Summary of the Second WSR-88D Level II-Data Stakeholders Workshop
Held at the University of Oklahoma on 26-27 September 2002

6 November 2002

1. Introduction

Some 45 individuals from academia, private industry, and the Federal government (including NOAA, NRL, and NSF) attended the Second WSR-88D Level II Stakeholders Workshop in Norman, Oklahoma on 26-27 September 2002. The goal of the workshop was to establish the needs and requirements of non-government users of WSR-88D real time Level II data, and to define a framework for meeting them in both the short and long term. At the present time, six private companies are receiving real time Level II data as R&D partners of the University of Oklahoma:

- WeatherData
- WSI
- Baron Services
- Vieux and Associates
- Geo-Marine
- AccuWeather

Several oral presentations from the CRAFT team as well as private sector users, augmented by extensive dialog in plenary sessions, led to a number of important outcomes that are summarized herein. Copies of slides shown at the Workshop are available on the CRAFT web site at http://kkd.ou.edu/craft.htm.

It is important to note that the Level II Stakeholders Workshop was organized by the University of Oklahoma in collaboration with the NEXRAD tri agencies. However, this document reflects only the views of workshop participants and does not represent the official positions or views of the NEXRAD agencies or any other government entities.

2. Outcomes From Workshop

Presented below, in bullet form and in no particular order, are the principal outcomes of the workshop. Although no formal "action items" are listed, the responsibility for most of the outcomes requiring action will rest with the CRAFT leadership.

- As described further in Section 3b, funding provided to OU/CAPS to maintain the current CRAFT infrastructure (excluding radars funded by other groups) ends in November, 2002. In light of the value of the experimental CRAFT Level II data stream, and of real time Level II data in general as underscored by letters now in preparation at the American Meteorological Society Board on Private Sector Meteorology and the UCAR Unidata Policy Committee, workshop attendees were unanimous and vehement in recommending that ongoing support be identified immediately.

- Private industry requires real time Level II **data latencies** (defined as the time elapsed from the completion of data processing for a sector of an individual tilt sweep at the radar site until the time when these same data first become available for practical use at the user location) of **no more than 10 seconds** for any given radar (the overall average should be much smaller).

- Private industry requires real time Level II **data reliability** (measured as the fraction of data available during regular radar operations, neglecting scheduled downtime for preventative or restorative maintenance) of at least 99.99% annually for any given radar, with no significant performance reductions during weather events. Eventually this figure may be stratified into quartiles (e.g., 95% reliability for latencies of 10 seconds or less, etc).

- The CRAFT team should work to improve immediately the latency and reliability of the current communications infrastructure (e.g., by replacing 56K phone lines with higher bandwidth connections that may include reliable DSL lines or cable service).

- The CRAFT team should work to improve immediately data quality of service (e.g., solve the LDM-to-BDDS reconnection problems).

- The value of real time Level II data to the private and academic sectors needs to be quantified, especially with regard to economics and public benefit. Specific examples of use and benefit should be provided.

- The value of digital Level II data ingest at the NCDC needs to be quantified.

- Efforts should be undertaken immediately to reduce the communication circuit charges for the 10 Southern Plains CRAFT radars.

- Results from the workshop should be conveyed as soon as possible to relevant stakeholders, especially NOAA/NWS, NOAA/OAR, NSF, UCAR/Unidata Committees, NOAA/NESDIS, DoD, and FAA.

- The NWS, DoD, and DoT (i.e., the NEXRAD tri agencies) should agree to leave in place the present CRAFT data collection infrastructure

- In the short term (next 18 months), the private, academic, and government sectors should establish a mechanism to continue supporting the current CRAFT infrastructure and perhaps expand it, as appropriate, with a view toward longer-term capabilities (see below).

- The NWS and other government agencies that benefit from the present CRAFT infrastructure (e.g., NCDC, DoD, NSF) should be asked to provide financial support until a more permanent infrastructure is established (see below). Such support seems justified given the dramatically improved reliability of archival at the NCDC (greater than 95% via the direct digital CRAFT feeds), reduction in hardware maintenance and data handling costs, and savings associated with the suspension of 8 mm recording at all CRAFT sites.

- In light of the possible expansion of the NEXRAD data stream owing to new volume coverage patterns, polarization diversity, and increased range and azimuthal resolution, and other factors (Table 2.1), any data delivery system emplaced must have the capacity to grow

Table 2.1. Possible WSR-88D Data Requirements for the Future

New Requirement	Factor of Data Flow Increase (Relative to August 2002)	Possible Implementation Date	Cumulative Factor of Data Flow Increase (Relative to August 2002)	Maximum Bandwidth Required Per Radar (Kbits/sec) With Compression
4.1 min VCP (Gamma)	1.24	March 2004	1.24	79
TCP/IP Wideband Interface (Message Header)	1	July 2004	1.24	79
0.25 km Radial Resolution Reflectivity Data	1.56	October 2004	1.93	124
0.5 Degree Azimuth Resolution Sampling	2	January 2005	3.86	247
Doppler Data to End of 2nd Trip	1.49	October 2005	5.76	369
Two Different Clutter Filters and SNR Thresholds	1.97	January 2005	11.35	726
Dual Polarization, Four New Polarimetric Moments (Differential Reflectivity, Correlation Coefficient, Differential Propagation Phase Shift, and Specific Differential)	2.32	January 2008	26.35	1686

- In order to create a two-component system for the long term (beyond the next 18 months), in which the NWS collects and manages Level II for its use – and also makes these same data available quickly for subsequent distribution within the non-government sectors, the NWS should provide and support the technology to split the Level II data stream as early as possible in the communication process (Figure 1), with the view that

- The private sector will develop and pay for its own distribution system

- The private sector system will be created in partnership and synergistically with the NWS (e.g., so that each can serve as a back up to the other)

- The private sector system could be created in collaboration with the academic community

- The "super site" strategy shown in Figure 1 provides considerable flexibility while isolating the responsibilities and modes of data transport among the government, private and academic sectors. In particular, it allows for an arbitrary number of "super sites", chosen perhaps via a competitive process among UCAR/Internet2 institutions and involving the degree of external and cost sharing support made available. Such a strategy, combined with the advantages of the "super sites" being closer to the radars, would drive the total costs down. Although the number of "super sites" would need to be based upon a number of factors, the cost scenarios presented in section 3 explore options for one to three such sites.

The costs, advantages and disadvantages of the issues listed above have been evaluated and are presented in section 3 below (see also the second Workshop presentation by K. Droegemeier at http://kkd.ou.edu/craft.htm).

3. Next Steps

Three principal and related activities need to be undertaken immediately. *Note that in all cases, final approval rests with the NEXRAD tri agencies*.

- Development and implementation of a plan for making real time Level II data available for formal operational use by the government, principally NOAA/NWS (timeframe of 18+ months);
- Development and implementation of a plan for making real time Level II data available for formal operational use by the private sector, and for meeting the research and educational needs of the academic community (timeframe of 18+ months);
- Development and implementation of a plan for maintaining and expanding/improving the current CRAFT infrastructure to meet *short-term* (from the present to 18+ months) needs for Level II data. This effort would be undertaken as a pathway toward implementing the fully operational systems described in the preceding two bullets, e.g., testing the concept of a single (Scenarios #1 and #2) versus multiple (Scenarios #3 and #4) super sites.

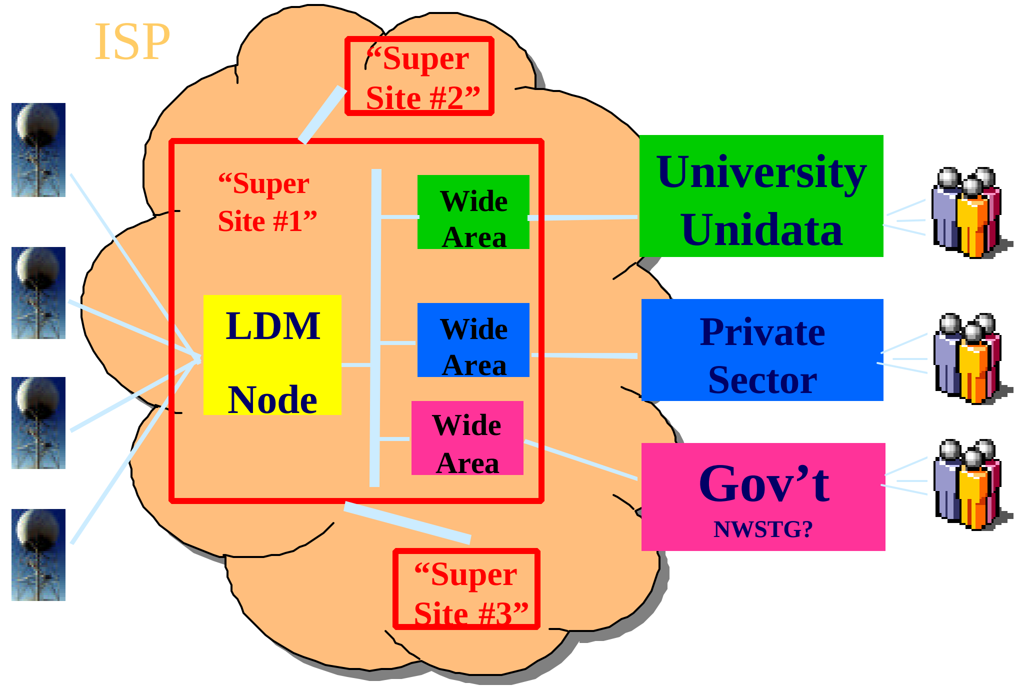

Figure 1. Schematic of a WSR-88D real time Level II data distribution system that makes use of the Internet and Abilene. Communication lines (perhaps more than one, managed by an Internet service provider, or ISP) from each radar feed a nearby LDM ingest node (connected to Internet2 or the Internet2 infrastructure and its Abilene backbone, perhaps at a university meteorology department or NOAA Cooperative Institute), connected to which is a series of links that transmit the data over separate wide area networks to the academic, private sector, and government user communities. The splitting of the data at a so-called "super site," which resides within the Internet cloud, would provide a framework for meeting all user needs while allowing the non-government sectors to develop their own data infrastructures once the splitting occurs. Multiple super sites, located on the Abilene network, would provide redundancy and improve overall quality of service.

a. Cost Scenarios for the Continued Operation and Possible Expansion of CRAFT to Meet Short-Term Needs (next 18 months)

Unanimous agreement was voiced at the workshop regarding the continued operation of the present CRAFT infrastructure (58 radars) and its possible expansion (improvements in performance were noted above). Six financial/technical scenarios, developed by CAPS and presented at the workshop, follow. In some cases (e.g., Scenarios 4 and 5), the possible courses of action represent minor variations on or additions to strategies now being considered by the NWS. They are presented in order of increasing cost and capability and summarized in the table at the bottom of page 9.

- Scenario #1: Maintain Current System of 58 Radars With OU as the Single Ingest Node. **Estimated Cost of $330,000/year.** *[Note that all summary cost estimates include fringe benefits and indirect costs, the latter charged at the on-campus rate of 46%. Indirect costs for the consortium model, described below, would be only 26%.]*
    - Assumptions
        - Line charges paid by the same groups as now (total leveraging of ~$360,000 per year)
            - 6 NOAA Sea Grant sites ($31,000/year)
            - 6 SRP sites ($72,000/year)
            - 21 Lincoln Lab sites ($200,000/year)
            - 4 Florida sites ($5,000/year)
            - 11 Other sites (FSL, NASA, GTRI, SLC, RAP, SEA; assume total cost of approximately $50,000/year)
        - Funded still would be required for the 10 Southern Plains sites ($80,000/year, which includes 2 military radars)
        - No 7x24 service; some improvements in QoS owing to conversion of Southern Plains sites to higher speed lines
        - Maintain current staff levels (1.0 FTE project technical manager and 0.5 FTE computer system manager)
        - $20,000/year for hardware replacement
        - $10,000/year in travel to replace/maintain/install new equipment
        - $1,000/year for supplies
        - Financial and administrative personnel (1 month each)
    - Yearly cost of $330,000 (assuming reduction in line charges for Southern Plains radars)
    - Advantages
        - No additional hardware costs (above replacement)
        - Continue using a reasonably reliable system, with some improvements to be made, as noted above
        - Leverages ~$360,000/year from other groups who pay their own line charges (see above)
        - Replacement of 56K lines in great Plains should reduce latency problems
    - Disadvantages
        - Not all NWS radars are included (only 56 NWS + 2 military)
        - Continue with a heterogeneous communications infrastructure (56K lines, DSL, direct T1, cable modem, direct NWS LAN)
        - Relies on existing groups to continue paying their local line charges
        - Little increase in QoS and no 7x24 support
        - Single ingest system at OU provides no redundancy
        - No clear pathway for dealing with anticipated increases in data volume (e.g., new VCPs, new azimuth and range resolutions).

- Scenario #2: Same as Scenario #1, But Add the Remaining 64 NWS Radars. **Estimated cost of $1.3M for first year and $900,000/year thereafter.**
    - Assumptions *beyond* those of Scenario #1
        - Add new technical staff at CAPS ($40,000/year) for QoS and assistance with managing larger network
        - $100,000 in one-time costs for LDM PCs
        - $200,000 in one-time router and communication line installation costs
        - $50,000 in travel to install new LDM PCs
        - $5,000 for supplies
        - $50,000 in hardware (hot spare) replacement costs
        - half the new lines are assumed to cost the average of the current Southern Plains lines, with the remainder at $50/month based upon costs of DSL and cable modem.
    - First year cost of $1.3M and cost thereafter of $900,000/year.
    - Advantages
        - Continue using a reasonably reliable system, with some improvements to be made, as noted above
        - Leverages ~$360,000/year from other groups who pay their own line charges (see above)
        - Replacement of 56K lines in great Plains should reduce latency problems
        - All 120 NWS radars available
        - Improved QoS and 7x24 support via new hire at CAPS
    - Disadvantages
        - Continue with a heterogeneous communications infrastructure (56K lines, DSL, direct T1, cable modem, direct NWS LAN)
        - Relies on existing groups to continue paying their local line charges
        - Single ingest system at OU provides no redundancy
        - No clear pathway for dealing with anticipated increases in data volume (e.g., new VCPs, new azimuth and range resolutions).

- Scenario #3: Same as Scenario #2, But Add UCAR as the Second Abilene Ingest Node. **Estimated cost of $1.5M for first year and $1.0M/year thereafter.**
    - Assumptions *beyond* those of Scenario #2
        - $100,000 in computer hardware at Unidata during first year
        - One new full-time Unidata technical staff member
        - UCAR would not provide 7x24 support of its node
    - First year cost of $1.5M and cost thereafter of $1.0M/year.
    - Advantages
        - Continue using a reasonably reliable system, with some improvements to be made, as noted above
        - Leverages ~$360,000/year from other groups who pay their own line charges (see above)

        - Replacement of 56K lines in great Plains should reduce latency problems
        - All 120 NWS radars available
        - Improved QoS and 7x24 support via new hire at CAPS
        - Greatly improved redundancy via the addition of a second Abilene node
    - Disadvantages
        - Continue with a heterogeneous communications infrastructure (56K lines, DSL, direct T1, cable modem, direct NWS LAN)
        - Relies on existing groups to continue paying their local line charges
        - No clear pathway for dealing with anticipated increases in data volume (e.g., new VCPs, new azimuth and range resolutions).
    - NOTE: Could consider adding Lincoln Laboratory as third Abilene node with an assumed additional cost of $200K the first year and $100K/year thereafter.

- <u>Scenario #4</u>: Same as Scenario #3, But With a National Telecommunications Carrier Providing Uniform Delivery Service to the Additional 64 NWS Radars ONLY. **Estimated cost of $1.6M for first year and $1.2M/year thereafter.**
    - Assumptions *beyond* those of Scenario #3
    - First year cost of $1.6M and cost thereafter of $1.2M/year.
    - Advantages
        - Continue using a reasonably reliable system, with some improvements to be made, as noted above
        - Leverages ~$360,000/year from other groups who pay their own line charges (see above)
        - Replacement of 56K lines in great Plains should reduce latency problems
        - All 120 NWS radars available
        - Improved QoS and 7x24 support via new hire at CAPS
        - Greatly improved redundancy via the addition of a second Abilene node
        - Uniform networking for 64 radars
        - Higher QoS (or Service Level Agreement) for the 64 radars
        - Upgrade to higher bandwidth for the 64 radars more easily and directly accomplished by the single telecommunications provide
    - Disadvantages
        - Continue with a heterogeneous communications infrastructure for the current 58 radars (56K lines, DSL, direct T1, cable modem, direct NWS LAN)
        - Relies on existing groups to continue paying their local line charges
        - No clear pathway for dealing with anticipated increases in data volume (e.g., new VCPs, new azimuth and range resolutions) for the current 58 radars.

- Scenario #5: Same as Scenario #4, But With a National Telecommunications Carrier Providing Uniform Delivery Service to ALL Radars. **Estimated cost of $2.0M for first year and $1.5M/year thereafter.**
  - Assumptions *beyond* those of Scenario #3
  - First year cost of $2.0M and cost thereafter of $1.5M/year.
  - Advantages
    - Continue using a reasonably reliable system, with some improvements to be made, as noted above
    - Leverages ~$360,000/year from other groups who pay their own line charges (see above)
    - Replacement of 56K lines in great Plains should reduce latency problems
    - All 120 NWS radars available
    - Improved QoS and 7x24 support via new hire at CAPS
    - Greatly improved redundancy via the addition of a second Abilene node
    - Uniform networking for all radars
    - Higher QoS for the all radars
    - Upgrade to higher bandwidth for the all radars more easily and directly accomplished by the single telecommunications provide
  - Disadvantages

Scenario #6: Use NWS Centralized Distribution System (e.g., AWIPS communications infrastructure)

- Disadvantages
  - Latencies feared to be too large owing to simultaneous access by a virtually unlimited number of users
  - Single point of failure at NWS Telecommunications Gateway

Scenario	No. Radars	Ingest Nodes	Comm Infrastructure	Quality of Service	Yearly Cost
1	58	OU	Heterogeneous	Low	$330,000
2	122	OU	Heterogeneous	Med	$1.3M (year-1) $0.9M (year-2+)
3	122	OU & NCAR*	Heterogeneous	High	$1.5M (year-1) $1.0M (year-2+)
4	122	OU & NCAR*	Uniform Commercial Provider	High	$1.6M (year-1) $1.2M (year-2+)
5	122	OU & NCAR*	Uniform Commercial Provider	High	$2.0M (year-1) $1.5M (year-2+)
6	122	OU & NCAR*	NWS	Unknown	Unknown

* Might be possible to add Lincoln Laboratory for approximately $200K first year and $100K thereafter.

b. <u>Possible Administrative Scenarios for the Continued Operation and Possible Expansion of CRAFT to Meet Short-Term Needs (next 18 months)</u>

At the present time, Project CRAFT is managed by Center for Analysis and Prediction of Storms at the University of Oklahoma, in collaboration with the NOAA National Severe Storms Laboratory, NOAA Radar Operations Center, and UCAR Unidata program. CRAFT has been funded since its inception in fall 1998 by a variety of research and development grants totaling $2.44M, the last $150K of which came directly from the private sector (see Table 3.1). These monies have been used to pay for telecommunication line charges, hardware (routers, LDM personal computers), computer and user support staff, and research ranging from network performance simulation to analysis of latencies and system reliability. Organizations presently receiving real time Level II data from CRAFT are shown in Table 3.2. (Note that this number intentionally has been kept low owing to the research orientation of the system and the limited number of personnel available to support users. Workshop participants are convinced that a broad dissemination system would attract hundreds of users, and this presumption is supported by the fact that, owing to its new system for automatically downloading *archived* Level II data directly from the HDSS mass store system, the NCDC now is disseminating more archived Level II data than any other data set – by a factor of 1.6! And the new dissemination system has been in place only for a few weeks!)

As much of the basic research and development associated with the CRAFT concept has been completed, research grant funding to support CRAFT no longer is a viable option. Furthermore, most funding for CRAFT ends in November, 2002 (apart from small private sector grants to provide quality of service statistics in a continuing evaluation of performance). Consequently, in light of the unanimous sentiment expressed at the workshop to continue providing Level II data from CRAFT, continuing funding needs to be identified and an appropriate administrative structure established for continuing operation.

Table 3.1. Funding for Project CRAFT from Inception (fall, 1998) to the Present

Funding Source	Amount	Period
Oklahoma State Regents for Higher Education	$210,000	1998-1999
NSF EPSCoR	$46,000	1999
NOAA/ROC	$156,000	1999-2002
NOAA/ESDIM	$540,000	2000-2002
NOAA	$474,000	2000-2001
NOAA/HPCC	$198,000	2001
NOAA/Sea Grant	$48,500	2001
NSF	$15,000	2001
Partner Match	$600,000	1998-Present
Private Sector Direct	$150,000	2001-Present
TOTAL	**$2,437,500**	

Table 3.2. Current Recipients of CRAFT Real Time Level II Data

Type of Organization	Number of Organizations/Entities
Academia + UCAR/NCAR	7
NOAA	5
Non-NOAA Government	2
Private Industry	6

Several possible administrative scenarios exist for the continued operation of CRAFT, and in creating the three that follow, we have assumed the following:

- The current management team (OU/CAPS, NSSL, ROC, Unidata) should continue to oversee the project
- The project should continue in its present collaborative format, where all participants (government, academia, industry) contribute for the good of the whole
- Data should continue to be made available to all sectors
- Data quality of service should be improved to the extent practicable
- Costs should be reduced as much as possible, e.g., through the installation of cheaper lines for the Southern Plains radars
- Academia should be at the center of CRAFT to effectuate the continued use of Abilene, and because the academic environment represents a particular administrative "neutral ground" where industry, government, and education can work together effectively

Note that the three scenarios presented below are *suggestions*, and that the CRAFT team welcomes input on them as well as recommendations for others. It is important to recognize, however, that *time is of the essence given that funding to operate the current CRAFT infrastructure ends soon*.

- Scenario A: Establish a formal CRAFT Consortium at the University of Oklahoma
    - Parameters
        - The consortium is managed by a board of members (per University rules) and deals only with the real time, Internet-based distribution of WSR-88D Level II data
        - At least 4 members are required to establish the consortium
        - The consortium does not "make money," but rather uses membership fees to pay for the provision of data
        - Members pay an up-front fee to join (these funds would be used for one-time costs, e.g., hardware for additional radars)
        - Members also are charged an appropriate fraction of the costs associated with the actual provision of real time Level II data
        - The membership system is tiered

        - "Partners" pay at a higher level and are allowed to sell the data and products created from them
        - "Affiliates" pay at a lower level and can use the data to create and sell products, but cannot sell the data themselves
        - Non-members are not part of the consortium and must purchase the data from Partners
    - Government organizations (e.g., NOAA, DoD entities) would provide funding as well and automatically become "Partner" members, with the caveat that they can distribute the data only within the government community
    - The academic community, presumably through NSF funding to the consortium or to CAPS directly, would receive the data free of charge, with the caveat that they can distribute the data only within the academic community
    - *NEXRAD Tri-Agency approval will be required*
    - By University rules, the consortium funding in hand must be +/- 5% of the actual costs associated with data distribution. If the funding in hand exceeds 5%, it is refunded to the members.
    - Members will be allowed to leave the consortium per University rules
    - Any enhancements to the CRAFT infrastructure (e.g., addition of radars) should be congruent with longer-term plans to establish a more "permanent" data dissemination infrastructure (see below)
- Advantages of the consortium model
    - Provides a well-known administrative framework for supporting financially the real time distribution of Level II data
    - Use of the off-campus indirect cost rate (26% versus the standard 46%), thus greatly reducing costs
    - Operates in a non-profit mode, thus maximizing the value of contributor funds
    - Represents a true partnership in which academia, industry, and government work together in the traditional spirit of CRAFT
    - Maintains continuity by using the present CRAFT infrastructure
    - Maintains use of the Abilene network backbone and provides great flexibility and opportunity for future enhancements (e.g., via continued involvement of the original CRAFT team)
    - Quality of service is limited principally by the degree to which users are willing to pay for an increasingly reliable and robust infrastructure.
    - Costs would be reasonable for all members if the consortium were sufficiently large, and if government agencies contributed given that they are major beneficiaries of real time Level II data. For example, to continue the present network, suppose NOAA, NSF, FAA and DOD each paid $50,000. This would leave $130,000 to be split among perhaps 10 private companies.

        - None of the participants would be "buying" Level II data, but rather paying for the infrastructure needed to make it available via the Internet
    - Disadvantages of the consortium model
        - A possible disadvantage is that it establishes a "cost for data" modality reminiscent of the NIDS agreement. However, such arrangements are not inherently "unattractive" if those requiring the data are willing to pay for the infrastructure needed to acquire and deliver it. The bottom line is that someone needs to fund the infrastructure if the data are to be made available.

- <u>Scenario B</u>: Establish a Non-Profit 501(c)3 Company to Perform the Same Functions Described Above
    - Without going into detail, this option would require considerably more work to establish than a consortium. If this company were located at an Internet2 institution, it could have access to Abilene without paying additional membership fees.

- <u>Scenario C</u>: An Existing Private Company May Wish to Assume Responsibility for Collecting and Distributing Real Time Level II Data
    - This seems like a long shot (i.e., risks and benefits are unknown in the presently fluid situation) but is included for completeness. As in Scenario B, a disadvantage is the cost to join the Internet2/Abilene consortium.

c. <u>Meeting Needs for the Long Term</u>

Meeting the longer-term needs of the private and academic sectors, possibly in the manner illustrated in Figure 1, will take considerable planning and coordination, as well as close interaction with and *approval from the NEXRAD tri agencies*. The chosen system will have to be engineered, implemented, managed, and supported financially for the long haul, and provide the degree of reliability required by the stakeholders. Given the complexities involved, it seems appropriate to establish a relatively small steering committee, representing all relevant groups, which will develop technical and administrative frameworks and communicate regularly with all stakeholders. The proposed membership is:

- Kelvin Droegemeier, University of Oklahoma
- Ray Ban, The Weather Channel
- Michael Kleist, WSI
- Michael Smith, WeatherData
- Ben Domenico, UCAR Unidata Program
- Greg Wilson, Baron Services
- Tim Crum, NEXRAD Radar Operations Center
- Kevin Kelleher, NOAA National Severe Storms Laboratory
- Guy Almes, Abilene/Internet2
- Jean Vieux, Vieux and Associates, Inc.
- David Helms, NOAA/NWS Office of Science and Technology