IPN-ISD TECHNOLOGY DEVELOPMENT PLAN - FY02

Optical Communications

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OBJECTIVE:
The objectives of this work area are to assess, develop and validate optical communications technology for support of future NASA missions.

GOALS and SIGNIFICANCE:
Provide a low-cost optical communications telescope laboratory that will support future flight demonstrations and help build experience needed for ground network operations. Conduct cost-effective system-level optical communications demonstrations in order to validate technology and retire future implementation risks. Evaluate performance of, and implementation approaches for, future optical deep space network (DSN) reception capabilities. Perform fundamental theoretical studies to establish optical channel capacity limits that will allow a re-assessment of device constraints, as well as, provide a basis for developing performance-enhancing codes. Assess atmospheric effects on optical communications link performance in order to improve the understanding of atmospheric attenuation statistics, link margin and availability. Develop new analysis tools for optical communications link performance predictions so that analysis time (cost) is saved while providing reliable link performance predictions.

PRODUCTS:
A 1m optical communications telescope laboratory and low-cost systems level demonstration of end-to-end optical communications. Deep space optical communications detectors and receivers for ground stations. Improved codes and laser modulation schemes. Atmospheric visibility models and improved link performance analysis tools.

DESCRIPTION:
Incremental end-to-end systems level demonstrations for technology validation and assessment will play a major role in retiring the risk of implementing optical communications for servicing and enhancing future NASA missions. Two work units to support demonstrations are being pursued. The first is the Optical Communications Telescope Laboratory (OCTL) that will deliver a 1-m class telescope system suitable for earth-to-space demonstrations. The second work unit will pursue familiarity in operating OCTL and developing instrumentation (laser system and transmit/receive optical train) required for systems level demonstrations. The latter also includes preparations for safely broadcasting non-eye-safe laser beams from OCTL.

Future optical communications systems from deep space must be capable of detecting faint signals in the presence of varying amounts of background noise. This capability is required by both ground and space systems. Research directed toward addressing the ground system aspect of the problem is being pursued. Efficient opto-electronic conversions, followed by high-performance methods of pulse position modulation (PPM) symbol detection and slot synchronization are the next step in receiving optical communications from deep space probes. A single work unit is dedicated toward development of a prototype PPM receiver for a ground station. In addition to delivering the receiver, a state of the art near infra-red enhanced detector will also be characterized.

Fundamental theoretical studies directed towards an understanding of optical channel capacity provides theoretical performance bounds, an assessment of device constraints and a basis for evaluating how performance can be improved by coding and/or alternate modulation schemes. A work unit will continue to pursue theoretical research to identify improved modulation and coding schemes, as well as, address the decoder performance using laboratory generated data streams that are stored and post-processed.

Analysis pursued under advanced concepts has identified approaches that allow significant performance enhancement in signal reception by mitigating atmospheric turbulence induced degradation of laser communications signals received on the ground. This concept relies on the use of adaptive array detectors. Early laboratory proof-of-concept demonstrations utilizing front-end array devices followed by adequate signal processing electronics will be pursued.

Finally, optical communications requires clear line-of-sight paths to operate and clouds in earth's atmosphere will cause channel outages. The atmospheric visibility monitoring (AVM) work unit will continue to monitor and compile visibility statistics from three sites in the South Western United States and use the data to determine channel availability models.

INTERDEPENDENCIES:

BMDO is a potential developer of an optical communications terminal for demonstrating air-to-ground optical links. The JPL OCD architecture is being baselined for the terminal design in order to take advantage of the scalability it offers over wide link ranges. Furthermore, the use of OCTL as a ground station is also being planned during the air-to-ground demonstration. .

DELIVERABLES:

Approve pre-shipment test results for optical telescope system (OTS)	**Q3**
Accept OTS for OCTL	**Q3**
Install OSHA Laser safety systems at OCTL	**Q1**
Preliminary design review of receive/transmit optical train for OCTL	**Q1**
Critical Design review of OCTL optical train	**Q2**
Installation of Tier I laser safety system at OCTL	**Q2**
Installation of Tier II laser safety system at OCTL	**Q3**
Reports and memos on Laser safety	**Q3,Q4**
Complete optical train at OCTL	**Q4**
OCTL characterization results	**Q4**
TMO PR on design of PPM receiver	**Q1**
TMO PR on NIR PMT characterization	**Q2**
Deliver PPM Receiver	**Q3**
PPM Receiver test report	**Q4**
Technical memo decoder performance analysis	**Q2**
Demonstration of constrained decoder performance using laboratory data	**Q4**
TMO PR on decoding	**Q4**
Prototype InGaAs array	**Q2**
TMO PR on characterization of InGaAs array	**Q4**
Quarterly visibility reports	**Q1,Q2, Q3, Q4**
TMO PR on AVM data	**Q4**

RESOURCE REQUIREMENTS BY WORK UNIT

	JPL Account #	*FY01*	*FY02*	*FY03*
OCTL	100713-70.100.25.5.1002	267	95	

OCTL TELESCOPE (315-90)	100713-70.100.25.5.1004	274	25	
OCTL LONG TERM PLANNING	100713-70.100.25.5.1005	274	500	
OPTICAL COMM GRND REC	100713-70.100.25.5.0002	200	-	
DEEP SPACE O-E RECEIVER	100713-70.100.25.5.0001	280	200	
SYMBOL DETECTION & SYNC	100713-70.100.25.5.4003	120	-	
OPTICAL SYS ANALYSIS TOOLS	100713-70.100.25.5.4002	150	100	
ADV CONCEPTS FOR OPTICAL COMM	100713-70.100.25.5.4001	170	100	
ATMOS VISIBILITY MONITORING	100713-70.100.25.5.3001	241	170	
Total -- Match WAD		1976	1190	1700

OTHER INFORMATION:

Please refer to the individual task plans for detailed information on partnering, infusion plans, commercialization potential/plans, and reporting plans.