GTWS Science and Operational Wind Data Product Requirements
(Under Conditions of Nominal Cloud Coverage)

	THRESHOLD			OBJECTIVE		
	S	**O**	**R**	**S**	**O**	**R**
Depth of regard (km)	0– 25	0 – 20	0- 20	0– 30	0 –25	0-30
Vertical TSV resolution (km)						
Top of DOR to tropopause	NR	NR	NR	2	2	2
Tropopause to boundary layer top	1	1	1	.25	1	.5
Within boundary layer	.25	.5	.5	.25	.25	.25
Height assignment accuracy (km)	.1	.1	.1	.1	.1	.1
Horizontal TSV dimension (km) (maximum for averaging)	100	100	100	25	25	25
Horizontal location accuracy (km)	.5	.5	.5	.5	.5	.5
Horizontal resolution (km) (distance between TSVs)	350	350	350	50	100	100
Minimum X-track regard (km) (# in ( ) is # of TSVs)	±400 (4)	±400 (4)	±400 (4)	±625 (12)	±625 (12)	±625 (12)
Number LOS perspectives in TSV (angular separation > 30 and < 150)	2	2	2	2	2	2
Accuracy(1σ) of LOSH (m/s)						
Above boundary layer	3(1.2)	3(1.2)	3(1.2)	2(1.4)	3(1.4)	2(1.4)
Within boundary layer	2(1)	3(1.2)	3(1.2)	1(1)	2(1)	1(1)
(number in ( ) is σ_S within TSV)						
Horizontal component bias (m/s)	.1	.15	.1	.05	.05	.05
Maximum horizontal speed (m/s)						
Above boundary layer	75	75	75	100	100	100
Within boundary layer	50	50	50	50	50	50
Temporal resolution (hours) (revisit period, orbit permitting)	12	12	12	6	6	6
Data product latency (hours)	NR	2.75	2.75	NR	2.75	2.75

S = Science **O** = Operational **R** = Reconciled **NR** = Not required

LOS = Line Of Sight direction **LOSH** = LOS observations projected into the Horizontal

Target Sample Volume (TSV): This is the maximum volume of atmospheric motion to which sample averaging is to be limited for the expression of a single wind observation.

Nominal Cloud Coverage (NCC): Includes a thin cirrus layer at 10 km and a broken cloud layer between 2-3 km. Optical properties detailed in Point Design Atmospheres.

	Threshold	Objective
Depth of regard (km)	0- 20	0-30
Vertical TSV resolution (km) Top of DOR to tropopause Tropopause to boundary layer top Within boundary layer	 Not Required 1 .5	 2 .5 .25
Height assignment accuracy (km)	.1	.1
Horizonta l TSV dimension (km) (maximum for averaging)	100	25
Horizontal location accuracy (km)	.5	.5
Horizontal resolution (km) (distance between TSVs)	350	100
Minimum X -track regard (km) (# in ( ) is # of TSVs)	±400 (4)	±625 (12)
Number LOS perspectives i n TSV (angular separation > 30 and < 150)	2	2
Accuracy(1 σ) of LOSH (m/s) Above boundary layer Within boundary layer (number in ( ) is σ_S within TSV)	 3(1.2) 3(1.2)	 2(1.4) 1(1)
Horizontal component bias (m/s)	.1	.05
Maximum horizontal speed (m/s) Above boundary layer Within boundary layer	 75 50	 100 50
Temporal resolution (hours) (revisit period, orbit permitting)	12	6
Data product latency (hours)	2.75	2.75

The abbreviated table (above) shows only the reconciled GTWS as published on the WWW in October 2001 for public comment.

Additional GTWS Requirements:

Orbit: Should provide coverage between at least 80N and 80S.

Data level reported: All raw (level 0) data from the A/D (detector signal) should be downlinked.

Data spatial references: LOS sounding angles shall be referenced to local vertical; LOSH heights shall be referenced to local MSL.

Velocity search space: The final wind speed signal processing window is not to exceed 20m/s in the LOS signal domain. This limit applies primarily to coherent detection DWLs.

GTWS mission lifetime: A minimum mission duration of two years is specified.

Definitions and explanations associated with the GTWS Requirements Table

The numbers in the requirements table are those that the GTWS Science Definition Team (SDT), with input from the GTWS workshop attendees, has determined to be necessary to assure a "useful" data product in terms of its likely impact on data assimilation and numerical weather forecasting models. It is understood that new Doppler Wind Lidar (DWL) observations will compete for usefulness with wind observations such as those from rawinsondes, ACARS, Cloud Track Winds, Water Vapor Winds, scatterometers and numerical model first guess fields. Winds derived from proposed future observing systems such as GIFTS are anticipated to be competitive with rawindsondes for accuracy and vertical coverage. The general guideline for specifying some of the threshold requirements is that any new DWL profiles should be provided globally and at roughly the same spatial and temporal density as provided by RAOBs today. This guidance applies mainly to the accuracy and horizontal resolution requirements. The cross track resolution and coverage is relaxed from this guidance in recognition of the difficulty of a single DWL to provide full global coverage in its first mission.

OBJECTIVE: These values represent the desired data requirement for space-based lidar winds. The SDT is confident that an instrument meeting the objective requirements would have a significant impact on both science and operational weather prediction in the 2005 – 2010 time frame.

THRESHOLD: These values represent the minimum data requirements for space-based lidar winds. A GTWS instrument that meets the threshold requirements would likely result in meaningful impact on science and operational weather prediction.

In addition to relaxing the "full global coverage" in the horizontal direction, the GTWS SDT also recognizes that there is a threshold for 'usefulness" in the vertical coverage. For active optical sensors, clouds and aerosols determine where observations are possible and what the quality of those observations will be. The team further recognizes that requiring 100% of the requirements to be met 100% of the time when optically thick clouds are not a factor is not defensible in defining a threshold set of requirements. Thus the SDT has adopted the following guidance in defining threshold coverage:

- A threshold fraction of 50 % of all the wind observations made by an orbiting DWL must meet the standards set in the GTWS requirements table.

- Individual observations that are judged to meet the requirements must be certified prior to their provision to the end user, i.e., each wind observation must be accompanied by a data quality flag that allows the user to discriminate between data of differing usefulness.

- Clouds will be present for many, if not most, of the occasions when a direct measure of the winds is likely to make a significant impact. Thus the GTWS requirements are expected to be met in the presence of "nominal" cloud coverage.

S: Science data user community's data requirements

O: Operational requirements as endorsed by the NOAA and NASA operational data assimilation and weather forecasting centers.

R: Reconciled science and operational requirements based upon review by the SDT.

Depth of regard: The altitude limits (km) between which the DWL will be designed to process signals returned from the atmosphere. This does not imply that the DWL would be able to produce useful data products from the entire depth of regard at all times.

Vertical TSV Resolution: The vertical distance (not slant range) over which averaging may take place to return a data value that meets the accuracy requirement. The boundary layer (BL) is defined as the lowest region of the troposphere bounded by the earth's surface and an elevated density inversion. For planning purposes, the depth of the BL is taken to be 2km.

Height assignment accuracy: The accuracy (RMSE) with which a LOS data value is assigned to the height that most properly represents the signal weighted mean of the averaged velocity information.

Target Sample Volume: (see explanation on Table) The cross-track and along-track distribution of TSVs need not be in a pattern of equal spacing. The look angles needed to meet the bi-perspective angle and spatial separation requirements will most likely dictate the TSV distribution. The general objective is to have the cross-track spacing of the TSVs be approximately the same as the along track spacing.

Horizontal TSV dimension: The maximum horizontal distance (km) over which DWL returns can be averaged to obtain a data value that meets the accuracy requirement. The geometry of the boundaries of the averaging region can range from a line to any two dimensional distribution whose maximum dimension is less than this requirement. Averaging over smaller distances may be acceptable if vertical coverage is not significantly compromised. (see additional comments in attachment 1)

Horizontal location accuracy: The allowable error in assigning a horizontal location for a single LOSH data value.

Horizontal resolution: The maximum horizontal distance (km) between data products meeting the TSV requirements. This resolution requirement applies to the along track direction.

Minimum X-track regard: The minimum width (km) of the "swath of regard" for the DWL. The distribution of lidar shots should not preclude the generation of several (>= number in ()) soundings in the cross-track direction. The cross track spacing between LOSH wind products should not exceed the horizontal resolution requirement. (See discussion under TSV)

Number of LOS perspectives in TSV: The number of angularly independent LOS data products generated within a TSV. The angle between any independent LOSH data products must lie between 30 and 150 degrees. A related restriction is that all the lidar returns that have been used to obtain a single LOSH wind estimate must be taken with pointing angles that do not differ from each other by more than 20 degrees (<.02 in the cosine function). The horizontal distance between the LOSH wind observations in a perspective pair should not exceed 10% of the "Horizontal resolution " requirement.

Accuracy in LOSH: The RMSE (m/s) of all LOSH wind component estimates represented to the model data assimilation routines by the instrument data system as meeting the accuracy requirement. This requirement is, in part, derived from the fact that for an observation to be used in a data assimilation scheme it will have to be assigned an observation error. It is expected that any DWL will be able to provide a data quality flag with each LOSH observation generated. The "accuracy" referred to in this requirement is the measurement accuracy of the instrument. It includes all known sources of error such as pointing knowledge, frequency jitter, signal processing uncertainty and atmospheric turbulence. The LOSH accuracy is defined as the total estimation error projected onto the horizontal plane for the average motion of the backscatter media within the illuminated volume along a LOS perspective. For example, a LOS estimation error of 1.5 m/s with a

DWL using a 30 degree nadir scan angle would result in a 3.0 m/s uncertainty in the LOSH component.

This accuracy requirement is expressed for both the BL and the rest of the troposphere. A set of "Design Atmospheres" will be provided to serve in establishing a point design. (see attached examples in Attachment 1.

Horizontal component bias: The maximum systematic instrument LOSH measurement error (m/s) that can occur without any known method for correction. For example, an un-correctable bias might occur for a portion of an orbit when the pointing knowledge system drifted (non-linearly) without re-calibration.

Maximum horizontal speed sensing: The maximum LOSH wind speed (m/s) that can be measured. The atmospheric targets related to these upper bound speeds are tropical cyclones, mid/upper tropospheric jets, and jets in the PBL.

Temporal resolution: The time (hours) between revisits of a TSV. A follow-up pass that comes within one half of a target resolution distance of a previous TSV will be considered a revisit. It is understood that the capability to revisit an area will be dependent on the orbit, hence this requirement is intended to preserve 12 hour resolution where possible. GTWS operations are to be provided during both the daytime and nighttime.

Data product latency: The maximum allowable time interval between the observation and the delivery of that information to the user.

Attachments:

1. GTWS Design Atmospheres

References (to be provided upon request)

1. Basis for cloud effects included in GTWS observation requirements.
2. Study in support of the bi-perspective sampling requirement (Rishogaard et al)
3. Implication of Data Requirements to Model-independent use of DWL Data Products, (Frehlich)
4. NCEP model wind vector fits to RAOBS and implications for accuracy requirements for GTWS observations (Lord et al)