve the needs of operational forecasters and decision-makers that rely upon environmental information to execute their missions. APL and GI scientists will work with both groups before embarking on new product development to ensure the deliverables are focused on customer needs. Conventional design to specification approaches is not good enough for UPOS. After successful exercise testing, APL and GI members will work with on-site contracts at the operational centers to optimize the integration of new software products into current systems.

A second objective of UPOS is to develop science and technology leaders for the future. This will be accomplished by sponsoring research in areas with operational payoffs within the 12-18 month time frame. Closely coupled is the need to provide education and outreach opportunities to members not directly involved in the program. This effort will demonstrate the ability of the university research community to contribute to national security requirements.

### **Philosophy**

The basic philosophy of UPOS is moving innovative 80-percent solutions into the field quickly to support operational customers. This will require merging new ideas with existing technology. The technology however, must be easily replaceable in the near term without any loss in operational capability. Since improvements to functional capability will be incremental, plug in upgrades will be used.

UPOS is also an attempt to implement new models for the acquisition of useful products. Currently the system has cumbersome procedures that require operators to document needs, submit them for validation, argue for specific funding, and then await the results of a costly and lengthy adversarial development process. The current process often develops answers to problems that may no longer exist and uses mature technology that is costly to maintain. The pace of technology advances and the evolution of mission requirements are now too rapid to rely solely upon the standard acquisition process. UPOS is designed to address these complaints by streamlining the solution process.

Some believe that acquisition reform initiatives force the government to rely totally on commercial vendors to build systems to solve problems may not always provide the best solutions. Commercial companies can fabricate solutions based on current technology and methods but they typically do not employ large staffs of R&D people to develop new ideas. Many new approaches that reside in laboratory and university communities seldom make it to the operational community because of difficult technology transfer issues. If commercial industry doesn't find a new approach profitable, it will not market the approach to the government. Consequently, DOD customers often acquire old technology solutions or solutions commercial vendors want to sell.

Industry and DOD buyers have rationalized that this use of "mature" technology is good because it reduces risk. Any industry responsible to stockholders can not place public service above profit. Companies have a fiduciary requirement to put stockholders' needs first. The lengthy acquisition process coupled with the short cycle time for technology has often assured that delivery of mature solutions can be obsolete when they become operational. UPOS provides an alternate method for DOD to acquire new concepts and technology quickly.

Another important aspect of UPOS is developing a long-term relationship with research scientist who understand operational problems and can offer realistic short-term solutions to difficult military problems in the atmospheric and space sciences and other disciplines. Since the turnover rate in the university community is normally less than found in for profit companies, the experience base of the laboratory community offers additional risk reduction to government sponsors if the process is successful.

One of the challenges facing UPOS is that university scientist is often unfamiliar with warfighter needs. Without a compelling national emergency, it has often been difficult to mobilize the research community to address national security issues. As DOD funding levels for science and technology have decreased, university scientist have moved into more profitable fields of research. Many researchers are already fully employed with other customers.

UPOS is important to the university community because it provides an avenue to bring funding into labs to support the development of new idea, technologies and solutions. Without operational sponsorship, the university laboratories will continue to rely on science funding grants which are focused more on understanding science issues and much less on applications of the research. Internal industry research and development is targeted at new product profits, which may not solve problems for military customers. As the DOD relies more on off-the-shelf

solutions acquiring tailored solutions without R&D will become more difficult. In this regard, UPOS is particularly interested in establishing a close relationship with Alaskan Command.

### **Process Flow**

The process flow for UPOS tasks is unusual because the program is designed to feed both operational and research community needs. The operational needs define the applied research that is conducted under UPOS, but basic research products are also required to ensure the pipeline is primed to satisfy evolving operational needs.

For a given project, the first generation of prototype products will be delivered for testing within six months from the start of the program. This phase will require APL and GI to focus on modifying research efforts that are nearly completed. Simultaneous work will begin on the program products that require a 12-month development effort. After six months, work will begin on the 18-month deliverables if that has not already begun. Programs that require more than 12 months to develop will be discouraged unless customer requirements dictate a special emphasis task.

Throughout the development process, task leaders will remain cognizant of the operational integration constraints. Software that cannot fit on operational systems or takes too long to run is beyond the scope of UPOS. The IPTs will closely monitor the development efforts. False starts not only cost money, but also cut into valuable timelines for developing other more valuable products.

On the other end of the spectrum, basic and fundamental research is also beyond the scope of this program. UPOS research will consist of synthesizing ongoing efforts, selecting the best combination of new ideas, coupling them with new technology and then placing the concepts into the operational pipeline for future operational exploitation. The IPTs are responsible for insuring that applied research tasks contain deliverables that can be moved quickly into the operational development track. However, some flexibility is needed to build and test high payoff solutions that may require a development of more than 18 months. These items generally are kept to less than 10 percent of the overall effort.

The basic process flow is outlined in Figure 1. All prototype products and research task must be directly traceable to customer needs. While Joint Required Operational Capability, validated requirements are desirable; UPOS tasks can be initiated by an approval from the UPOS steering committee. Similarly, if the steering committee believes a development effort is not cost effective or is taking too long to accomplish, they can terminate the effort quickly and refocus efforts on needs with a higher payoff. UPOS is an aggressive program focused on providing quick solutions. Most UPOS prototypes are expected to enter the testing phase in about 12 months. Since IPTs will ensure that prototype efforts are meshed with future operational capabilities, the time required to convert to operational implementation should be minimized.

As the program evolves it is envisioned that efforts will expand to include other institutions. This is done to capitalize on different expertise at these institutions not available at either APL or GI. This also brings additional insight and experience into the process.

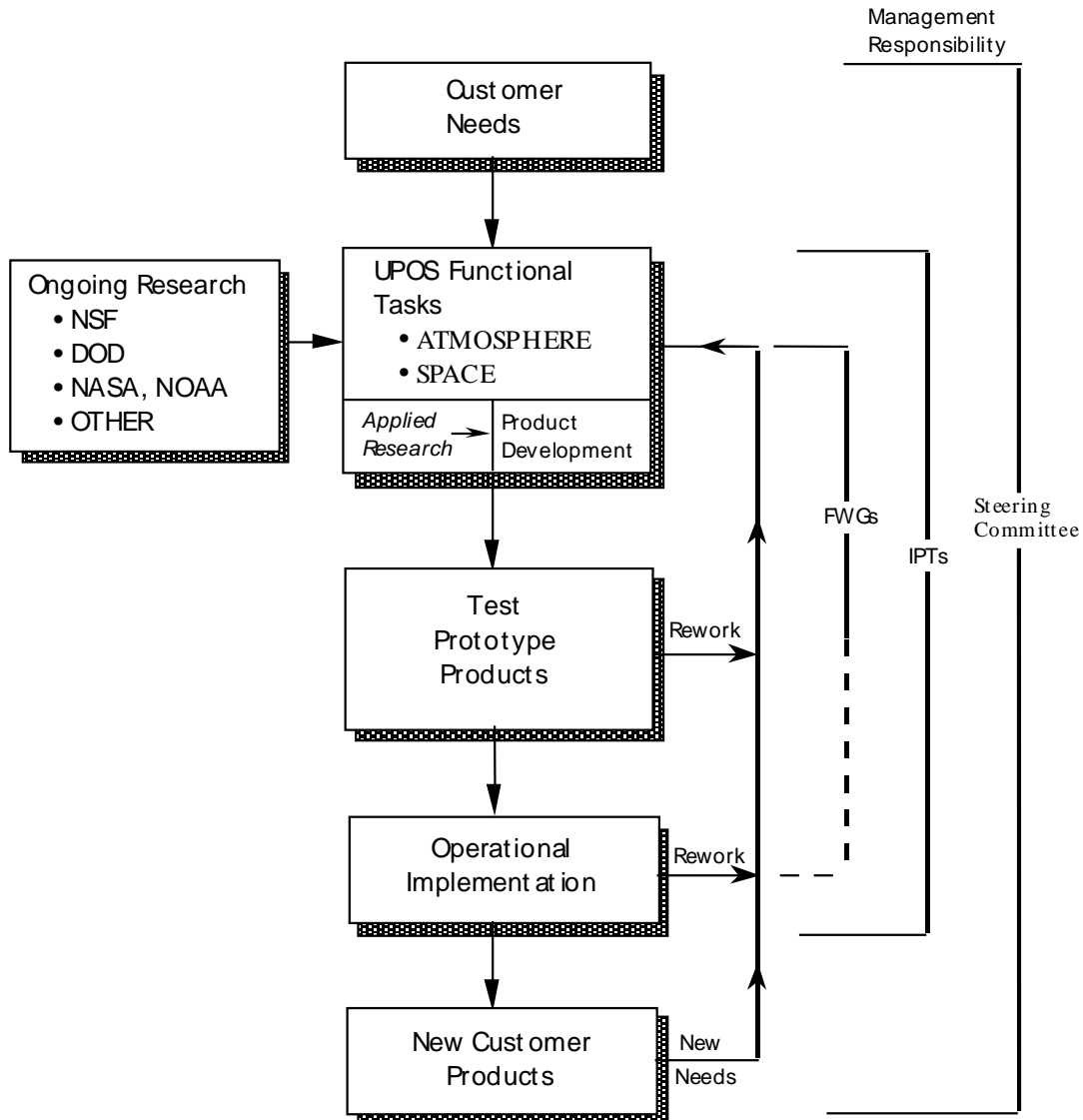


Figure 1. A diagram showing how the development of UPOS projects. This figure shows the decision points and levels at which they are made in order to make the project responsive to changes and efficient in the delivery of products.

## **Program Administration**

As a prototype effort, the structure for the UPOS program is different in some areas than what one may find in typical research or acquisition programs. This is due to the wide spectrum of UPOS customers and a search for finding new methods of meeting requirements after funding draw downs and acquisition reform within the DOD. UPOS uses a streamlined management structure with heavy reliance on decisions made at the lowest levels. The basic structure consists of an Executive Steering Committee, Integrated Project Teams for the atmospheric and space environmental areas, and functional working groups to produce each product under the two areas. In addition, senior leaders at the APL and GI monitor the program process.

The Executive Steering Committee provides overall program direction. The steering committee consists of one senior representative from the Air Staff, the Army staff, APL, GI and an executive secretary. The committee meets at least semi-annually and is responsible for:

- Guiding the program
- Approving the operational deliverables and costs
- Approving new research areas for future operational products
- Providing feedback to the IPTs on prioritization and user needs
- Developing strategy for future funding

Integrated Product Teams exist in atmospheric and space science and are charged with developing the near-term operational prototype products and the research efforts for future enhancements. The IPTs ensure that the prototype products will fit into operational systems by coordination with operational onsite contractor work with software integration contractors. Membership is made up of one knowledgeable technical and/or operational member from the AF, the Army, APL and GI. Members are appointed by the Executive Steering Committee. The IPTs meet at least quarterly and are responsible for:

- Overall program management
- Defining the work breakdown task
- Monitoring progress
- Nominating prototype products and research task to the steering group
- Resolving prioritization issues
- Developing education and outreach efforts
- Formulate and track measures of success

Functional Work Groups (FWGs) or task teams exist in each institution to execute the work tasks. To minimize the geographic coordination need to produce prototype products, most tasks are encapsulated as functional work packages for either APL or GI. Each institution works with the IPT to resolve problems as soon as possible. The laboratories are responsible for providing workspace and access to facilities needed to develop the products. Since prototype products will be delivered for simulation testing and use in CINC, and Command Post exercises at the 6-, 12- and 18-month intervals after program initiation, these teams report periodically to the IPTs on

the status of work task and problems encountered. Waiting for quarterly IPT meetings to surface issue will not support the fast pace of UPOS. FWGs are responsible for:

- Managing individual tasks
- Developing the prototypes
- Providing monthly reports to the IPT on the development effort
- Interfacing with operational customers, research scientists, and commercial operational software integration

UPOS speeds up the delivery and decision process by empowering Integrated Process Teams (IPTs) in the functional area of atmospheric and space sciences to make implementation decisions at the worker levels. This team will consist of operational forecasters at the Air Force Weather Agency, the AF Weather Hubs, Army Support Units, and the Space Weather Support functions (as appropriate) along with scientists at the Applied Physics Laboratory and the Geophysical Institute.

### **Measures of Success**

UPOS is a prototype program designed to supplement the acquisition process with fast track university technology transfer. UPOS operates more like the DARPA model than the standard DOD acquisition models. UPOS projects are small science and software projects which should make them easier to manage than larger complex efforts. If we learn after a startup interval that UPOS would cost more, and take longer to deliver products the approach should be re-evaluated in favor of the conventional for-profit approaches.

Since UPOS serves at least two communities, operations and research, metrics to measure success will be somewhat more complex. Instead of measuring profitability, UPOS needs to measure the innovation generated by the research ideas for the program sponsors. This may be in the form of research papers, patents, leveraging existing research. One fundamental measure is the ability to improve the technology transfer process from the university laboratory environment to the field.

A second category for measurement is the amount and quality of education and outreach that UPOS fosters. Since both laboratories are part of university systems responsible for educating technology leaders of the future, it is anticipated that interns, visiting scientist and other groups will become part of the UPOS effort. Nurturing future science and technology leaders is difficult to quantify, but it remains an important part of UPOS.

### **Description of Science Areas**

UPOS efforts are focussed on scientific research and development in the areas of tropospheric meteorology and in the near earth space environment including solar physics related to the near earth space environment. Tasks in each of these areas may include basic and applied research as necessary to develop new products and models. The amount of basic research is minimal and is

only to do the necessary research to complete product development. UPOS also can perform studies to assess the military utility of new or existing products and models, to support operational testing of new or existing products and models, and their integration into operations. Following product or model implementation, UPOS tasks may include impact analysis on military operations. General descriptions of the two major areas are given below along with an example of a completed project for each.

Tasks in the area of tropospheric meteorology are intended to develop new operational forecasting techniques and products to support warfighter operations in the lower atmospheric regions. These techniques and products include, but are not limited to, new fine scale weather applications and algorithms that include topics such as high resolution terrain, convective processes, soil moisture parameterizations, and aviation variables like turbulence and icing. Other products developed under UPOS efforts are directed toward environmental effects on weapon systems and improved tactical operations. Products are being developed in areas like volcano plume, dust transport, and support to standoff precision guided munitions weapon systems launched from air, land or sea.

UPOS tasks in the area of Near Earth Space Environment and Solar Physics are intended to address the upper atmospheric space environment and its effects on military systems. These techniques and products include, but are not limited to, those that quantify, specify, and forecast the state of the near earth space environment and related solar conditions. Products are being developed that depict the effects and impacts of the space environment on operational military systems, and improved operational support in areas such as HF communications, satellite navigation, and spacecraft resource protection.

### **Examples of Completed Projects**

#### **Volcano Plume Tracking Product – PUFF**

The following information is extracted from the PUFF Users Guide that was delivered to AFWA along with the operational prototype product by Dave Tillman. This documentation is developed for each project as part of the delivery and transition process.

The PUFF project started as a means to improve AFWA products as the primary source of information on world wide volcano plumes as flight hazards for DoD and as the backup to the NOAA in the US. The PUFF program models the dispersion of volcanic ash from an eruption. Its key inputs are the U and V wind velocities versus geopotential height on a grid covering the area of interest and several parameters describing the characteristics of the eruption. Its output comprises a series of ash files in network common data form (netCDF) format that describe the distribution of the ash at different points in time. A graphical depiction of the ash overlaid on a map is available from an associated utility.

PUFF was developed at the Geophysical Institute, University of Alaska Fairbanks and used by the Alaska Volcano Observatory (AVO) for volcano monitoring. Initially, PUFF was a research tool conceived by Dr. Hiroshi Tanaka for predicting the movement of eruption clouds. Dr.

Craig Searcy conceived and developed the present version of PUFF as part of his doctoral program. Ken Dean and William Stringer were his Graduate Advisors. The original version of PUFF is currently being used by the National Weather Service (NWS) and AVO to track volcanic eruption clouds in the Alaskan region.

The UPOS project entailed taking the existing program and converting it to a world wide capability along with adding MM5 model data as a meteorological source for the model. Further refinements in the Graphical User Interface (GUI) and data conversions were implemented by The Johns Hopkins University Applied Physics Laboratory (JHU/APL) in a joint project with the University of Alaska. The model is copyrighted at the University of Alaska. The processes used in the model and an analysis of model results versus observations are given in “PUFF: A high-resolution volcanic ash tracking model,” Journal of Volcanology and Geothermal Research 80 (1998), PP 1-16.

Figure 2 shows a typical output screen for a sample run of the PUFF model. The PUFF model as developed under the UPOS project was delivered to AFWA in November 1999 and is undergoing extended review and testing by the satellite branch now. Feedback from AFWA on the PUFF model has been generally positive. Many of the issues with the original delivery have been corrected or the changes requested by the users have been completed.

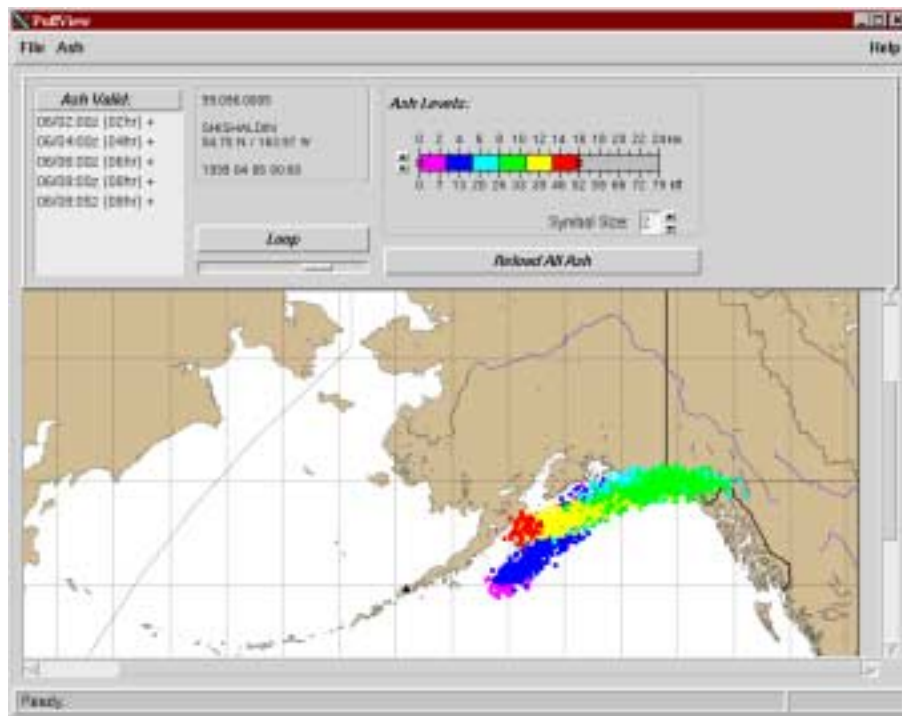


Figure 2. An example of the output page from the PUFF model that was delivered to AFWA in November 1999. The volcano is located on the Aleutian chain and is marked by the triangle. The figure depicts the position of the ash cloud some time after the eruption has ceased. The colors show the amount and locations of the ash at various altitude levels.

## **Auroral Oval**

The following information was extracted from the draft user guide entitled: Operational Auroral Boundary and Particle Precipitation Nowcasting User's Guide UPOS-A53-01 06 December 1999 By Linda M. Hasselbarth.

The primary purpose of the Auroral Boundary and Particle Precipitation Nowcasting software system is to provide AFSWC the capability to monitor the auroral oval position. Specifically it tracks the equatorward and poleward edges using multipoint measurements whenever possible. Additionally, a short-term (one hour) forecast of auroral power is made based on the particle precipitation data (specifically using the polar cap size and the ion isotropy boundary). The latter data is also used to calculate an equivalent instantaneous Kp, which is a planetary geomagnetic disturbance index.

To characterize the magnetosphere requires the selection and monitoring of appropriate state variables. Two such state variables are the amount of open geomagnetic flux available for explosive energy release in the magnetotail (in megawebers) and the ion isotropy boundary called B2i. B2i is a measure the stretching of the magnetotail and therefore its current instability. The open geomagnetic flux is simply the integrated magnetic field inside the poleward edge of the auroral oval. This is the energy reservoir available for explosive release in dramatic solar-terrestrial events. Equivalently, it is a measure of the strength of the cross-magnetotail currents (which are disrupted and/or diverted to the ionosphere during magnetic activity). The ion isotropy boundary (ion precipitation maximum for keV ions) has been demonstrated to measure how stretched the magnetotail is. The more highly stretched the magnetotail is, the more unstable its configuration. Collectively these two variables tell how unstable the magnetotail is, and how much energy is available for release if an event occurs.

The equatorward edge of the auroral oval is useful in determining the limits of radio signal disruption. Previously developed pattern-recognition techniques for processing DMSP particle data [Newell et al., J. Geophys. Res., 101, 1996] are used to recognize these boundaries. The Johns Hopkins University Applied Physics Laboratory has developed software to automatically identify regions on both the dayside and nightside of the auroral oval and to use these regions to generate images showing the shape of the ovals [Sotirelis et al., J. Geophys. Res., 1997 and Newell et al., J. Geophys. Res., 1998].

The output of the project is shown in Figure 3. The first two images display the position of the auroral ovals for each of the polar caps. In the images, the land masses are outlined for reference. The present oval is shown in solid yellow. The previous oval is represented as an oval filled with broken red lines. The satellite tracks used to compute the oval are shown in blue. The lower portion of the image contains several additional pieces of information. The first is the Geomagnetic Activity Forecast. The color of the box indicates the activity level. Green signifies low, yellow signifies medium and red, high. Also shown are the time this forecast is valid and the value for the equivalent Kp. The other images show the history of the total flux and the normalized B2i value for the last six hours. Each of these plots contains a dashed green line to indicate the value averaged over three years.

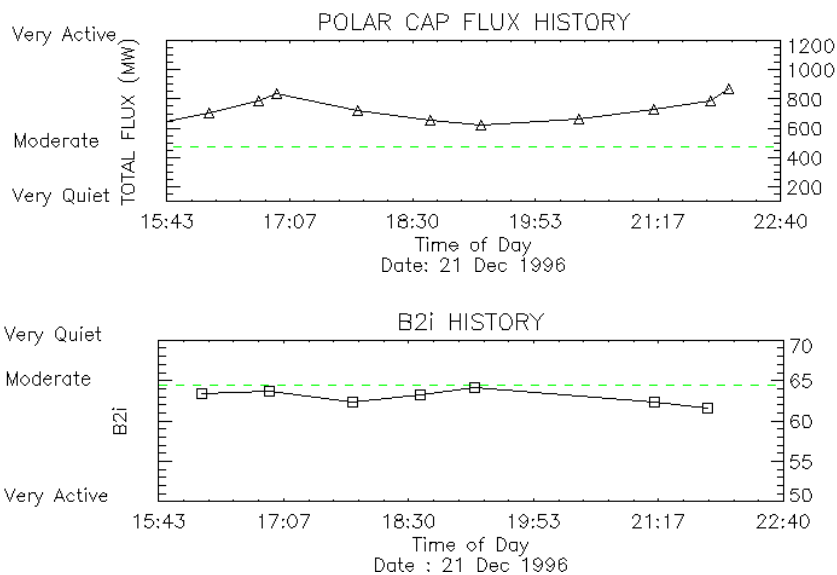
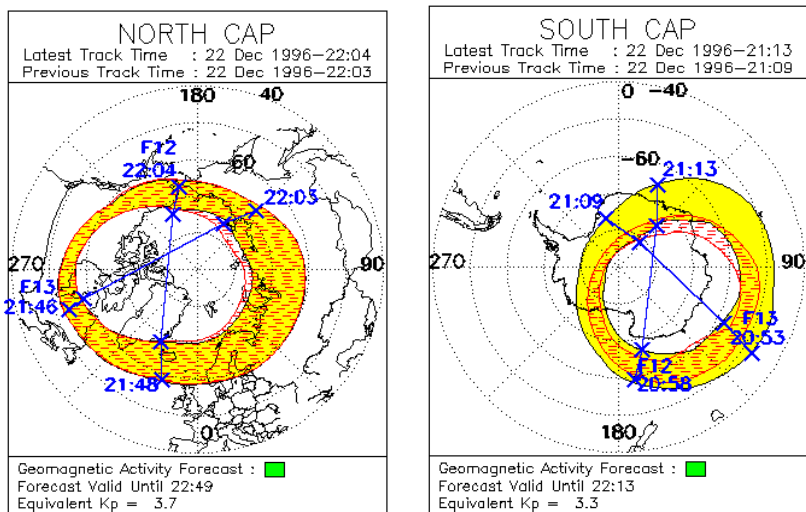


Figure 3. Example of the output of the Auroral Oval Project. The main output is a series of four GIF images. The first two depict the geographic position of the auroral oval for both the northern and southern hemispheres, along with the inferred Kp and a “green light/yellow light” forecast. The third GIF image depicts a plot of the total flux over the past several hours. The fourth GIF image depicts a plot of the normalized b2i value over the past several hours.

### Web Page Access

Most if not all of the standalone products being developed under the UPOS efforts will have a web interface at the request of the sponsors. Web interfaces make it easier to integrate the final prototype products at the user sites and will facilitate the development. A UPOS web page is

being developed as a site for the products with web interface. The users of the products can use the web page to review and in some instances tryout the prototype software in a beta mode during the development and testing phase. While the web page is not considered to be operational, the data used by the models located on the page, it is as current as possible. This gives the end users a chance to see what the products will do with everyday conditions as opposed to canned data.

The first products to be hosted on the web page were discussed in some detail above. These applications were selected because they are "ready" in the sense that a significant part of their intended functionality can be demonstrated. Also, their respective user interface types are indicative of the possible range and variety of similar web-based applications that can be provided in the UPOS context. For PUFF, the web interface will be mainly one of providing users the means for selecting, displaying, downloading a range of preprocessed GIF images. However, this does not seriously limit the option of making many preprocessed images available immediately. We will also provide a simple form for users to fill out and submit when they need "non-standard" images to be generated for a test case. For the Auroral Oval, a nearly complete web interface is already in place. To complete the project, the required files must be ported to an area outside the firewall, where it (and eventually other applications) can be made available to the end users for review.

### **Summary**

UPOS provides a unique approach to move new technology and ideas from university laboratories rapidly into the field. It provides a means for the research community to focus assets on the tangible needs of operational customers. UPOS also supports the educational and outreach goals of the government by investing in and developing future leaders in the applied sciences. It enables a university to leverage ongoing basic research and attempts to solve the difficult technology transfer problems that usually delay innovations. With DOD becoming more reliant on commercial solutions, UPOS will give the government users direct contact with laboratory innovators. UPOS empowers the DOD and university laboratories to decide which ideas can be quickly exploited to meet warfighter needs.