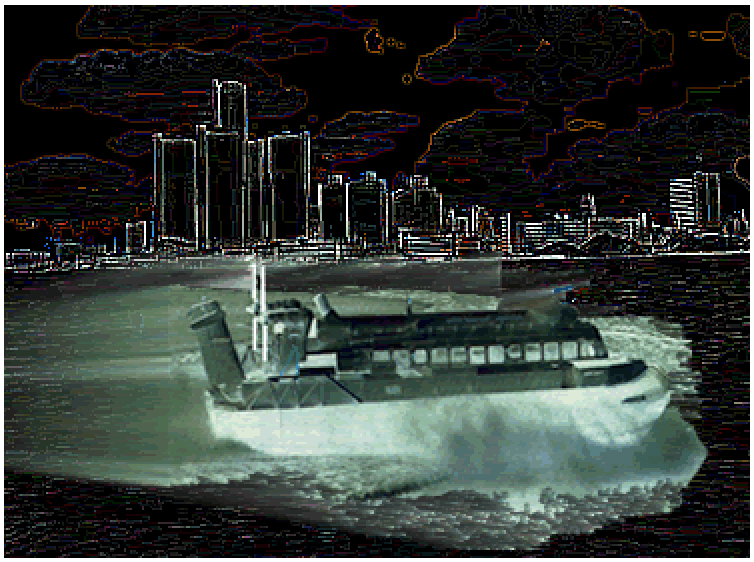
Investigation of Hovercraft Operation in Detroit Weather Conditions

Alan Hoback, Scott Anderson

MIOH-UTC Research Report



Dec. 31, 2007

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Table of Contents

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Abstract:

I-94 on the east side of Detroit will be rebuilt because of deterioration and congestion problems. Traffic congestion will be exacerbated by the rebuilding process, which will last three years. On I-75 between Toledo and Detroit, and on I-94 between Port Huron and Detroit, lane reductions due to reconstruction and maintenance have occurred for several days nearly every construction season in the last 10 years, leading to further congestion and frustration. Additionally, over the next decades the freeway system will become very congested. An alternative mode of travel using comparably priced and fast hovercraft on the river has been investigated.

The first step leading to a hovercraft transit line is to evaluate the effects of Detroit's weather on its operation. The sacrifices that need to be made using hovercraft transit in a cold region are listed in this report. Sacrifices include added maintenance, delay and cancelled service. Depending upon further investigations, hovercraft might need to cancel service more than other transit modes. They might need to cancel service as frequently as ferries do.

Narrative:
a) Background:

i) Historical Context:

Detroit Context: Metro Detroit has a very low rate of transit use compared to other major metro areas. No rapid transit exists in Detroit with the exception of an underused closed loop People Mover downtown. Streetcars once went down many Detroit roads, but were discontinued decades ago. It is likely that the area will have the benefit of commuter rail service between Ann Arbor and Detroit within a few years, making use of an existing rail line. Detroit and Michigan have rich histories in water transportation. The river provides a possible means to bring a water taxi service.

UDM Context: A team of interdisciplinary researchers including people from Nursing, Mathematics, Business and Engineering have worked on previous transit projects: 1) Health Effects of Riding Transit, 2) Link Between Transit Funding and Personal Income. Both of these are wrapping up and are in the dissemination phase of research.

ii) Institutional Initiatives

Current Initiatives at UDM: The interdisciplinary transit team at UDM next hopes to tackle several projects: 1) Water taxi along the Detroit River, 2) Economic Impact from transit. The UDM Civil & Environmental Research page has more information on these.

b) Research Vision:

i) Vision:

The vision is that a high profile transit system in southeast Michigan would carry riders around construction projects and, by the publicity gained, move forward the push for additional transit. Hovercraft could quickly and inexpensively carry riders from suburban park-and-ride centers on the river to downtown. The publicity might bring calls for expanding the hovercraft downriver when portions of I-75 southwest of Detroit are reconstructed. The hovercraft would link with bus lines serving downtown, which will reduce the demand for parking. Although this would serve primarily the city's Central Business District, the riders could link via the DDOT Woodward bus to the New Center area. This would improve demand and linkages between the current transit systems.

ii) Objectives of the project:

A. Support of the objectives and priorities of the U.S. DOT.

(**3.b.2** Congestion Chokepoints) The possibility of congestion chokepoints being relieved was investigated through a new mode of mass transit.

B. Responsiveness to the critical needs, challenges and opportunities in our region.

With traffic congestion projected to increase, and the practical difficulties of building and widening roads to compensate, we look for ways to provide alternatives. One way is to find ways to increase transit use thereby reducing traffic and system stress. There is great potential for improvement in metro Detroit given the current state of transit.

C. Building upon past work in this area.

Some regions, including Baltimore, Rochester and Toronto, have water-taxi services. The speed and capacity of these systems vary. A fast and high capacity hovercraft line has run for many years across the English Channel. It currently competes with the Chunnel. The Chunnel crossing takes 30 minutes and the hovercraft 35 minutes. (Yoder, 2000)

c) Weather Conditions:

i) Conditions of Concern:
Weather conditions in Detroit of concern to water travel are: fog (reduced navigation), freezing rain and splashing of freezing water (icing on craft), wind and waves (speed reduction, comfort, vehicle stability, and safety), ice dams (ability to navigate).

Solid, flat ice is advantageous to hovercraft because ice has a lower friction than water. A solid surface is preferable. More energy needs to be expended to maintain the air cushion over water because the air blows the water which is constantly replaced by new water flowing in. However, thick ice in an ice dam is an obstacle.

A hovercraft transit plan could be implemented by Hoverstar which is the private partner on this project. Hoverstar's plan is to take the transit beyond the Detroit River, as far south as Toledo. Therefore, Lake Erie weather conditions are of concern too.

ii) Fog:

Fig. 1. Detroit River Fog
http://www.pbase.com/

Fog is a cloud at ground level. Fog can be easily created artificially on a cold winter day by breathing from the mouth.

When warm moist air cools the relative humidity goes up because the ability to carry water goes down. As the air reaches saturation of its capacity to carry water, water droplets form. A cloud of water droplets causing the visibility to be less than 1 km (5/8 mi.) is considered fog. (Summarized from AMS, 2007; and Weather.com 2007)

Bodies of water are sources of heat or cold, and moisture; therefore they are more likely to experience fog than over land, just like lake effect snow comes from moist air. The special term for fog over water is Sea Fog. See Fig. 1 and 2.

Table 1 shows the number of days that Detroit has had fog in 2007.

Fig. 2. Sea Fog in San Francisco
www.cloudman.com

Table 1, Fog in Detroit (NWS, 2007)

Month (2007)	Fog with visibility < 0.25 mi. (days)	Any Fog (days)
Jan.	1	22
Feb.	1	14
March	2	16
April	3	14
May	3	11
June	0	11
July	2	9
Aug.	1	19
Sept.	3	18
Oct.	1	19
Nov.	1	16
Dec.	5	23
Total	23	192

Considering the Sea Fog effect, it is safe to assume that each of the 23 days with low visibility occurred on the Detroit River.

iii) Ice Dams:

This section covers how frequently ice forms on the Detroit River, what conditions cause the ice to form jams or dams, and the typical severity of this on the Detroit River.

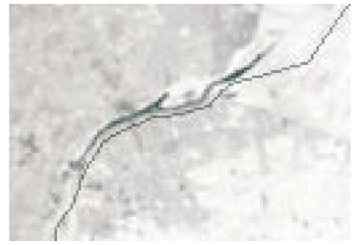

Fig. 3. Detroit River Freezing Over, Jan 25, 2007
NASA MODIS Satellite

A. Ice Formation:

Obviously ice forms whenever water temperatures reach the freezing point.

Bodies of water are slower to warm and cool than air. Therefore, lakes have a moderating effect on the weather around the lakes. Ice forms on the Great Lakes much after the air reaches freezing temperatures, because they contain large volumes of water. The first places on the lakes to freeze are near land, and along the Detroit River. See Fig. 3, 4, 5.

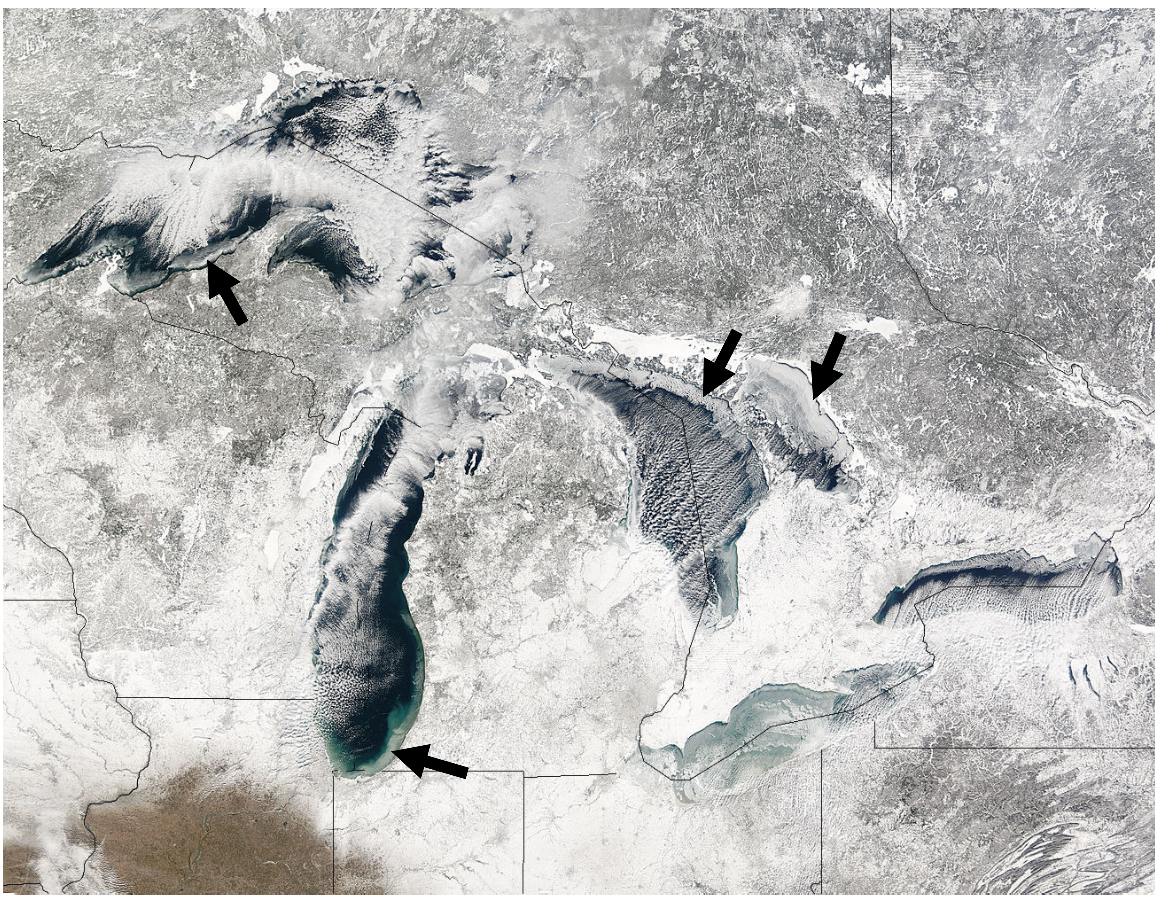

Fig. 4. Great Lakes Freezing Over, Jan. 25, 2005.
NASA MODIS Satellite

The water in a lake does not have a constant temperature, but the water at the surface has the greatest contact with the air and so freezes first. Lake Erie freezes over first because it has an average depth of 62 feet which is much less than the other lakes. (Grady, 2007)

Lake St. Clair, western Lake Erie, and the Detroit River all are at least 90% covered with ice for around 60 days each year. (Fig. 5) The ice is generally 90% or more through the months of January and February. A cover of 10% ice could be on the river up to 120 days in a worst case year, and a record of ice over about half a year. (Fig. 6)

Ice dams are more likely to occur when there is more ice. Therefore 60 days is selected as the range over which there is a risk of ice dams. Small ice floes can occur any time there is ice. Therefore in a worst case year, up to 120 days could have small ice floes.

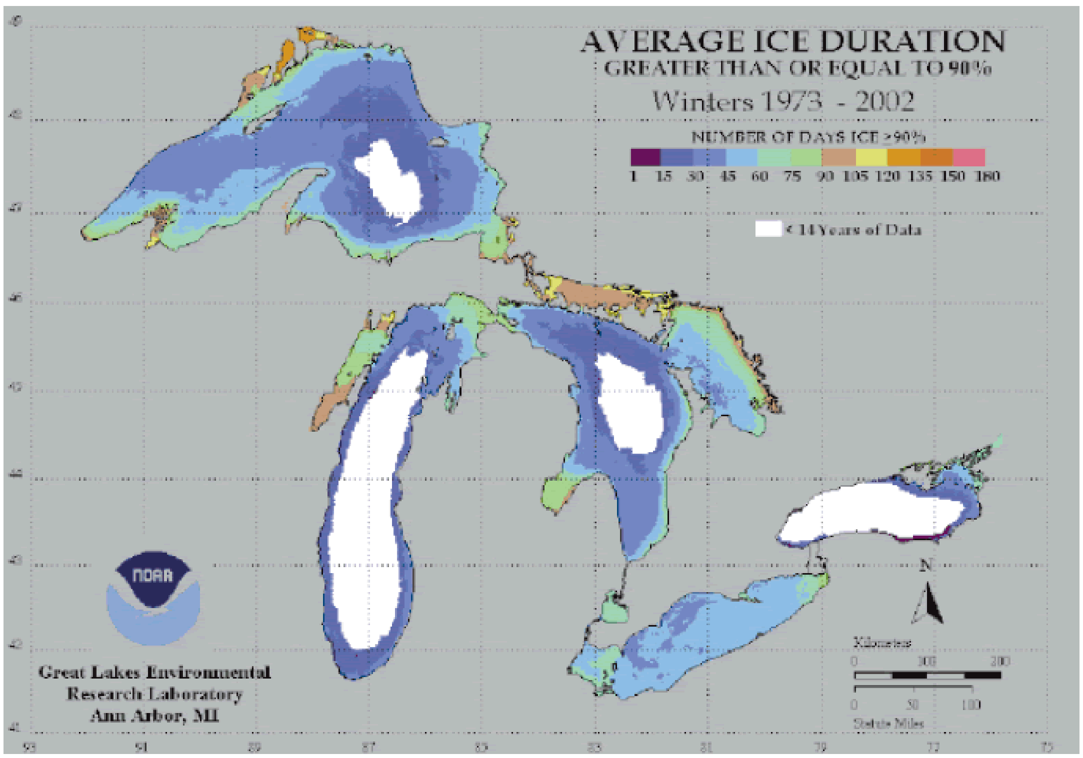

Fig. 5. Ice Duration of 90% Concentration
(Assel, 2003)

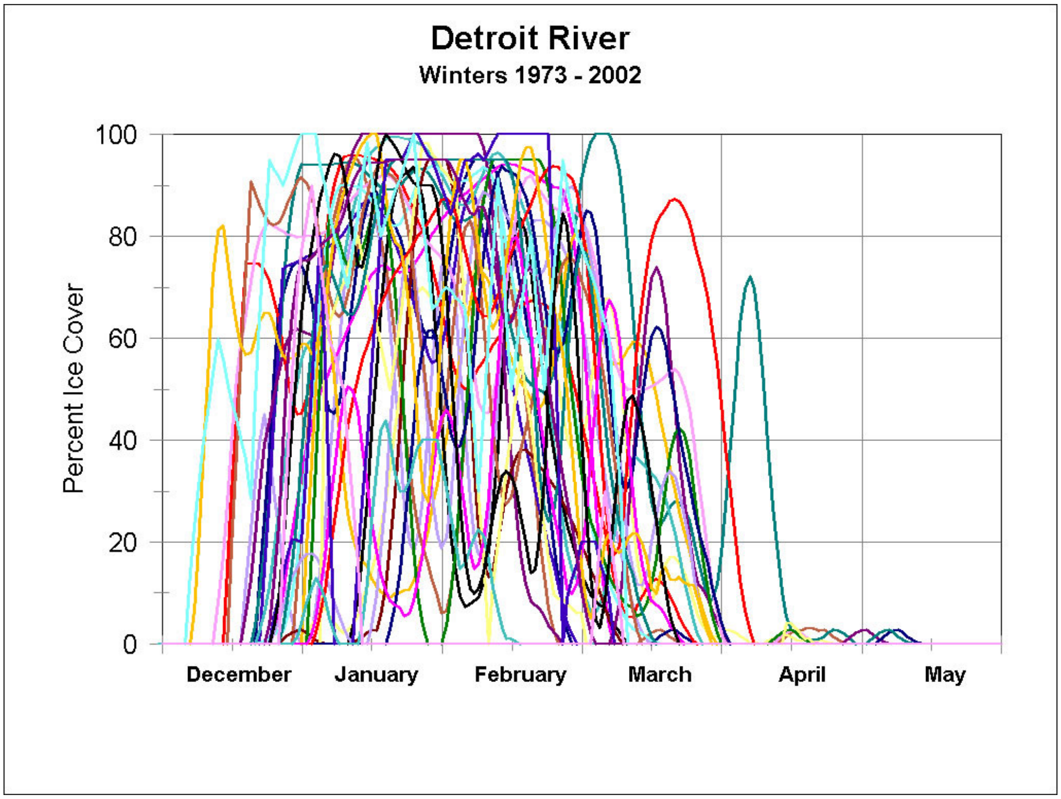

Fig. 6. Daily Ice Cover Time Series on Detroit River
(NOAA 2003)

B. Ice Dam Formation:

Large jams or dams of ice would be a concern for hovercraft that would need to go around or over the dam. An actual ice dam is when ice completely closes the river, which is rarer than ice floes on the Detroit River.

Ice floes are ice pieces piled on top of each other. Ice cracks when water flow causes it to shear, or boat traffic slices it. Wind or water flow causes ice to move, and large masses of floating ice press against each other causing them to pile or tilt. (Fig. 7)

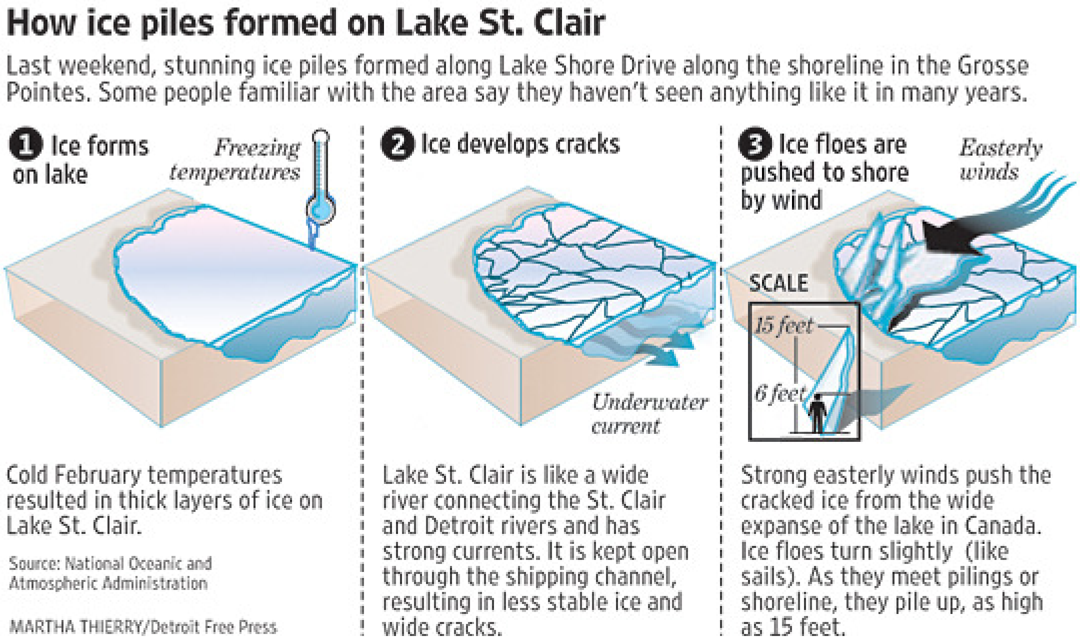

Fig. 7. Ice Floe Formation
Detroit Free Press, March 10, 2007

C. Severity of river ice on the Detroit River:

Much of the Detroit River has ice floes consisting of ice piles less than three inches tall. (Fig. 8) The main channel of ice is not covered with floes, but has areas that are navigable. (Fig. 9) However, the entire river has floating ice. (Fig. 10) Certain areas have thick, dense piles of ice. (Fig. 11) These large piles happen most frequently where the open channel ends, because that is the location where the floating ice collects and is piled. (Fig. 12) (Fig. 13) It is most severe where the Detroit River enters Lake Erie because the fast running river water hits the slowly moving lake water. This would be a problem for a hovercraft transit line going to Toledo.

According to Captain Dalgety of the Blue Water Ferry, in the winter of 2006-2007 (which was a typical year) they were shut down a total of ten days, and each time it was because of ice. They never shut down for any reason except ice jams. The ferry operates every 24 minutes in each direction (every 12 minutes summer weekends) from Marine City, Michigan to Sombra, Ontario. It operates 365 days a year (except as above) from 6:00 a.m. to 10:30 p.m. It conveys pedestrians, bicyclists, automobiles, buses and trucks.

Fig. 8. Detroit River Ice
Alan Hoback, 2007

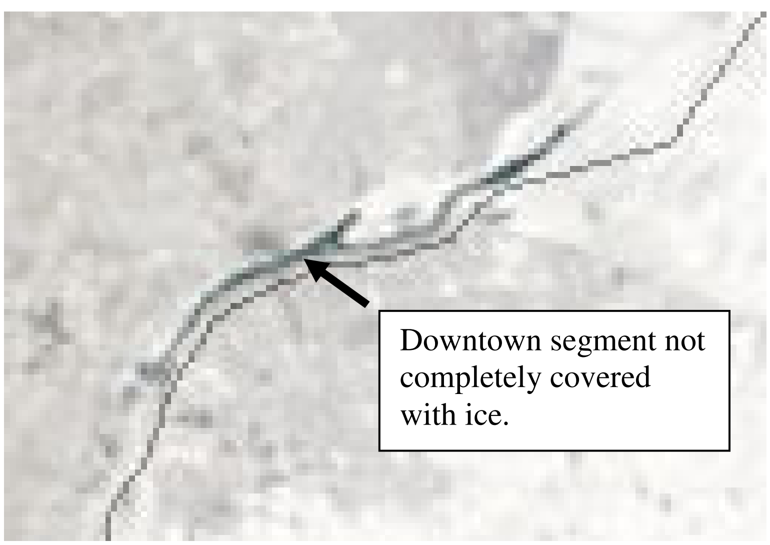

Fig. 9. Less ice in main channel, Jan 25, 2007
NASA MODIS Satellite

Fig. 10. Floating Ice in Detroit River
Alan Hoback, 2007

Fig. 11. Tug in Thick Ice on Detroit River
www.boatnerd.com

Fig. 12. Cuyahoga Entering the Detroit River, Dec. 28, 2000
(www.boatnerd.com)

Fig. 13. Ice at Mouth of Detroit River, Jan 25, 2007
NASA MODIS Satellite

iv) Vehicle Icing:

Vehicle icing can come from freezing rain or splashing of freezing water.

A) Splashing of Freezing Water:

Water near the freezing point can be cooled to the freezing point when it flies through freezing air or splashes on a freezing watercraft. This can result in ice formation. (Fig. 14) Hovercraft do not cause wakes in normal cruising, however they do cause mist from the propulsion and air cushion fans. (Fig. 15) Small water droplets such as mist are even more likely freeze on contact than a large splash because mist has more contact with cold air than a splash.

Fig. 14. Ice on a boat from splashing water
http://www.bocasgary.blogspot.com/

Fig. 15. Mist produced from air cushion fans
http://www.freerepublic.com/focus/f-news/1910047/posts

There is no data about how to predict the level of ice mist generated by hovercraft, but there are inventions to minimize this. See later sections.

The water temperatures are near freezing for about two months per year. (Fig. 16) January and February are most at risk for freezing water splashing onto a craft and causing ice.

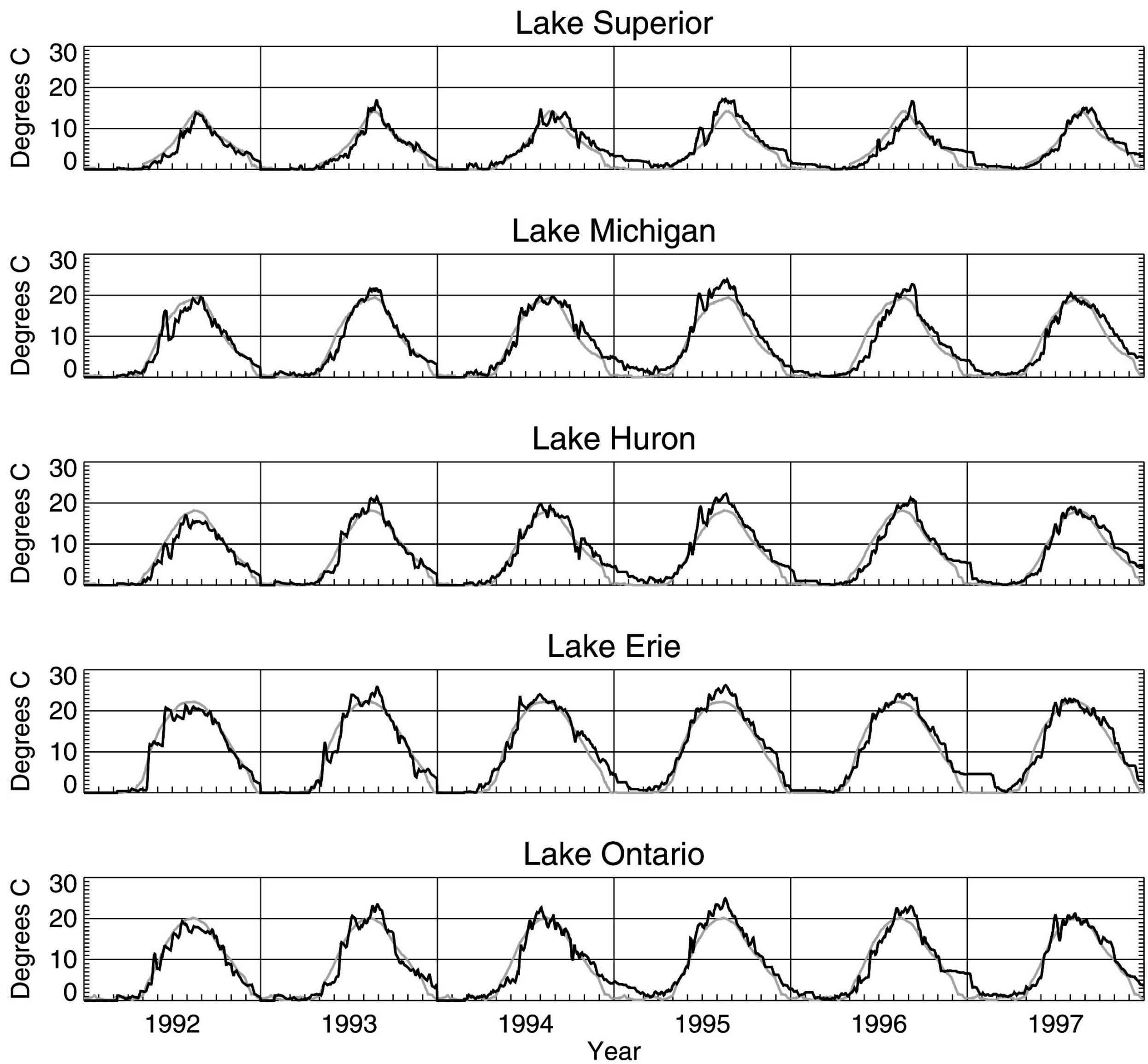

Fig. 16. Surface Water temperatures for the Great Lakes. (Schwab, 1999)

B) Freezing Rain:

Freezing rain is a type of precipitation that begins as snow at higher altitude, falling from a cloud towards earth, melts completely on its way down while passing through a layer of air above freezing temperature, and then encounters a layer below freezing at lower level to become supercooled. This water will then freeze upon impact of any object it then encounters. (AMS, 2007) See Fig. 17.

Usually freezing rain is associated with the approach of a warm front when cold air, at or below freezing temperature, is trapped in the lower levels of the atmosphere as warmth streams in aloft. (UofI, 2007)

Table 2 shows freezing rain in Detroit to be heavy 2 days a year. Light freezing rain is not a concern. It will be shown that hovercraft can handle this. However, the two days a year of freezing rain may be a concern.

Fig. 17. Maritime History of the Great Lakes http://www.hhpl.on.ca/GreatLakes/
Last Boat of the Season, Sault Ste. Marie, Ontario, CA

Table 2, Freezing Rain in Detroit (NWS, 2007)

Month (2007)	Freezing Rain (days)	Light Freezing Rain (days)
Jan.	1	5
Feb.	0	1
March	0	2
April	0	0
May	0	0
June	0	0
July	0	0
Aug.	0	0
Sept.	0	0
Oct.	0	0
Nov.	1	1
Dec.	0	3
Total	2	12

v) Wind and Waves:

A) Wind:

Wind speed influences the ability of hovercraft to move since hovercraft move by creation of artificial wind. Both the predicted wind speed and the maximum gust are an issue. The predicted wind speed determines whether the hovercraft will slow too much to reach its destination on schedule. The gust is an issue because it affects safety (for instance, a high gust could blow the craft off course). Monthly wind summaries for Detroit are shown in Table 3.

Table 3, Monthly Wind Summary in Detroit (NWS, 2007)

Month (2007)	Average Wind Speed (mph)	Max. Constant Wind (mph)	Max. Gust (mph)
Jan.	10.3	104*	37
Feb.	11.3	35	46
March	10.6	37	41
April	11.0	37	44
May	7.5	33	43
June	6.6	36	48
July	7.0	31	43
Aug.	6.3	37	51
Sept.	6.0	33	41
Oct.	8.5	38	47
Nov.	8.8	33	48
Dec.	9.0	39	53

*Likely Data Error since wind of 104 mph is unlikely, especially considering the maximum gust was 37 mph for the same month.

From Table 3, December was an average month for wind. Daily wind speed is shown for the month of December 2007 in Table 4.

Wind on the Detroit River is roughly the same as in the metro Detroit region, but would be higher on Lake Erie.

Table 4, Daily Wind Summary in Detroit (NWS, 2007)

Day (Dec. 2007)	Average Wind Speed (mph)	Max. Constant Wind (mph)	Max. Gust (mph)
1	5.5	20	30
2	9.5	30	38
3	20.4	33	43
4	10.3	17	25
5	9.2	17	22
6	8.3	23	23
7	8.9	16	20
8	5.9	13	15
9	6.2	10	23
10	2.6	7	9
11	3.4	10	15
12	6.0	17	21
13	8.7	25	31
14	11.0	20	25
15	10.1	16	22
16	16.8	30	43
17	12.5	18	23
18	9.2	15	18
19	9.4	18	23
20	3.7	10	14
21	6.0	16	26
22	6.6	16	25
23	24.5	39	53
24	16.7	31	38
25	7.1	14	16
26	2.3	10	15
27	6.0	16	21
28	10.0	30	39
29	13.7	28	36
30	3.5	13	15
31	3.9	12	18

B) Waves:

Waves and wakes influence the quality of the ride on hovercraft. Wakes are primarily a function of the ship's speed and hull shape, but also of water depth, current and keel clearance. Wake height is controlled by limiting the speed of vessels.

From observation of vessels in the Detroit River, the wake heights from large vessels were estimated at about one foot. The wake dissipates further from the vessel.

Surface waves can be caused by wind or tsunami. For wind caused waves, the longer the fetch length that wind can blow over to build up a wave, the larger the wave will be. In the Detroit River, the longest fetch length is approximately one mile.

Ocean waves reach and average of 3 feet in height when the wind is 28 knots (32 mph). (Dietrich, 1971) The Detroit River would require much higher wind speeds to cause 3 feet wave heights because of its shorter fetch than the ocean. Hovercraft can not go over waves higher than 3 feet.

d) Hovercraft Operation:

i) Parameters of Operation:

The 8100TD Griffon hovercraft that Hoverstar intends to use has these characteristics: (Griffon, 2007)

80 passengers
Max. Speed 50 knots (57 mph)
Cruise Speed 40 knots (45 mph) at zero wind and zero wave.
Payload 10 tonnes.

The daylight speed limit on the Detroit River is 40 mph for craft exceeding 20 m in length. (US Coast Guard, 1995) The night speed limit is 12 mph. However, the Coast Guard District Commander has authority to amend speed limits. The authors assume that an amendment will be granted for hovercraft (length 20.1 m) to travel at 45 mph day or night. Lacking such an amendment, hovercraft would not be able to operate effectively in the winter when it is not daylight during the morning or evening rush hours.

ii) Fog:

Ships rely upon radar for travel at night and in fog. Radar is an electromagnetic wave that bounces off an obstacle. When the reflection is detected it is plotted on a screen. Radar can detect objects of any density. Boats use them to locate other boats. Weathermen use them to locate clouds. The reflectivity is the brightness of the reflection and is based on the density of the detected object. Therefore, debris in the water could be detected as well as other ships.

It is possible that ice could hide debris from radar. No information could be found as to whether ice causes a dramatic scatter that could hide debris.

One means of driving safely in fog is to use fog lamps. Normal lighting reflects back off the fog, but fog lamps are low and so shine along the surface of the road or water. This helps a motorist stay in the proper place on the road, and is most effective at low speed. The lamps do not increase visibility through fog; therefore, in hovercraft fog lamps would only aid in looking for debris in the water.

The authors hesitate about letting hovercraft transit rely entirely upon radar in fog. Maximum operating speeds are recommended here.

With one mile visibility, a hovercraft going at the 45 mph cruise speed would have 1 minute 20 seconds warning to stop or swerve around an obstacle. Reaction times for crash avoidance are usually set at 3 seconds. If the obstacle is another hovercraft approaching head on, 5 seconds is enough to swerve out of the way. However, if it is also traveling at 45 mph then the maximum time before impact is 40 seconds. Eight seconds is much less than 40 seconds. A visibility of less than 0.2 miles requires a change in operating speed to avoid a crash. A visibility of 0.1 miles requires a maximum speed of 22.5 mph.

Another scenario is a large immobile obstacle that can't be avoided, but requires the hovercraft to come to a stop. One mile visibility gives 1:20-0.03 = 1:17 to slow to a stop. No data is available about Griffon stopping distances. Other large hovercraft require a range of stopping distances: Atlas of 350' (Atlas, 2007) to SR.N4 MK 1 of 480 m. (0.3 miles) (Hovercraft Museum, 2007). Until better data is available about the Griffon 8100TD, a stopping distance of 0.25 miles at 45 mph will be used. This requires a visibility of 0.29 miles to travel 45 mph. With a 0.1 mile visibility, the maximum speed would be near 15 mph.

Between the two scenarios, immobile obstacles control the maximum speed. The operating speed of hovercraft would be 45 mph at anything better than 0.29 mile visibility. With a 0.1 mile visibility the maximum speed would be 15 mph.

However, it is at the US Coast Guard's discretion to apply temporary speed limits during fog. It is unlikely that an exception would be granted to hovercraft despite the use of radar. Therefore, whenever fog exists, the service will be slowed to an unacceptable speed, just one quarter its normal operating speed.

From the weather data in the previous sections, 23 days of fog less than a quarter mile visibility are expected per year. Even if the Coast Guard granted an exception for speed limits in fog, the fog is likely to slow down service. Since fog is worst in the morning, it would effect the morning rush hour the most. The best case scenario is a couple days a year with delayed service. The worst case scenario is 23 days of cancelled service.

<u>iii) Ice Dams</u>:

Interestingly, the weight of hovercraft makes it an effective icebreaker. (Hindley, 1978) However, ice breaking could cause more ice floe and dam formation. Flat ice is not a problem for hovercraft, but layer ice is. Therefore it is possible that hovercraft could make its own operating environment worse.

The Griffon 8100TD can climb over obstacles more than 3 feet high. (Hinton, 2006) Ice on the Detroit River very rarely exceeds 3 feet. There are only a few locations where shore geometry causes this to happen. (Detroit Free Press, March 10, 2007) Therefore, no ice floes are expected that the hovercraft could not go over.

However, going over ice floes will result in two problems. First, going over rough terrain increases wear on the hovercraft apron or skirt. The US Coast Guard suggests that the skirt would have to be frequently replaced. (USCG Detroit, 2007) Second, the hovercraft would have to slow to go over an ice floe, causing delay.

There is no measurement of the number and size of ice floes or ice dams that a hovercraft would have to go over on a transit route. However, there are methods to approximate the delay that going over an ice dam would cause. Assuming that the hovercraft would have to slow to near zero to go over an ice dam, and assuming a comfortable acceleration of one eighth gravity, and adding 20 seconds to go over the obstacle, the delay would be forty seconds. This alone is not enough to cause a significant delay in a transit schedule. However, if there are significant ice flows as shown above (Fig. 12) then there could be unacceptable delays. Further testing of hovercraft in Detroit ice conditions is necessary to validate that the craft have no problem with lengthy ice dams.

It is assumed that a transit route going to Toledo would have to go over such ice flows at the junction with Lake Erie. If ice dams are a problem then this is likely where the most problems would occur. Transit service restricted to the Detroit area would have fewer cancellations and delays for river ice. There is no good measurement of how many days of large ice floes, nor whether the floes are severe enough to warrant cancelled service. The Blue Water Ferry cancellation record of 10 days per year is a possible guide to the expected number of days for hovercraft.

It is unlikely that smaller ice floes as in (Fig. 8) would slow hovercraft travel. They occur for up to 120 days in the coldest years.

The best case scenario is that ice dams can be easily gone over. Minor delays might result. The worst case scenario is that Lake Erie might have large ice dams up to 60 days a year which prevent travel.

<u>iv) Vehicle Icing</u>:

Icing due to spraying mist is partly alleviated through use of special a spray suppression apron. (Wade 1979)

Icing from spray or freezing rain adds to the weight of the craft. This is important for airplanes not just because of the weight of ice, but also because it changes the aerodynamics.

The aerodynamics of hovercraft is not as big an issue as it is with airplanes; however, the weight is a big issue. If a hovercraft has too large of a payload it will not be able to hover. The 8100TD has a payload capacity of 10 tonnes (Metric Tonnes), or 22,000 lbs.

Fig. 18. Hovercraft Cabin
Griffon (2007)

When used for passenger transit, the weight of the occupants plus the seating is the payload. Per rider the payload capacity is 22,000 lbs / 80 riders = 275 lbs. Considering average weights of riders and chairs, there is little margin for ice build up. Assuming a margin of 25 lbs between payload weight and capacity per person, maximum ice buildup of 2000 lbs is allowed. The vehicles size is 10.1 m X 21.2 m = 214.1 square meters = 2300 square feet. This allows about 1 lb per square foot. This is less than a quarter inch of ice. So long as ice is not expected to exceed ¼" there is no problem, but if more than ¼" of ice is likely, the craft would have to operate at less than full passenger capacity.

Vehicle deicing could partly be accomplished through heating the exterior of the craft. However, this is expensive and difficult to do on the craft's control surfaces. Deicing glycols are another possibility. They are sprayed at high temperature and pressure to remove ice on airplanes. Then the glycols must be recovered so that they do not enter the wastewater treatment stream. Airports have collection systems. Hovercraft landing pads are just a slab of concrete. A major expense would be added if in-ground collection and storage of glycol runoff is required. Conversations with hovercraft enthusiasts suggest that ice on the apron could be simply kicked off. However, only a small amount of the vehicle surfaces is the apron.

Vehicle icing is not a safety issue with respect to buoyancy. If a hovercraft becomes overloaded it hovers down and floats instead of flies. Floating makes the craft go slower.

From the sections above, freezing splashes could be a concern up to 60 days a year, but apron equipment could alleviate this. Heavy freezing rain is expected two days a year, but will not likely add up enough to cancel service. Further study with hovercraft is necessary in order to test if icing will be a problem.

<u>v) Wind and Waves</u>:

The Griffon 8100TD can go over obstacles up to 3 feet tall. Therefore, ship wakes are not expected to be a problem, nor wind driven waves on the Detroit River. Wind driven waves on Lake Erie will be higher than in the Detroit River because the lake has longer fetch distances. However, the wave height is limited on the upper bound by ocean wave heights of 3 feet with a wind of 32 mph. At that speed, the wind itself is a concern.

Strong wind can slow down hovercraft or make it unsafe to operate since hovercraft are powered by artificial wind. With an operating speed of 45 mph, and a maximum speed of 57 mph, the authors suggest limits on the average wind speed and the maximum gust.

Obviously a maximum headwind gust of 57 mph can not be exceeded or the craft would move backwards. From a practical point of view, hovercraft need to maintain maneuverability even in gusty weather. The hovercraft need to be maneuverable when traveling at 45 mph. If it had a tail wind of gust 45 mph, then its engines would be idled. Griffon hovercraft steer by using rudders to control the direction of rear fan's propulsion. (Fig. 19) To steer, the craft must use its rear fans. However, these are reversible, so the craft is maneuverable even when coasting. With a headlong gust of 45 mph, the craft would essentially be immobile. However, during a short term gust at that speed it would have some maneuverability.

Fig. 19. Steering with rudders
Griffon (2007)

Normal operation in windy conditions prevents the average wind speed from being too high. It could be rationalized that the effect of the wind would cancel out because a wind that slows the craft on one leg of the trip would speed it up on the return leg. However, from the sections above, the hovercraft will probably not be allowed by the US Coast Guard to exceed 45 mph. Therefore, the wind could not be used to make up time.

Since the hovercraft has a maximum speed of 57 mph, with a headlong wind of 12 mph, the hovercraft could travel at normal operating speeds of 45 mph. Any increase in wind would cause delay.

A crosswind could also cause delay. From a force component analysis in Fig. 20, a maximum crosswind of 35 mph could be allowed. However, this is at the limit of maneuverability. A lower limit of 25 to 30 mph is more prudent.

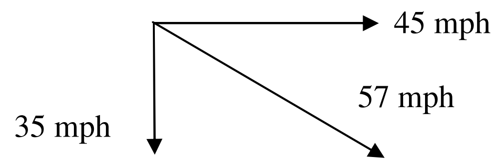

Fig. 20. Wind Force Component Analysis

No hovercraft vehicle route is completely straight. A route would have segments that have crosswinds, head winds and tail winds. Therefore, the limiting average wind speed for the worst case needs to be used. A headwind exceeding 12 mph will cause delay. However, vehicle routes might be primarily straight. For example, pulling into dock might be the only leg with a headwind. That segment is small, so a higher wind could be allowed from that direction.

Wind and wave happen together since wind causes waves. Waves make the ride more uncomfortable, therefore a stricter limit on wind speed may be necessary.

Delay would occur anytime the wind exceeds 12 mph in any direction. The delay would be significant whenever, the craft slows to 40 mph, so significant delay is caused by 17 mph wind. Unsafe operation is expected whenever the wind gusts exceed 45 mph.

The transit line could not operate in quiet morning winds if gusty afternoon winds were expected. (Commuters could not be stranded at work because the wind picked up.) Therefore, any day that the forecast exceeds the safe operational limits, even for a short time, the service would have to be cancelled. However, delay can be tolerated a little more than cancellation. A hovercraft operator might take a chance that wind that causes significant delay might not occur during the morning or afternoon rush hours.

From Table 3, six months had at least one day of wind exceeding the limits of safe operation. However, eleven months had gusts exceeding a margin of safety placed at 40 mph. December was one of those months. From Table 4, only one day in December exceeded safe operational wind gust speed. However, three days were within a margin exceeding safety. From this analysis, it can be estimated that due to wind, hovercraft service would not be possible on 8 to 23 days. Eight days were actually documented. Twenty three days are projected. (5 mo. @ 1 day + 6 mo. @ 3 days = 23)

From Table 4, in December there were three days when the average wind speed exceeded 17 mph and a significant delay would be expected. Those were the same days when the wind gusts exceeded the safety margin. Assuming that this is true for the other gusty days, then service is significantly delayed 23 days a year, which are the same days it is unsafe.

On days when wind is a concern, shuttle buses could be ready on standby. Hovercraft could operate on the river until actual windy conditions develop. The windiest part of the day might happen off the peak travel hours, therefore the cancellation of service for wind is likely to be less that 23 days a year.

e) Summary:

River ice in large ice floes could slow hovercraft. Going over ice floes also adds to the skirt or apron maintenance costs. A craft that goes up and down the river would have more obstacles than ferries that cross it. More experience with hovercraft and more data on Detroit River ice dams is necessary in order to say whether there would be any delay.

Vehicle icing may be a concern if much mist is thrown onto the craft. Vehicle icing can be controlled through expensive deicing similar to that used on airplanes. Significant freezing rain is uncommon so it is unlikely to create frequent problems.

Fog is a significant obstacle from a safety standpoint. Radar can see through fog, but the US Coast Guard is less likely to grant speed limit exceptions for hovercraft during foggy conditions. Demonstration of capabilities to the US Coast Guard is probably necessary in order to get exceptions to speed limits.

Wind will cause delay whenever it exceeds 12-17 mph. The service would have to close if gusts exceeding 40-45 mph were expected because such gusts make the hovercraft unmaneuverable therefore unsafe. Up to 23 days a year a hovercraft transit system would need to have shuttle buses on standby. Waves or wakes are not expected to add significant delay on the Detroit River.

The total number of days cancelled a year due to all weather events is not the addition of the days for each, nor just the worst of the four conditions. The weather conditions are each roughly random with respect to each other. Fog and wind usually don't happen together because wind blows away fog. On the other hand, wind is gustier in winter months, when ice is on the river. Likewise, fog, freezing rain, and wind are all associated with weather fronts. Therefore, there is some correlation between them. To calculate the total number of days per year with unacceptable weather, a random relationship between weather conditions is assumed. Assuming a worst case scenario for each weather condition there are 55 days of bad weather a year. Hoverstar plans to operate only during weekdays. Therefore, 5/7 of 55 days or 39 days represents the worst case scenario for the number of days in which the service must be cancelled. The best case scenario is that service is never cancelled, but on the windiest days a back up bus service is implemented.

Typical cancelled service is shown for transit agencies in Table 5. Nationally 0.14%, of all operating days were cancelled due to strikes or emergencies for all modes of publicly funded transit. (NTD, 2006) That would be equivalent to one day every other year. Transit systems frequently have to cancel individual trips on days during which they are operating, but data of this is not readily available.

In the worst case scenario hovercraft transit doesn't meet the standard of one cancellation per every two years. In the worst case scenario it would more closely follow the cancellation record for ferries.

Table 5, Whole-Day Cancellation with modes of travel-2006.

Mode (closest City)	**Cancellation**
Blue Water Ferry (Marine City MI)	10 days out of 365
DDOT *Bus* (Detroit)	0
SMART *Bus* (Metro Detroit)	0
SMART *Paratransit* (Metro Detroit)	2
People Mover AGT (Detroit)	0
CTA Heavy Rail (Chicago)	0
Hiawatha Light Rail (Minneapolis)	0

Slowed travel times cause delay in arrival of a commuter at his final destination. It is also possible that delay could add up as the day progresses. For transit systems where one vehicle loops continuously, any delay sets back the entire schedule. However, this does not seem to be the intent of Hoverstar. Their commuter oriented scheduling is more adaptable to having a long slack time between when the vehicle is scheduled to arrive, and the next departure.

Bus transit has an advantage when it is operated at a frequency of every 5 minutes. It handles delay by simply shifting back schedules. To a person wanting to catch a bus that comes by every five minutes, they may think they are catching the 7:40 bus, but they don't know or care if it is really the delayed 7:00 bus they are catching. When bus service is not frequent, then wait times can be severe.

Delay is more acceptable in air travel because for most people it is not an every-day occurrence. Daily delay in winter commuting is unacceptable.

f) Administrative:

i) Faculty Team:
Alan Hoback,
  Faculty-Civil Engineering
Scott Anderson,
  Consultant (pre-Fall 2007-2008),
  Faculty-Mathematics (post-Fall 2007-2008).

ii) Student Team:
Danielle Crane [1,2]
China Sellers [1,2]
Nick Visger [2]
Tim Hooper [2]

Note:

1. MIOH-UTC funded.
2. Federal Workstudy funded.*

Table 6, Student Schedule

Time Span	Student Assistants
Jan. – April 2007	Nick Visger [2] Tim Hooper [2]
June – Aug. 2007	Danielle Crane [1] China Sellers [1]
Sept. – Dec. 2007	Danielle Crane [2] China Sellers [2]

iii) Match Documentation:

Per attachments on the next pages. Alan matches at $100/hr. UDM matches at 58.5% of Alan's rate for overhead and fringe benefits

As a consultant, Scott agreed to match at $125/hr.

GM match $2500. (see attached.)

* Federal Workstudy does not count as a match of non-federal money sources.

Table 7, Match Hours.

Month	Hours	
	Alan Hoback	Scott Anderson
January 2007	1:30	
February 2007	2:30	
March 2007	0	
April 2007	0:15	
May 2007	1:30	
June 2007	1:45	
July 2007	1:30	
August 2007	1:00	
September 2007	0	
October 2007	0:30	
November 2007	0:30	
December 2007	25:45	16:30
Total hours	36:45	16:30
Match:	Alan: $3675 UDM: $2150	Scott: $2062.50

Mailboxes	Compose	Rules	Settings	Log Out

Next Unread	Reply	Reply To All	Forward
Back to INBOX	Delete	Set Flag	Close as Unread

From: candace.j.butler@gm.com
Subject: Hovercraft/Water Taxi Feasibility Study
Date: Wed, 26 Jul 2006 13:39:41 -0400
To: hobackas@udmercy.edu

Hello Dr. Hoback,

Per our discussion earlier today, the following is my contact information:

Candace J. Butler
Manager, Economic Development
GM Worldwide Real Estate
200 Renaissance Center
MC 482-B38-C96
Detroit, MI 48265
(313) 665-6598 phone
(313) 665-6745 fax
candace.j.butler@gm.com

When you have confirmed, please send me the detail on transmitting the $2,500 in matching funds to support the continuation of the referenced study.

Additionally, as you proceed with this study, I will serve as your GM contact for any questions or other input you may need from GM.

I look forward to hearing from you.

Regards,
Candace Butler

Mailboxes	Compose	Rules	Settings	Log Out

Next Unread	Reply	Reply To All	Forward
Back to INBOX	Delete	Set Flag	Close as Unread

From: "Patricia A. Martinico" <martinpa@udmercy.edu>
Subject: Re: hovercraft budget
Date: Wed, 10 Jan 2007 10:21:27 -0500
To: "Alan S Hoback, CE Chair at UDM" <hobackas@udmercy.edu>

Alan:
Attached is the Hovercraft budget. The numbers are not different than what I sent you previously. I have fill out a little more information.

Bev Matlas e-mailed to me that I was correct in thinking that fringes and indirect are not to be charged on the $$ value of your contributed in-kind work.

We are using $100/hr as a basis for calculating the value of faculty work on the education outreach projects. It is not so important on this project but it would be good process to keep a rough estimate of your time spent on this. You might discover that it is actually 40 hrs not 10 hrs.
Pat

Patricia A. Martinico
Assistant Director, MIOH University Transportation Center
University of Detroit Mercy

313.993.1510
martinpa@udmercy.edu

7035 Springborn Rd
China, MI 48054
June 28, 2006

Dr. Leo Hanifin & Dr. Alan Hoback
College of Engineering and Science
University of Detroit Mercy
4001 West McNichols Rd.
Detroit, MI 48221

Dean Hanifin and Professor Hoback,

I look forward to working with Dr. Hoback and the research team on the proposed water transportation project. As you know, I coauthored the "Health and Transit" series of papers with Dr. Hoback and others. I have been involved with local public transportation issues for many years, since my days riding the Linwood bus from my off-campus apartment to my job near the old ballpark.

I have worked with state and local officials, such as State Rep. Marie Donigan and Ferndale City Manager Tom Barwin, and written on transit issues for the Michigan Land Use Institute. As a mathematician and computer scientist, I know how to create defensible models for complex phenomena and also how to get a computer to produce a correct answer, based on such a model.

I also serve as a consultant to a steel plant in Dearborn, where my focus is on improving the logistics of in-plant transportation (trucks, trains and specialized vehicles).

I believe our team will be able to produce an effective document that will give our regional planning and transportation officials valuable input as they work to improve conditions in the metro region.

I can provide an in-kind grant; I will provide 80 hours of uncompensated research. At my normal consulting rate of $125 this would normally be valued at $10,000.

With kind regards,

Scott C. Anderson

g) References:

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