VT CORS (VECTOR) Benefits

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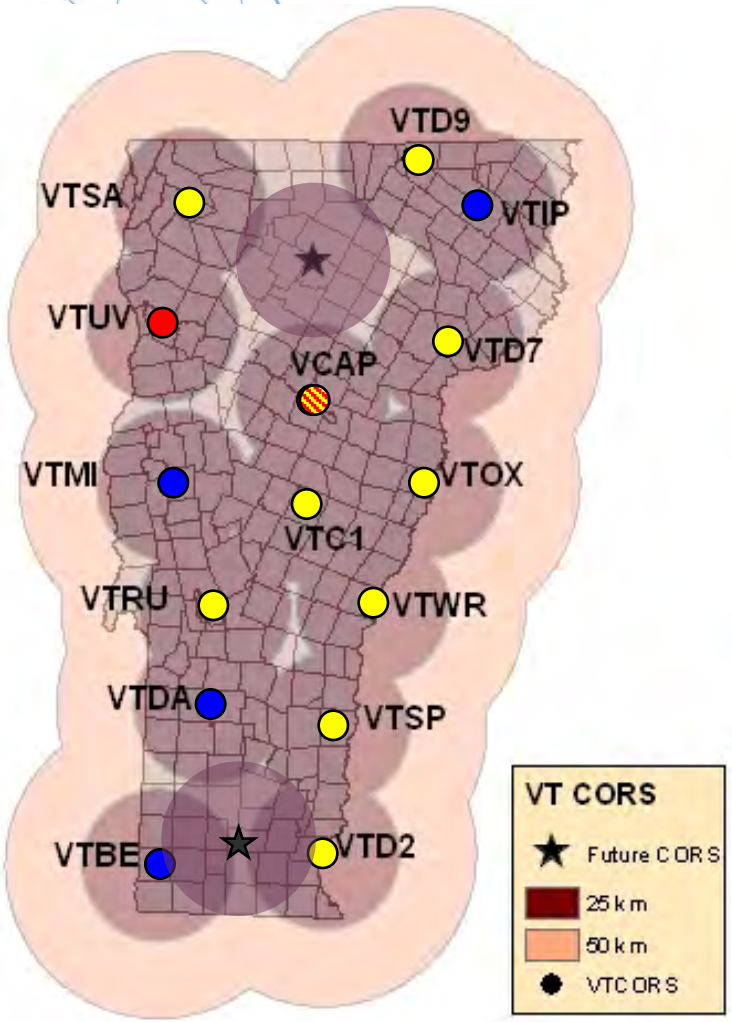
What is VECTOR??

- Network of Continuously Operating GNSS Reference Stations.
- Provides access to the National Spatial Reference System (NSRS)
- Access available for post processing (Static) and Real-time.

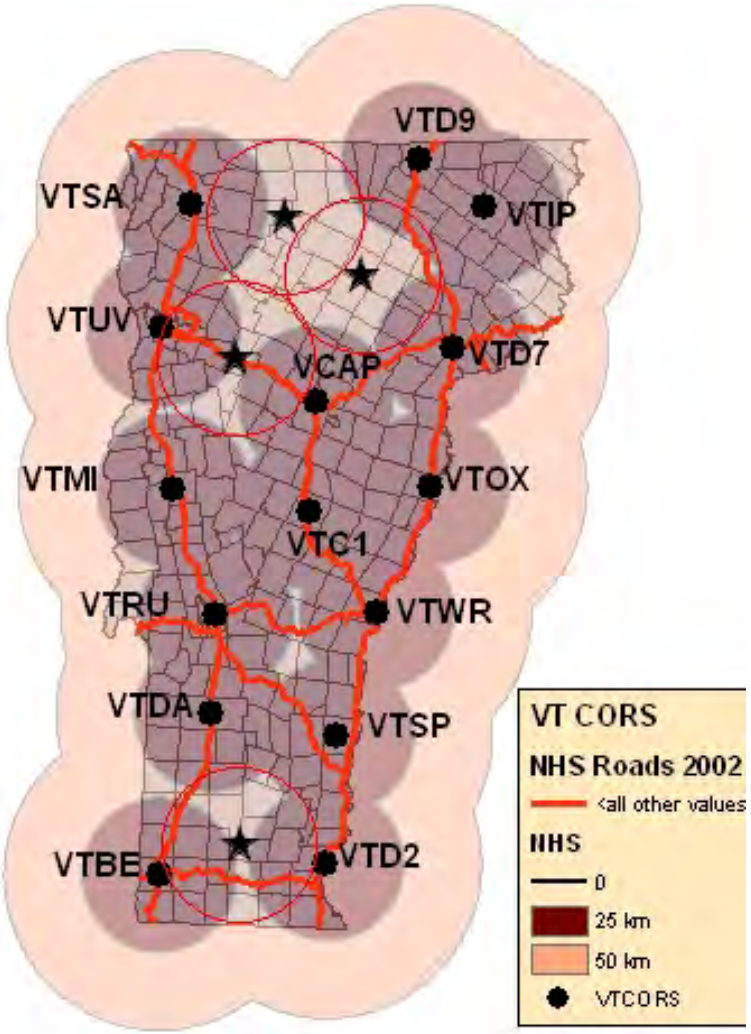
VECTOR Expansion



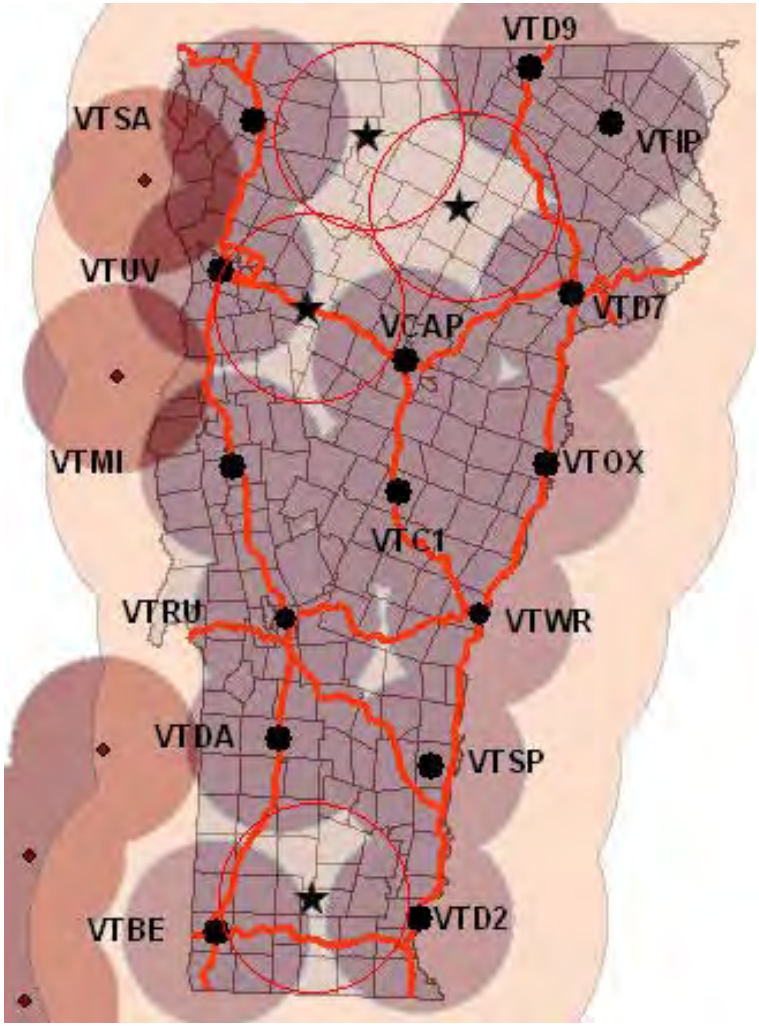
- 1996 - VCAP
- 2004 - VTUV
- 2006 – VTD2, VTSP, VTWR, VTOX, VTD7, VTD9, VTC1, VTSA, VTRU, (VCAP Upgrade)
- 2008 – VTBE, VTDA, VTMI, VTIP

- Minimum of 1 station needed to fill out network (Eden), ideally another (Dover, Stratton, Jamaica, or Wardsboro)

Option 2 for Network Build out

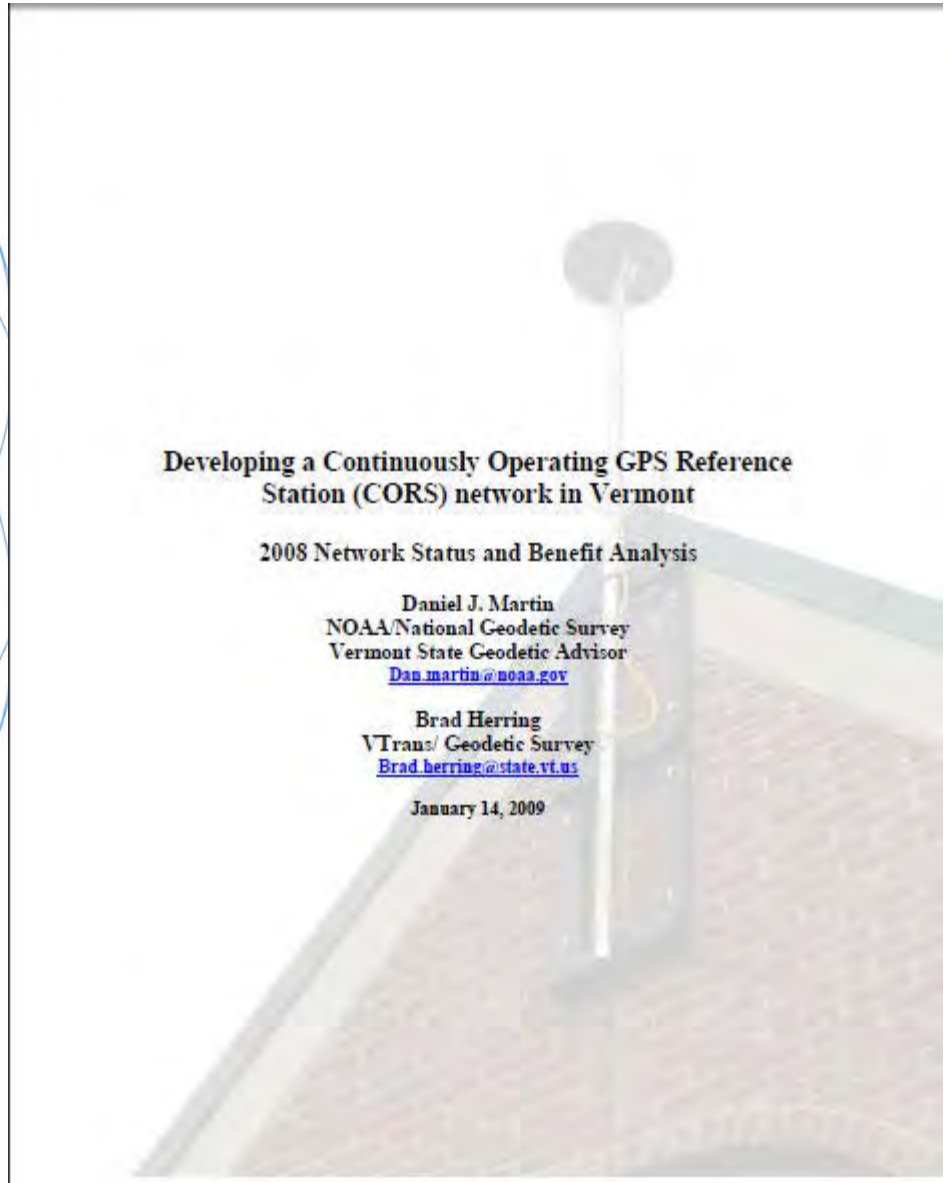


Option 2 for Network Build out



So What??

- What is the benefit to having these station out there?
  - Are they being used?
  - How are they being used?
  - Who is using them?
  - How are they being accessed?
  - How much are they being accessed?



Developing a Continuously Operating GPS Reference Station (CORS) network in Vermont

2008 Network Status and Benefit Analysis

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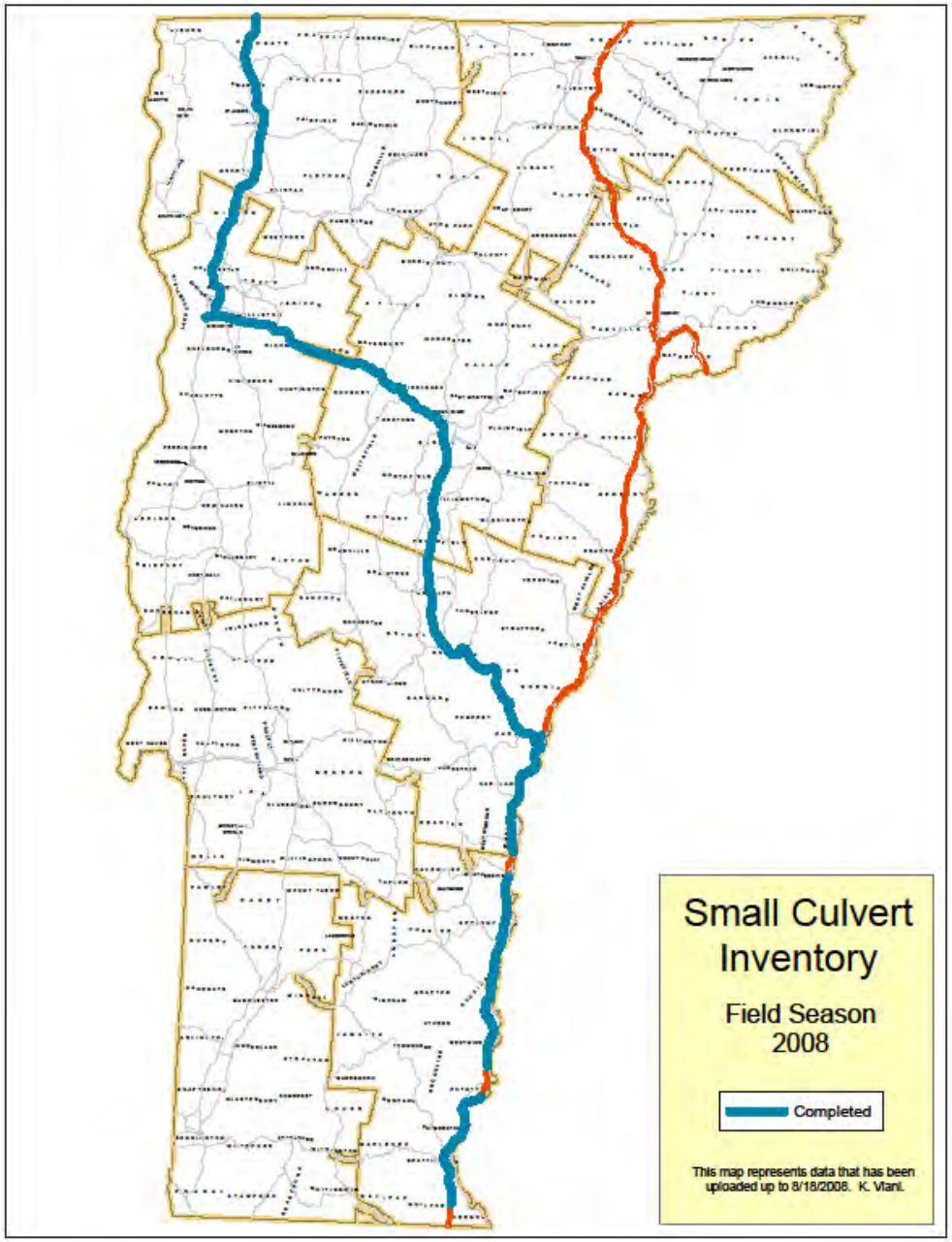
How are they being used?

- Highway Surveys
- Collection of inventory and resource data
  - Culvert inventory, Rest Area re-design, and ITS elements such as RWIS, PCMS/VMS, and WIMS location and planning
- Control surveys for photography and LiDAR
- Topo
- Boundary
- Flood Plane mapping
- Wetland Surveys
- Construction stakeout
- Geodetic and Geophysical applications
  - Ionospheric modeling
  - Plate tectonics
  - Precipitable Water Vapor modeling (weather forecasting

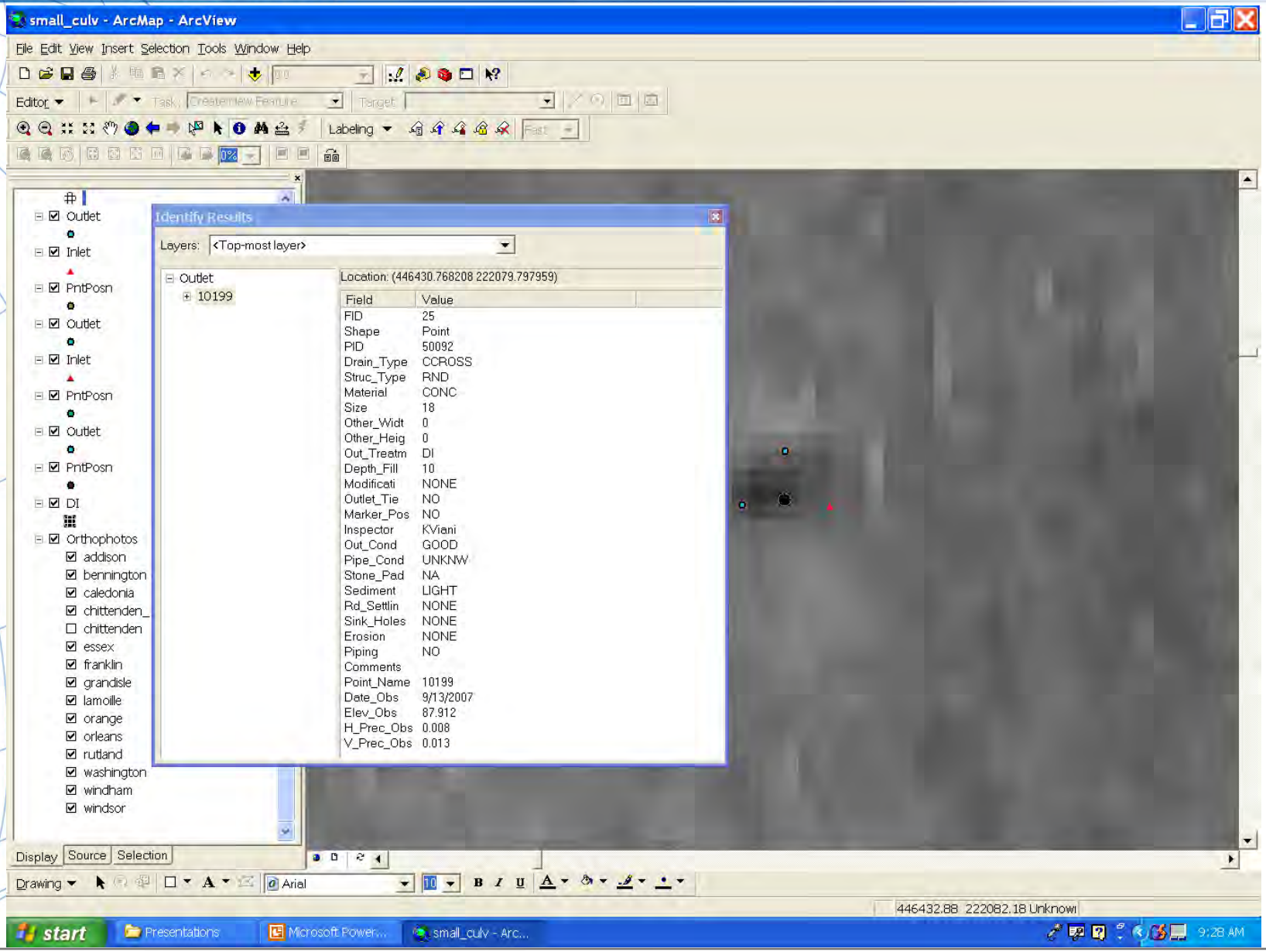
QA/QC for LiDAR (Real-time)

Interstate Small Culvert Inventory 2007-2008

- I89
  - ≈4000 Culverts
  - ≈2800 DI's
  - ≈10,800 Total Shots
- I91 (first 95 miles)
  - ≈2700 Culverts
  - ???? DI's
  - ≈5400 Total Shots+DI's
- 59 crew weeks
  - ≈ $60k savings



I89 Small Culvert Inventory


small_culv - ArcMap - ArcView
File Edit View Insert Selection Tools Window Help
Editor
Labeling
Identify Results
Layers: <Top-most layer>
Outlet
10199
Location: (446430.768208 222079.797959)
Field Value
FID 25
Shape Point
PID 50092
Drain_Type CCROSS
Struc_Type RND
Material CONC
Size 18
Other_Widt 0
Other_Heig 0
Out_Treatm DI
Depth_Fill 10
Modificati NONE
Outlet_Tie NO
Marker_Pos NO
Inspector KViani
Out_Cond GOOD
Pipe_Cond UNKNW
Stone_Pad NA
Sediment LIGHT
Rd_Settlin NONE
Sink_Holes NONE
Erosion NONE
Piping NO
Comments
Point_Name 10199
Date_Obs 9/13/2007
Elev_Obs 87.912
H_Prec_Obs 0.008
V_Prec_Obs 0.013
Outlet
Inlet
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start
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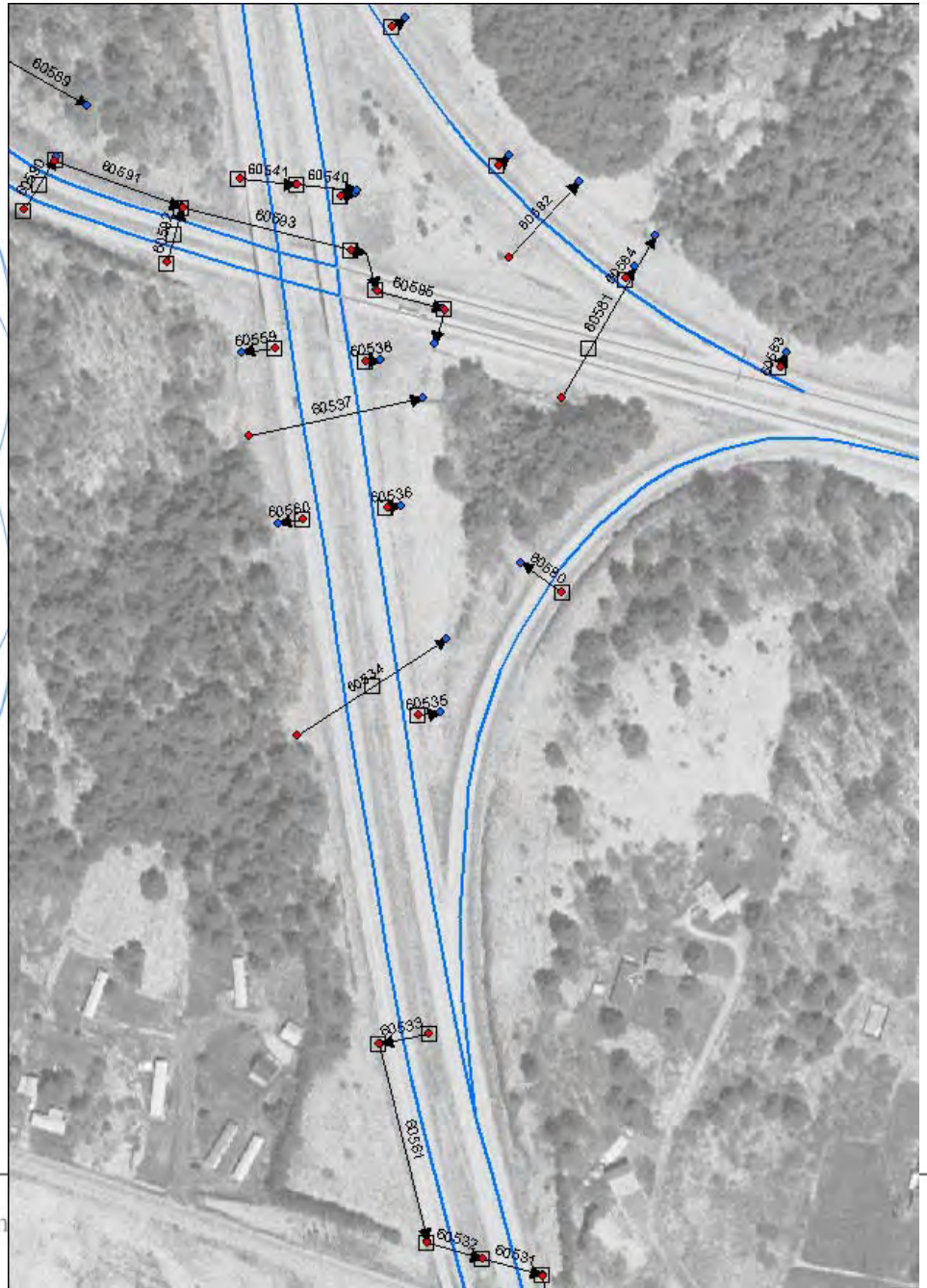
60589
60591
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60582
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60581
60539

Who is using them

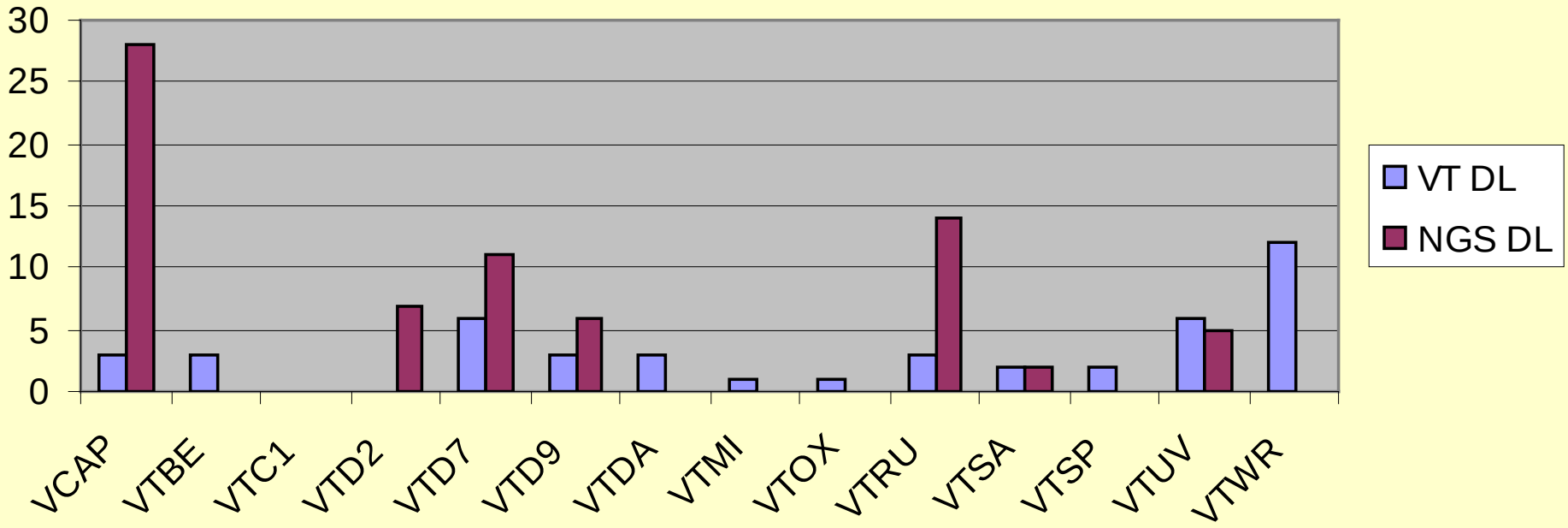
- VTrans
- Land Surveyors
- Engineering firms
- GIS Professionals
- Foresters
- Other State Agencies Such as Agency of Natural Resources and Department of Agriculture
- Other non-VT State Agencies

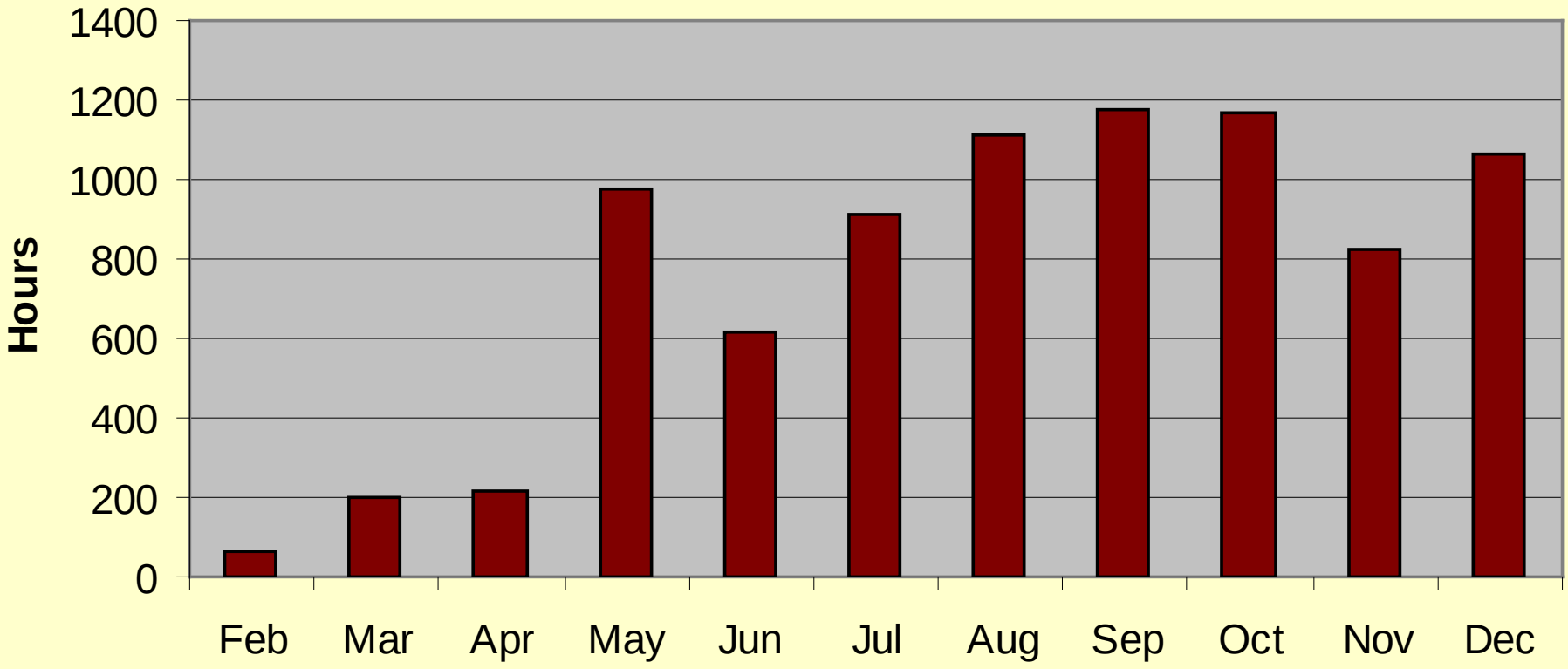
- Federal and International Agencies and educational institutions
  - National Weather Service
  - National Geodetic Survey
  - US Geological Survey
  - Geodetic Survey Canada
  - International GNSS Service
  - UVM, UNH, UMaine, Lyndon and Johnson State, Norwich University

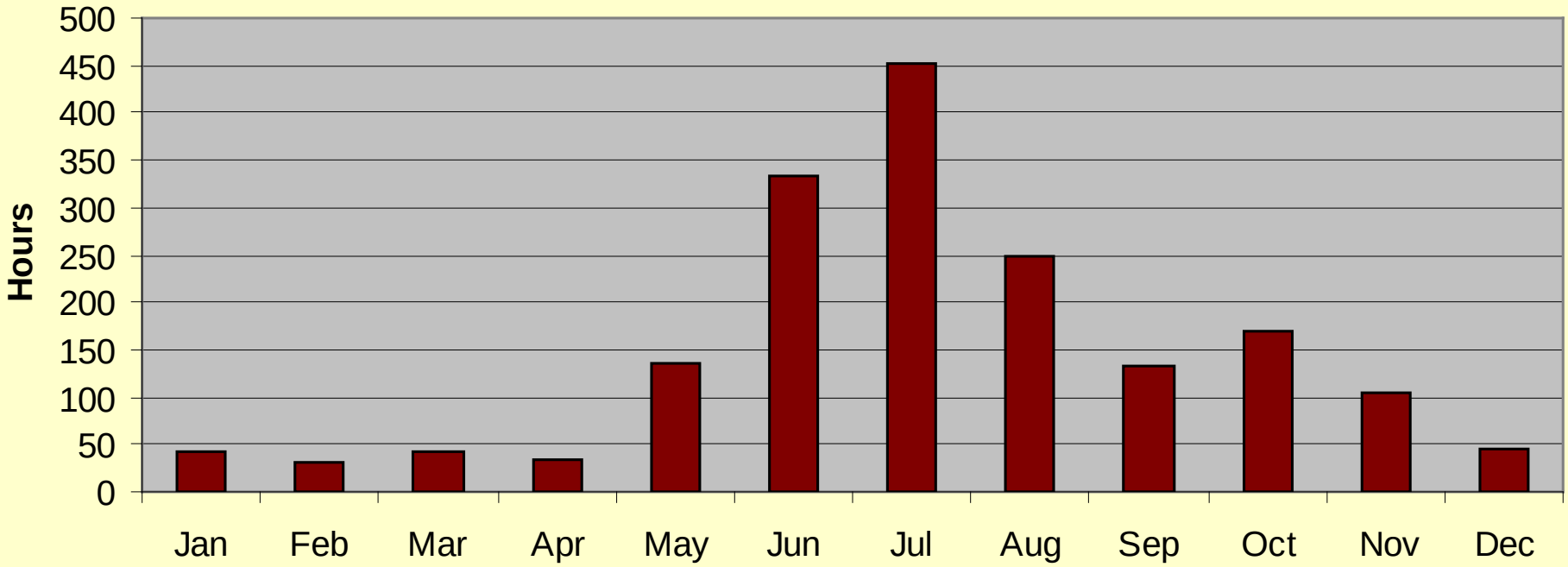
How are the VT CORS being Accessed?

- Raw Data (post processing)
  - VTGS Web
  - VTGS FTP
  - NGS Web (UFCORS)
- Derived Products
  - OPUS_S
  - OPUS_RS
  - OPUS_DB
  - RTK Corrections
- Incorporated into other networks (NY, Keynet, MTS)

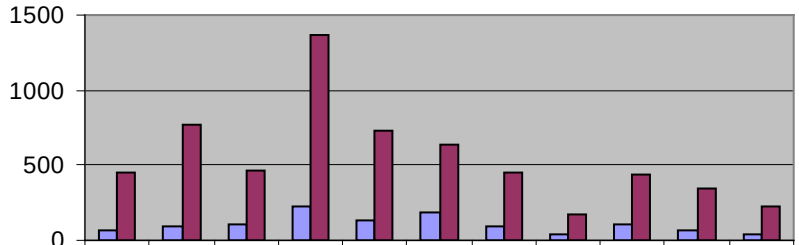
CORS Downloads Via Web Page
December 2008
118 total download sessions (222 VT Files)




FTP Downloads in 2008
Hours
1400
1200
1000
800
600
400
200
0
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

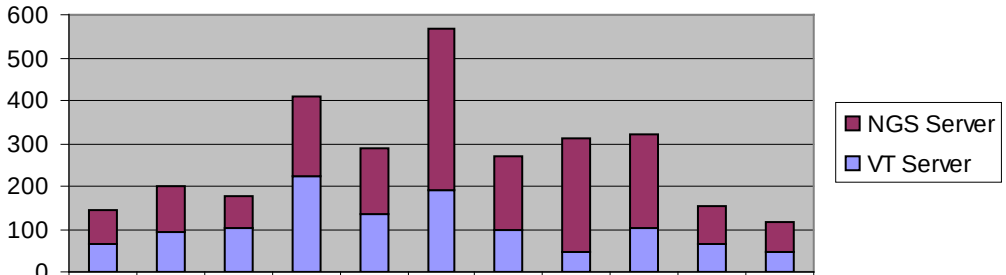

Real Time Use in 2008
Hours
500
450
400
350
300
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Vermont CORS DL Activity in 2008 (VT Server)

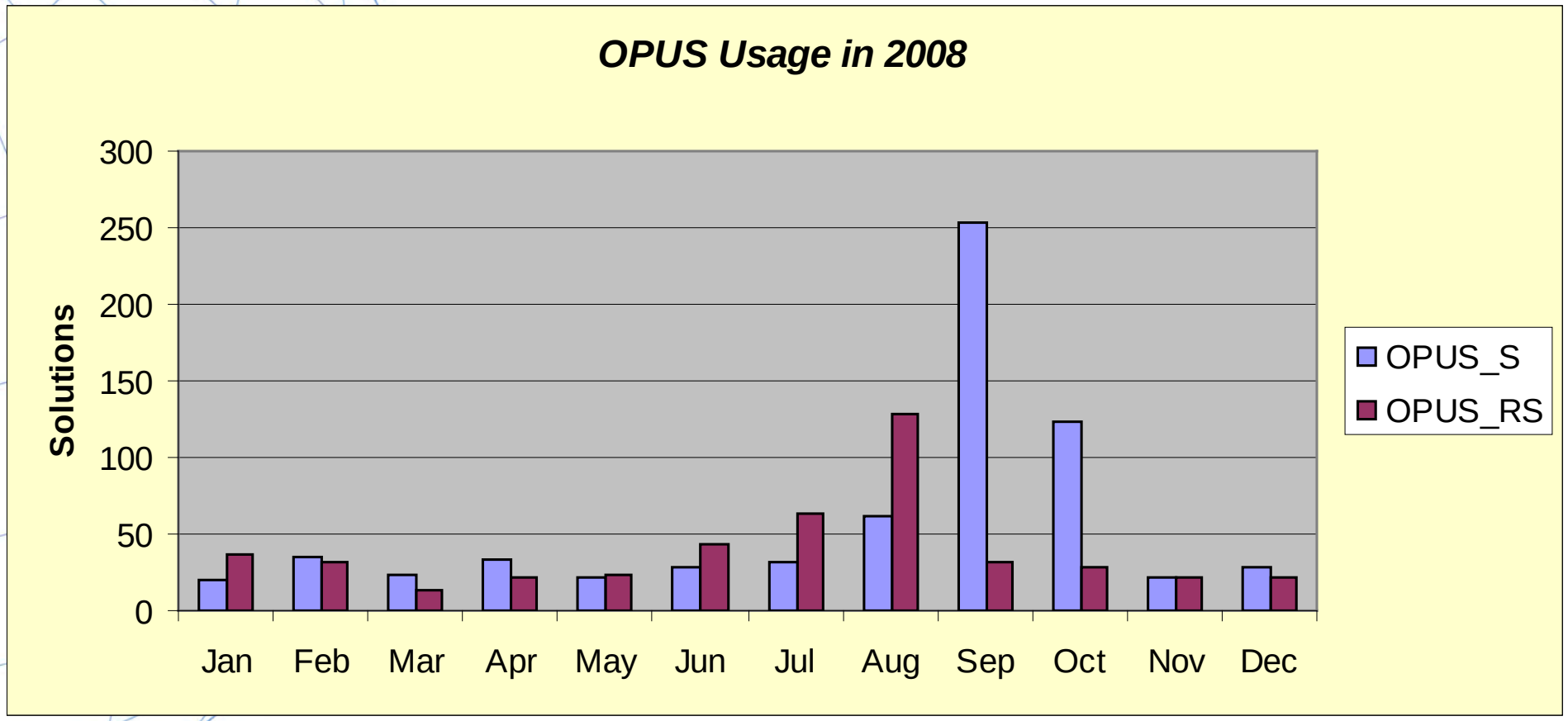


	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
DL Sessions	66	91	102	221	136	191	98	46	103	66	45
Files DL	449	770	468	1364	728	632	450	175	443	350	222

Total Monthly Download Sessions in 2008 (VT & NGS)



	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
NGS Server	79	108	77	189	154	377	170	267	218	86	73
VT Server	66	91	102	221	136	191	98	46	103	66	45


OPUS Usage in 2008
Solutions
300
250
200
150
100
50
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
OPUS_S
OPUS_RS

COST/Benefit of VT CORS (Initial Investment)

- Initial system investment into the VT CORS Network which was made to support the fiber optic project on the VT Interstates ≈ $340,000
  - 9 receivers and antennas
  - system software,
  - Installation
  - required field equipment needed to make use of the system (4 rovers)

Benefit

- Easy to quantify (included in report)
  - Reduction in person hours to accomplish a task
  - Reduction in purchased equipment to accomplish a task
  - Reduction in purchased software
- Difficult to quantify (not included in report)
  - Reduced training (multiple types of equipment)
  - Reduced maintenance (multiple types of equipment)
  - Consistency and reliability of a system

Some generalities need to be made

- One CORS replaces one receiver and operator
- Without CORS network, one receiver and observer would need to spend an average of 2 hours to collect and download one hour of data (including travel)
- Average UFCORS download consists of 2 hours of data
- Cost of one observer and receiver is $50/hour
- Most VT FTP users are “Resource Grade” users who require less accuracy. Could operate without VT CORS but would be subjected to even lower accuracy. FTP data has half the $$ benefit of data retrieved from the web page

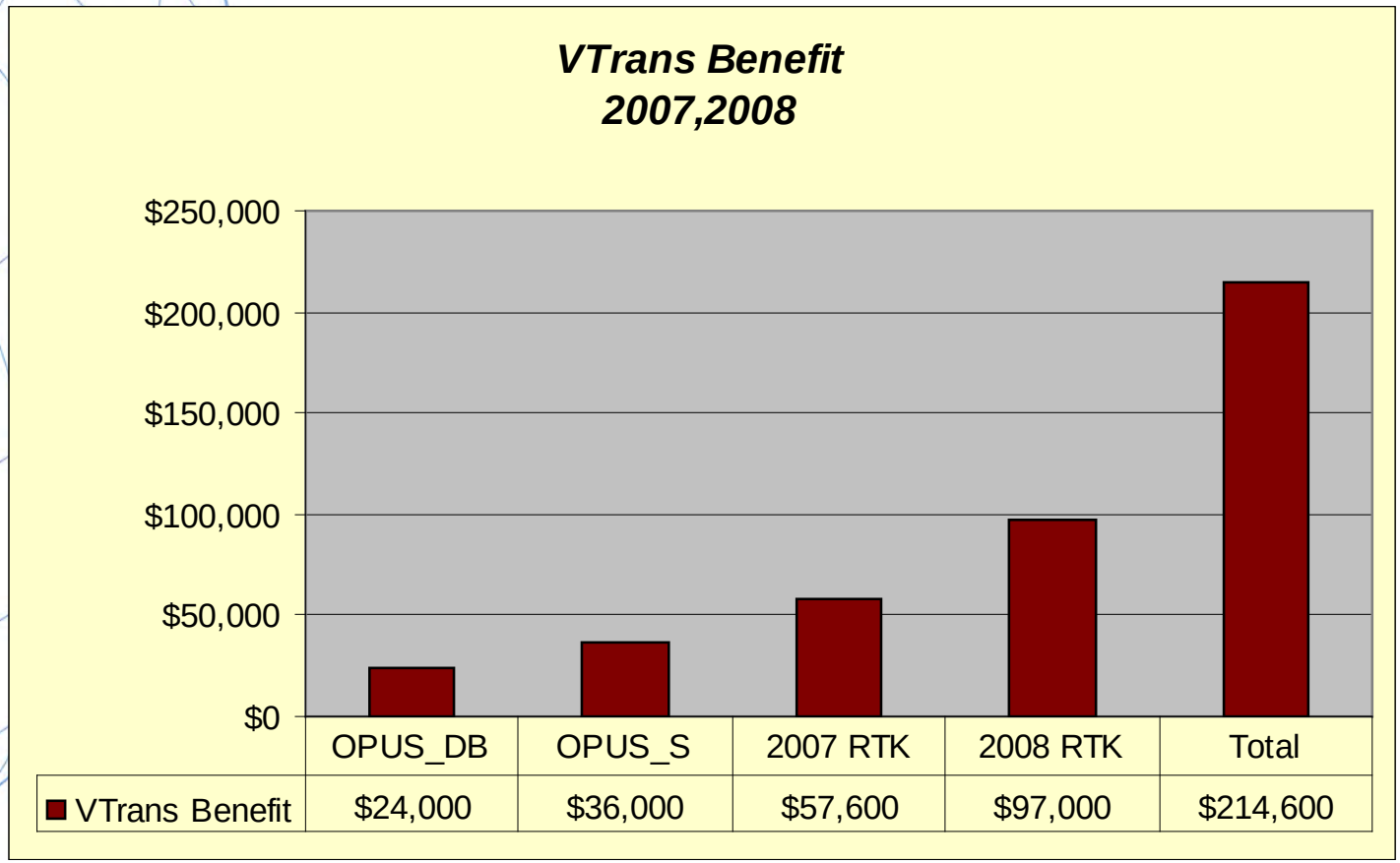
Benefit for VT CORS Products

Product	*User Benefit*
UFCORS	**$200/download**
VT Web Download (VTDL)	**$100/1-hour file**
VT FTP Download	**$50/1-hour file**
OPUS_S	**$600/solution**
OPUS_RS	**$600/solution**
OPUS_DB	**$400/submission**
RTK	**$100/hour**

Direct Benefit to VTrans (work on Interstate)

- RTK
  - 2007 use = 576 hours
  - 2008 use = 970 hours
- OPUS_S
  - 60 solutions in 2008
- OPUS-DB
  - 60 submissions in 2008

Direct Benefit to VTRANS



Direct Benefit to VTrans

- 2 year benefit (2007-2008) ≈ 63% of initial system investment
- If 2009 benefit is equal to 2008 then the three year benefit ≈ 99% of initial system investment (three year return on investment)

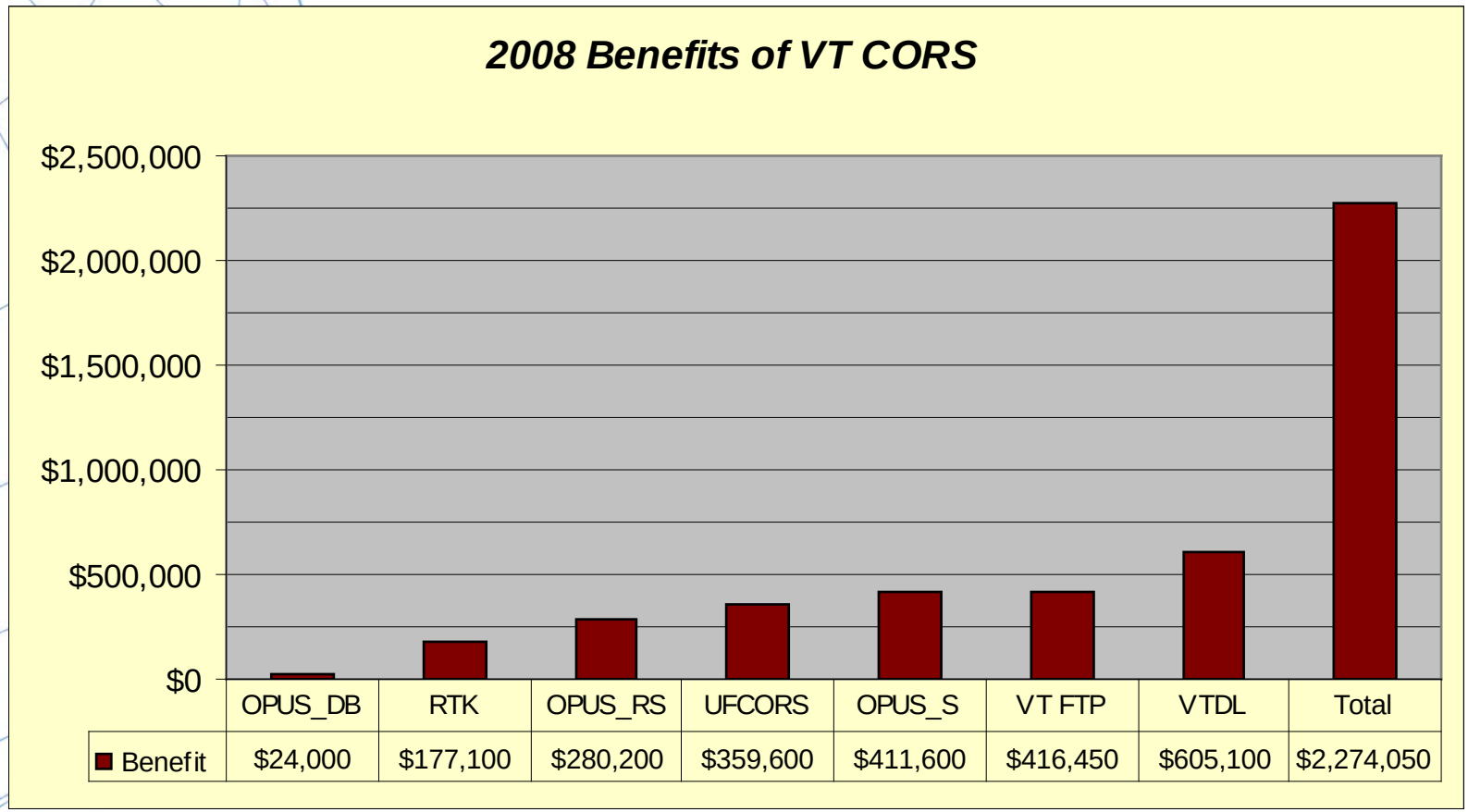
Cost / Benefit (Current level of investment)

- Current level of investment ≈ $481,400 which includes the initial investment ($340,000) plus $141,400 after year 1
  - 4 new CORS
  - Extended Warranty on firmware and software

Total Usage in 2008

Product	*2008 Usage*
UFCORS Downloads	1798 2-hr files (ave)
VT Web Download (VTDL)	6051 1-hr files
VT FTP Download	8329 1-hr files
OPUS_S	686 Solutions
OPUS_RS	467 Solutions
OPUS_DB	60 Submissions
RTK	1771 Hours

2008 Benefit to VT Taxpayers



Taxpayer Benefits

- Total system benefit ≈ 472% of current investment
- 2008 CORS not available until October of 2008, so it is fair to say that most of the 2008 benefit was derived from the initial level of system investment
- 2008 prorated benefit ≈ $1,900,000 = 559% of initial system investment.

Summary

- The VT CORS Network has provided significant benefit to VTrans and the taxpayers of VT
- It supports a wide variety of different applications from a diverse user community
- Anticipated three-year cost recovery based on VTrans usage only
- 2008 benefit realized by entire user community exceeds total investment by almost 500%

Recommendations

- Continue with expansion of network to provide state-wide coverage
- Work to get as many stations into the National Network as possible
- Work to increase the use of the network inside VTrans
- Continue to promote the network outside of VTrans