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Operations Technical Activities Report on the Proposed Dome Drive Upgrade

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Basis for upgrading the Dome Drive system

From research into the dome drive hydraulics system upgrades needed for remote operations under the observatory automation project (OAP), it has been discovered that costs to instrument the current system are quite expensive, in excess of $20K. This led to a feasibility study researching the existing system which highlighted the obsolete or no longer manufactured components and thus prompted a further investigation of more modern options for upgrading the system. OAP requires that the dome drive system shall be controlled and monitored remotely. The current system can be remotely controlled via the Telescope control system (TCS) if the hydraulic pumps on the first floor are turned on, however this is currently a manual step. Also, instrumentation information for temperatures, pressures, and flows from the current system are only available on manual gauges in the 1st floor machinery room and the 4th floor control room. The studies shows additional costs to instrument the current system give reason to consider investing that money in upgrading the dome drive system.

Existing system costs

Several components of the dome drive system are no longer manufactured and obsolete which makes them expensive to maintain and rebuild. The table below identifies some of the obsolete components of the system which are rebuilt to keep the system running, the costs of maintaining them, and additional resources required for maintaining the existing system.

Component	Obsolete	Repair Cost	Useful life
Abex-Denison Piston Type High Pressure Pump (x2)	yes	$2965.36	2-3 years
Eaton Hydraulics Vane Low Pressure Boost Pump (x2)	yes	$440.25	2-3 years
Leroy Somer Electric Motor (x2)	yes	$781.25	2-3 years
Hydraulic oil	no	$_____	5-6 years
Hydraulic fluid analysis	n/a	$225.00	4x a year, quarterly
Hydraulic fluid filters	soon	$1,000.00	Washable elements, replace every 7-10 years

To maintain the system the cost can be seen in the table below for the last couple of years. But be aware that there have been no major failures during this time.

Annual Dome drive system maintenance costs

• 2009	• $9,956.00
• 2008	• $17,058.16
• 2007	• $10,828.00
• 2006	• $5,167.00

• 2005	• $342.00
• 2004	• $3,668.00
• 2003	• $17,345.00
• average/year	• $9,194.88

In the case of a catastrophic failure of one of the components that is no longer available on the market, loss of observing time is very probable as the components can not longer be readily replaced.

The estimated cost of electrical consumption to operate the existing system has been measured to be about $10.00 for every hour of operation. An estimate for the annual electrical consumption cost is about $20,000 to $30,000 which depends heavily on the number of nights observing and nights down due to weather, length of the exposure before a dome rotation, instruments, etc.

The estimated time in manpower currently spent maintaining the existing system is ___hours per month which is mostly spent performing preventative maintenance.

Safety and environmental impacts at the summit are other considerations we must be mindful of. A hydraulic leak can lead to serious injury and can be very expensive to clean up.

Upgrade Alternatives

Two major alternatives were considered, explored and researched through feasibility studies. The first is to upgrade the current system to a more modern hydraulic system to today's standards, replacing the parts that are obsolete with higher efficiency components. The second

option is to replace the hydraulic motor on each drive unit with an electric motor, and no longer use hydraulics to power the dome rotation.

Hydraulic system upgrade

Currently there are three (3) hydraulic low/high pressure pumps/motor assemblies not being used. They were originally purchased in the past with the intention of replacing the obsolete pump/motor assemblies. Unfortunately these parts were never implemented and a new system was never installed. Fortunately these pump/motor assemblies are still modern and efficient to today's standards and we can save money on the upgrade build by putting them into service. One option would be to send the pump/motor assembly units to Motion Industries in Phoenix, AZ where they will be re-plumbed, tested, and integrated into a new 400 gallon hydraulic power unit complete with monitoring capabilities. It is expected that implementing this system would require approximately 2 nights or less of down time to remove the old hydraulic power unit and replace it with the new one, hook up the supply and return hydraulic lines, test, and restart the system.

The quote for the assembling and testing the hydraulic power unit (HPU) is approximately $40k. This does not include the shipping costs to and from Phoenix. On-site installation costs should be minimal as the new unit is designed with existing electrical wires and hydraulic lines available. Unfortunately the estimated savings in electrical costs with this new system will be small (maybe $1,000-3,000 a year) because even though the system will be more efficient it will still be using 20hp electric motors to pump the fluid and small efficiency gains will only reduce the motor load slightly. A reduction in maintenance costs will only be nominal as well because the pumps and motors will still have to be rebuilt at some point, but their operation life before rebuilds will be longer and more cost effective due to more readily available rebuild vendors and parts. Preventative maintenance time from internal manpower should decrease accordingly since the system will have a longer time frame before repairs will begin to be made.

Electric system upgrade

This option would replace the hydraulic motor coupled directly to the gear reduction box on each drive unit (three (3) total) with an electric motor. The hydraulic power unit discussed above, and on the first floor; will be replaced with an electronic motor controller (drive unit) system on the fifth floor. The electric motor can be attached to the gear reduction box (transmission) via an adaptor plate sold by the original manufacturer of the gearbox; therefore minimal changes would be required on the three (3) dome drive units. The motor control units (three total) for each motor would provide information required for remote operation and monitoring such as motor current, motor torque, motor speed, etc. The plan for implementing this system is to perform the upgrade without any loss of time on the sky. One motor and motor controller will be tested on the fifth floor with a spare drive unit (already in-house) to mimic operations, when the unit has been tested and is ready only one drive unit will be pulled out of service and upgraded to the new system. Once acceptance tests have been performed on the new unit the remaining two (2) will be installed. This will allow for time to test and troubleshoot the new unit while the other two (2) drive units are still in operation from the hydraulic system.

Three (3) manufacturers have been considered in the feasibility study upgrade: Bosch Rexroth, Rockwell, and Baldor. Rockwell and Baldor have been selected to continue system design work and to be included in the Preliminary Design phase planned for December 2009.

The estimated costs of replacing the old hydraulic motors on the drive units, making the required room and mounting modifications, and electrical upgrades needed are approximately $66k.

The electric components in this configuration are more efficient than their hydraulic counterparts. The hydraulic system has been calculated to have an overall mechanical efficiency of 37%. The new electric system will have an overall efficiency of 97-94%. The estimated reduction in

electrical costs to be on the safe side should be ½ or better than what we pay now. Once the system has been tested thoroughly and fine tuned, the reduction in maintenance costs will be reduced to monthly electrical preventative maintenance (PM) checkups. The time spent on past preventative maintenance will be transparent as the daycrew will gain back the majority of the manpower that was previously spent on dome drive hydraulic system PM's and repairs.

Conclusions

The risk of operating the current hydraulic system with components no longer manufactured or obsolete and the rising costs of maintaining an aging system are strong motivators to upgrade the dome drive system. Converting the existing system to an electric motor drive system, reduces electrical consumption, preventative maintenance and repairs, internal manpower obligations, and environmental impacts which are all cost factors involved with the existing hydraulic system.

The danger of moving to this new method of driving the dome are low according to the research performed and the fact that several other observatories are now using very similar drive systems to the one that is being considered. For instance, Keck has had much success with their Baldor dome drive electric system, with only one failure in the past twelve years and minimal time required for preventive maintenance.

The annual estimated electrical savings by converting to the electrical system could be half of what we pay now. If you include the cost of routine preventative maintenance in manpower and the cost for parts and supplies we would see a payback for the cost of the system returned in less than 4 years.

In addition to the time and money savings, there are additional benefits. Dome seeing studies have revealed heat sources to be a major contributor to the degradation of seeing in our dome. The lower consumption of electricity and hence subsequent smaller heat generation as well as

the plan to remove the heat from the motor controllers in the dome should help in this regard. Also with one fewer hydraulic system at the summit there is reduced risk of serious hydraulic leaks which could result in injury or environmental impacts from a leak or spill.

For these reasons, the replacement of the hydraulic dome drive system to an electric dome drive system is planned. A vendor will be selected after the preliminary design review. The detailed design review will be planned before April of next year with a timeline for completion and a plan for implementation by October 2010.