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User Guide and Description
For
Interim Remote Sensing Program Credit Utility

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1.0 BACKGROUND AND SUMMARY

A remote sensing device (RSD) can measure instantaneous hydrocarbon (HC) and carbon monoxide (CO) exhaust emissions from a vehicle operating under actual in-use conditions. Instrumentation is presently being evaluated to also measure nitrogen oxide (NOx) emissions. RSD though does not measure evaporative HC emissions.

A number of states have expressed interest in using RSD as part of their vehicle inspection and maintenance (I/M) programs. A number of RSD studies [1-5] using RSD and an independent emission test such as the Federal Test Procedure (FTP) or IM240 (a transient driving cycle developed by EPA for use in vehicle inspection programs) on a sample of vehicles representative of the in-use fleet have been done by California and EPA. This includes, of course, vehicles both above and below specific RSD cutpoints (which can be used to designate RSD passes/failures). These studies demonstrate the effectiveness of RSD in identifying vehicles with excess emissions that can be reduced in a vehicle I/M program.

On September 12, 1995, EPA convened a meeting of RSD technical experts (including those from states, EPA Regions, academic institutions, RSD contractors) doing research and involved in state I/M programs to outline the EPA approach to determining RSD credits and soliciting their input; about 40 people participated in this meeting. The technical experts reviewed a number of draft papers [6-11] prepared by EPA staff on which to provide input. Then, EPA sought input from the Modeling Workgroup of the Federal Advisory Committee Act Technical Advisory Subcommittee for mobile source issues. This Workgroup prepared a statement [12] on the interim methodology for RSD credits. The Modeling Workgroup had also been asked to review an initial version of this document to be sure its earlier recommendations were followed and to have an opportunity for additional input. The Modeling Workgroup provided this review and another statement [13] on the initial draft of this report. This additional statement was approved by a majority vote of the standing members of the Modeling Workgroup. Also, the draft report and the utility were sent to members of the I/M Subcommittee of STAPPA ALAPCO (State and Territorial Air Pollution Program Administrators - Association of Local Air Pollution Control Officials) for review of the utility itself to determine how easy it is to use [14]. The STAPPA/ALAPCO members were able to provide only limited feedback in the time available.

As a result of the input from various technical experts, EPA has developed a methodology and mathematical formulas to generate interim RSD emission reduction credits for use in assigning credits in a state I/M program. These algorithms tie together the important remote sensing variables such as I/M program design, remote sensing coverage, and remote sensing effectiveness. This process enables a state to model the effect of more frequent inspections using remote sensing and subjecting remote sensing failures to test-only inspections in a test-only I/M program. (A test-only I/M program is one in which the I/M test is administered by a facility that does only I/M testing and does not provide repair services for failing vehicles.) States can also model benefits from use of RSD in conjunction with a test-and-repair I/M program with either test-only or test-and-repair inspections of vehicles failing RSD. (A test-and-repair I/M program is one in which the I/M test is administered by a facility that does I/M testing and provides vehicle repair services as well). States can also model the benefits from using RSD in a hybrid program with test-only inspection of RSD failures. (A hybrid I/M program is one with test-only inspection of some vehicles and test-and-repair inspection of other vehicles). States can also model the benefits of using RSD to locate high emitters in areas that do not operate an I/M program for the entire vehicle fleet. The high emitters located by RSD would receive a test-only or test-and-repair I/M test and repairs if the vehicle failed the confirmatory I/M test. In such a program, the only vehicles receiving the test-only or test-and-repair I/M test are those failing RSD. As another option, RSD can also be used to exempt some clean vehicles ("clean screening") from their next scheduled I/M test.

The EPA vehicle emissions model MOBILE5 is used to model vehicle fleet emission levels, and how these levels are affected by most emission control strategies. Inspection and Maintenance (I/M) is one of the emission control programs which can be modeled by MOBILE5. Remote sensing with some type of confirmatory I/M test and enforcement process is another control program which now can also be modeled by the MOBILE5 model.

MOBILE5 is herein supplemented with a utility program to determine remote sensing exhaust credits by linear interpolation between the MOBILE5 I/M benefit for a biennial program (denoted as "B" for purposes of discussion later in this document) that applies without remote sensing and the MOBILE5 benefit (denoted as "A" later in this document) that applies if all vehicles in the fleet received a remote sensing test and if remote sensing identified every vehicle which would fail the confirmatory I/M test on an annual basis. This interpolation reflects the facts that remote sensing coverage will not be 100 percent, and that remote sensing misses some vehicles which would have failed a confirmatory I/M test. The interpolation occurs for each pollutant (HC, CO, and NOx) and each model year cohort in the vehicle fleet for the year of interest. The interpolation allows remote sensing to be assigned the incremental credit increases which result from increased inspection frequency, and test-only (or test-and-repair once the effectiveness of test-and-repair programs are determined as explained below) confirmatory testing of remote sensing failures.

In preparing this guidance, EPA faced a tradeoff between when its first formal guidance on remote sensing credits could be released and how comprehensive and representative those credits could be. The choice EPA has made is to provide credits sooner rather than later, realizing that they may not be as large as they might have been with more investment of time, and may not cover every case of interest to users. Thus, states can have some numerical guidance in a timely fashion to estimate what RSD benefits might be.

One tradeoff factor has been the availability of relevant data; EPA has chosen to make use of data collected up to and including the 1994-95 Sacramento study, and not wait to receive and analyze data collected in Arizona or elsewhere in 1996 or 1997. The data from the Arizona RSD program will indeed be valuable in helping determine what RSD credits could be; however, EPA did not have the staff or contract resources to analyze the Arizona data available so far and still release this document in a timely fashion. A consequence of this choice is that the guidance does not address HC or NOx cutpoints. Also, it does not quantitatively address the advantages or disadvantages of using multiple RSD readings to decide how to treat a vehicle. Possibly, the data that were available for this guidance is not as favorable to remote sensing as will be data collected with more modern versions of the instrumentation and with more modern practices on how to site

RSD units and validate the data they collect.

Another factor has been the obvious advantage of issuing a credit tool which would be consistent with the current versions of MOBILE5, instead of taking the considerable time and staff hours needed to revise MOBILE5 itself, and rather than requiring users to go through complex hand calculations. The choice to stay consistent with MOBILE5 means that this guidance does not cover every program type in which a user might be interested. For example, the guidance assumes that a state would not use remote sensing to subject a given vehicle to I/M testing more often than once per year. Another limitation of this guidance is that it does not consider residual benefits of remote sensing from year to year, particularly in test-and-repair programs. A vehicle which escapes proper testing and repair, but is caught by remote sensing may obtain an effective benefit that extends into a later year in which by chance it is not seen by remote sensing at all. The current structure of MOBILE5 is such that it would have taken considerable rethinking and reprogramming to capture this effect, so this guidance does not.

Recognizing that this guidance may not do full justice to the potential for remote sensing, EPA intends to continue to analyze newly available data and refine its modeling approaches with a view to revising or supplementing the guidance when practicable to do so. EPA currently plans to have an updated RSD treatment in MOBILE6 if not before MOBILE6 is released. In addition, EPA can meet with guidance users who are interested in collecting local data that would allow reality based remote sensing credits to be developed for their specific area and program design. The local data can be pilot studies on coverage; these studies, for example, as discussed later, may show how RSD increases compliance with an I/M program by detecting high-emitting vehicles that should have received I/M testing but do not. The local data can also include updated information on the effectiveness of RSD.

Public acceptance of remote sensing is very important for its success. States should attempt the educate the public about the uses and importance of remote sensing, before it is used. Also, pilot testing might be done before the remote sensing program is implemented. One critical issue discussed in more detail later is where to set cutpoints, so that there are not too many false failures causing the public to lose confidence in RSD or too many false passes lowering the effectiveness of RSD in reducing emissions.

As stated previously, one element of the benefit of remote sensing in a test-and-repair or hybrid I/M program is to catch some vehicles which, for whatever reason, escaped a true repair in the last scheduled inspection cycle. The incremental benefit of any given level and type of remote sensing therefore depends on how many such vehicles there are, or more precisely, how much of the fleet emissions reduction potential they represent. EPA regulations on I/M previously specified a uniform estimate of the emission reduction loss or discount for test-and-repair I/M programs. The recent National Highway System Designation Act directs EPA to no longer apply this uniform estimate. Instead, each state will be given interim I/M program credit for whatever estimate the state makes in good faith. Prospective remote sensing credits will also depend on this good faith estimate of the I/M program credit since the discount included in this estimate is an important factor in determining remote sensing credits. A test-and-repair state that estimates a small or zero discount will model a smaller incremental remote sensing credit than a state that estimates a larger discount. Unfortunately, the current versions of MOBILE5a are hard wired with a significant percent discount (i.e., 50%). EPA plans to issue a new version (MOBILE5b) which will accept a user input for the discount factor. Meanwhile, users may need to perform interpolations between the MOBILE5a outputs for test-only (zero discount) and test-and-repair (50 percent discount) to develop emission factors and RSD credits for discounts between zero and 50 percent. Roughly speaking, using the guidance in this document, the upper end estimate of incremental HC benefit from remote sensing is about 1 percent of fleet non-I/M emissions if the test-and-repair discount is zero, but it is higher (about 4 to 5 percent) if the discount is significant. The upper end NOx benefit ranges between 0.2 and 1.3 percent. These upper end estimates assume complete fleet coverage and stringent remote sensing cutpoints that, in fact, detect all (or almost all) excess emissions in the vehicle fleet.

The National Highway System Designation Act provides for an 18-month evaluation of each I/M program to determine if the I/M program is as effective overall as the good faith estimate made earlier. Beyond this 18 month evaluation, a longer term evaluation is being developed under the auspices of ECOS (Environmental Council of States) which will be more focused at program effectiveness. A substantial remote sensing program can help assure that an I/M program will get a good result on the 18 month evaluation, since it can catch many of the cars that would otherwise contribute to a discount. For example, if a state's 18-month evaluation reveals that the scheduled inspection element of a test-and-repair program is in fact suffering a significant percent discount, having an upper end remote sensing program would make the overall credit for the program 4 to 5 percentage points greater than it otherwise would be. These extra percentage points would be of substantial benefit in preparing subsequent state implementation plans. A substantial remote sensing program can therefore be considered a backstop to other state efforts to replace good faith, interim I/M credits with demonstrated, final credits. There is a synergistic nature of interactions between the remote sensing and baseline I/M programs (e.g., remote sensing can catch vehicles that were improperly inspected for whatever reason in the I/M program or would not have gone through the I/M program). Thus, EPA believes even those states whose I/M programs do not suffer a substantial discount could benefit from deployment of substantial remote sensing programs. Accordingly, EPA believes that, if done properly, such programs with remote sensing could potentially warrant additional SIP credit, above and beyond whatever amount of SIP credit is awarded to their baseline I/M programs. For that reason, EPA urges states to carefully consider the remote sensing option.

Of course, a lower level of remote sensing is also the most economical way to meet the statutory requirement for on-road testing. In addition, on-road testing for emissions performance is required of 0.5% or 20,000 vehicles (whichever is less) of vehicles subject to the I/M program. This on-road testing can also provide useful information on the fraction of fleet complying with the I/M testing requirements and the overall effectiveness of the I/M program. Remote sensing can, in conjunction with the confirmatory I/M test, help provide information on the overall distribution of emissions in the fleet and how it changes with I/M.

Beyond using the remote sensing credit utility provided with this guidance, there are two other opportunities that states can pursue to increase the credits for remote sensing. The first is that EPA will consider state proposals for extra remote sensing credit on the basis that remote sensing can help enforce the requirement that vehicle owners renew their vehicle registrations on time, and that they register in the immediate I/M area. Remote sensing can provide information on how many vehicles driving in a given area are registered elsewhere. Also, remote sensing can get extra credit for helping to enforce against commuters who should get their vehicles inspected but do not. It is not clear at this point what additional options states have for more enforcement to increase compliance. Additional credit can be given to the extent that both of these situations contribute to non-compliance with the state's vehicle inspection program as accounted for in the state implementation plan (SIP) emission inventory and will be reduced by remote sensing. I/M programs already take measures to reduce such evasion and to monitor the degree to which this is a problem. The determinations under the National Highway System Designation Act will help define how effective a state's overall I/M program is and can provide information on what extent RSD can make up shortfalls such as those from improved program compliance.

For example, many states assume a 96% compliance with the local I/M requirements. The 4% non-complying vehicles are assumed in MOBILE to have emissions twice that of the average vehicle that fails I/M. There are substantial benefits for a state able to increase its compliance. For example, a 1% increase in compliance with an I/M program for a state having a 20% I/M failure rate could result in a 21% overall failure rate but the extra 1% failing vehicles have twice as much emissions as the other failures. Individual states though are best able to ascertain what their compliance rates truly are and how easy it is to increase the compliance rates through use of RSD to obtain these additional benefits.

This draft document was prepared to discuss how RSD credits using the utility program in conjunction with MOBILE5. Beyond release of this document, work will be underway to further update it as needed to reflect the additional experience states will have gained while implementing RSD. For example, California, Arizona, Colorado, and possibly other states will have experience using RSD and will be in a good position to provide data from their actual experience for use in updating these credits. In particular, as recommended by the Modeling Workgroup, EPA is reviewing the Arizona RSD data from its program.

2.0 DESCRIPTION OF REMOTE SENSING

The objective of RSD is to identify high emitters in the vehicle fleet. These include vehicles that were clean on their last cycle (with or without need for repair to get clean), but have since experienced an emissions problem. They also include vehicles that were not properly inspected and repaired "on-cycle," for example, at test-and-repair stations. This section discusses in detail factors for states and others to consider in implementing RSD programs to accomplish this objective.

2.1 Remote Sensing Operation and Fleet Coverage

Remote sensing is a process by which the instantaneous HC and/or CO (and NOx as NOx instrumentation is now reasonably well developed) exhaust emissions and vehicle identity (i.e., license plate) of in-use vehicles can be monitored when vehicles pass through the RSD measurement beam while operating on the road. The RSD system is set up alongside the road to measure emissions and also incorporates video license plate recording equipment to record the license plate number of each vehicle to enable the state or local government to trace vehicle registration. Although remote sensing units are automated in that data collection does not require operator action on a vehicle-by-vehicle basis, no researcher nor I/M program is now leaving remote sensing units unattended while in operation. (One pilot involving unattended equipment is in planning.) The units require daily set up and calibration, and on-site technicians can avoid downtime that will only be discovered later if the unit were unattended. Also, security from theft, damage, and even vandalism is a concern. When technicians are using the equipment at the side of the road, attention must be paid to their physical needs and to their safety from oncoming traffic, etc.

Additional equipment should also be used in conjunction with the system to monitor instantaneous vehicle speed and acceleration. Vehicle acceleration is especially important since high acceleration rates (and the resultant high load) can lead to enrichment events and high instantaneous emissions which may not be representative of a vehicle's overall emissions. Deceleration is also important since deceleration can result in low instantaneous emissions not representative of a vehicle's overall emissions. Measuring other parameters, such as vehicle engine or catalyst operating temperature (i.e., is the vehicle or catalyst warmed up?), with RSD is in the initial stage of development and application. A vehicle under cold-start conditions (a cold catalyst that has not yet become effective in reducing HC and CO) will also result in high instantaneous emissions. Such technology should decrease the false passes and failures associated with RSD and should, thus, improve the effectiveness of RSD. RSD data with such systems on a large number of fully random vehicles (including vehicles passing and failing RSD as they would occur representatively in the in-use fleet) on which a mass emissions test (e.g., g/mile HC, CO, and NOx from an IM240) is also obtained would be very valuable in revising this guidance.

I/M program planners must decide where and how often to operate the remote sensing devices and how to use the remote sensing results to designate a vehicle as a high emitter. A greater number of remote sensing sites and measurement days allows more of the local fleet to be tested, which results in more opportunity for emission reductions. However, optimal RSD sites for vehicle speed and acceleration to assure that most vehicles are not under high loads (and thus in enrichment operation leading to erroneously high RSD readings as mentioned above) may not always have high traffic flow. A state should evaluate its chosen RSD sites carefully to minimize erroneously high RSD readings from such enrichments. For example, use of RSD after a stop sign may not be appropriate due to high acceleration rates. Tighter RSD cutpoints identify more of the high emitters present on the road, thus generating more emission reductions. However, tighter RSD cutpoints also fail more clean vehicles that are momentarily high emitting because of driver behavior (e.g., heavy acceleration) or cold-start conditions as the vehicle passes the remote sensing unit. In addition to using acceleration measurements and catalyst temperature measurements, a state may wish to consider reducing such false failures by not failing any vehicle unless it has been measured to have high emissions in two (or more) separate remote sensing measurements. However, this reduces the fraction of the fleet which can be targeted, since some "dirty" vehicles may not have two (or more) encounters, and repair benefit of these vehicles from using RSD are sacrificed.

The number of vehicles that can be successfully tested per day with remote sensing varies from site to site; weather can also be a factor. Each area has to experiment to see what can be accomplished. As a rough guide, 500 unit-days of testing in Sacramento [1] at 337 sites produced about 1,330,000 records containing an emission reading, 865,000 of which also contained a manually decodable license plate image. Overall, a valid test was obtained on 376,000 unique, identifiable vehicles. Of the 810,000 vehicles registered in Sacramento County, 47 percent received at least one valid RSD reading.

2.2 Follow-Up On High Emitters Identified by RSD

After the vehicle's emissions and license plate number are recorded by the remote sensing equipment, various strategies can be utilized to notify vehicle owners that their vehicles have been identified as high emitting. These can range from an electronic sign along the roadway which notifies the motorist of a potential emissions problem (similar to those used to alert a driver of a vehicle's speed in an effort to reduce speeding) to a written summons in the mail to bring the vehicle to an official emissions testing station for "off-cycle" I/M testing with subsequent repair of a failing vehicle so that it passes the I/M test. Also, a state may issue fines or suspend vehicle registrations for vehicle owners not complying with a RSD summons for a confirmatory I/M test.

The failure rate in a remote sensing program depends on many factors, including, of course, the cutpoints used but also the state of repair of the local fleet (affected by the specifics of the periodic testing requirement), the roadway and traffic flow characteristics of the remote sensing sites, and the age mix of the vehicles passing the remote sensing sites. Local pilot testing or experimental testing as done by California Bureau of Automotive Repair (BAR) in Sacramento, CARB in El Monte, and EPA under contract with Automotive Testing Laboratories in Mesa, Arizona (and Hammond, Indiana) is the best approach to determining failure rates for the local fleet. The State of Arizona is now performing large numbers of remote sensing tests in the Phoenix area as part of its I/M program, and EPA will work to help communicate its experiences to other states. EPA has received some of the Arizona IM240 and RSD data; although these data could not be analyzed in time for this document, they are now being reviewed.

However, in a recent draft report [15] from the Arizona Department of Environmental Quality (ADEQ) from a program done in late 1995, 97 in-use vehicles were identified as possibly being high emitters by a single RSD measurement. Since these vehicles were potentially high emitters, they do not represent a cross-section of typically emitting vehicles in the fleet; thus, these results cannot be compared with those from a random set of vehicles such as in the California and EPA studies. The data from these vehicles suggested to the ADEQ that a single RSD measurement did not give a satisfactory pass/fail result. The report also suggests RSD error of commission rates (i.e., false RSD failures) of 15 percent results in RSD identification rate of 80 percent for vehicles failing I/M based on this sample. However, the sample does not include vehicles passing RSD (some of which will be I/M failures) to the extent these vehicles occur in the fleet.

Other state programs implemented or planned will provide valuable information on RSD failure rates. These include a Colorado pilot-type program in Greely and California's implementation of RSD with summons to failing vehicles. Also, an experimental program under rigidly controlled conditions was recently completed in Toronto.

Some vehicles that fail remote sensing, which later obtain an off-cycle inspection (or even an immediate roadside inspection) using the I/M program's normal tailpipe emissions test, pass the off-cycle inspection even though no repairs have been performed. Numerous studies listed in the references have produced information on the frequency of this occurrence of falsely failing RSD. (These references also discuss how frequently vehicles can falsely pass RSD tests.) As technology to utilize speed, acceleration, and engine/catalyst temperature readings along with emission readings is perfected, false passes/failures should greatly decrease.

It is reasonable to expect from the available evidence that false failures on remote sensing are most frequent (as a percentage of all remote sensing failures) among newer vehicles because they have the lowest incidence of actual emissions problems. Newer vehicles can be exempted from remote sensing by discarding their data once model year is determined via the license plate. Doing this may greatly reduce false failures with only minor loss of benefits from missing the relatively few high emitters in newer vehicles.

In addition to actually identifying "dirty" vehicles and forcing them to get repaired, remote sensing may have a motivational effect on vehicles' owners and others which could produce indirect but real benefits. A vehicle owner may request, acquiesce to, or otherwise receive an improper on-cycle inspection possibly at a test-and-repair I/M station in an I/M program for which the state has determined a large discount. Such an improper I/M test can also be associated with an improper or even no repair test that would lower emissions. With the vehicle owner aware of the new risk of failing a remote sensing test with its attendant expense and inconvenience to have the vehicle reinspected and repaired correctly, the vehicle owner instead would make a greater effort to obtain a proper I/M test and repair. Also, I/M facilities would have a greater incentive to correctly administer I/M tests with RSD monitoring in-use emission levels. Also plausible is that vehicle owners who notice a driveability problem or a "check engine" (malfunction indicator) light coming on between inspections might seek more prompt repair lest their vehicles fail remote sensing. (Also, vehicle owners ignoring the "check engine" light coming on can have serious damage, such as to the catalyst, which would be expensive to repair.) In general, a remote sensing program may induce drivers to keep vehicle emissions equipment in good repair, to avoid the inconvenience of additional testing. The magnitude of such a deterrent effect is currently unmeasurable. However, much depends on the level and hence public visibility of remote sensing, the public's perceptions of the possibility of avoidance, whether fines apply to remote sensing failures or only a requirement to pass a confirmatory test, and other factors. This document does not address the potential magnitude of any additional benefits that this deterrence effect might provide to inspection programs. Quantifying deterrent effects is very complex and involves much social science. EPA though welcomes advice from technical experts on what work would be needed to provide data to accurately quantify such effects. Another strategy that does not subject vehicle owners to inconvenient off-cycle inspection is to use remote sensing readings as one input of an algorithm with which to request that certain vehicles obtain their "on-cycle" I/M test at a certain type of inspection station, particularly at a test-only inspection station. In this way, some high-emitting vehicles are ensured a full I/M test that does not suffer from conflict of interest (i.e., the facility doing the test also does the vehicle repairs) or other testing problems (e.g., test-and-repair I/M facilities generally test fewer vehicles than test-only facilities and thus cannot afford more complex and accurate test equipment). This document does not cover developing and using such an algorithm, but EPA will work with states interested in this concept. Recent work by consultants to the California Bureau of Automotive Repair [1] provides a good starting point for EPA to work with other states. California is presently developing such a system as part of its hybrid I/M program.

One additional benefit that remote sensing may provide is additional emission reductions resulting from vehicles with evaporative system problems that are identified as part of the off-cycle inspection required by remote sensing. Since remote sensing measures exhaust emissions, such testing would not be expected to target vehicles with evaporative system problems. However, it could be assumed that some vehicles with evaporative system problems would be targeted by RSD for failing exhaust emissions and required to have an off-cycle inspection on a random basis which could also catch evaporative emission problems. In the case of clean screening, it would be assumed that some vehicles exempted from inspection would also have evaporative system problems and their benefit would be lost to the program. This effect of exhaust failures flagged by remote sensing also having evaporative problems, both positive (with remote sensing exhaust failures getting evaporative emissions repairs) and negative (with clean screening passing what would be exhaust I/M failures), would be linked to the additional failure rate associated with remote sensing requirements. This document only addresses the exhaust benefits of remote sensing options and does not estimate this indirect effect of remote sensing on evaporative emissions, since there are no data yet to quantify credits for repair of evaporative emissions on RSD failures.

More information about the remote sensing process and references to a considerable literature of remote sensing studies are contained in EPA's latest fact sheet on remote sensing [16] which also lists numerous other RSD studies. The report from the recent Sacramento remote sensing study [1] in particular contains many analyses and findings not summarized here. A recent EPA review paper [17] summarizes available RSD studies.

2.3 Other Aspects of a RSD Program

One innovative use of remote sensing is to identify vehicles with the lowest emission levels which are then exempted from the periodic I/M program inspection. A state should use multiple RSD readings in arriving at a clean-screening exemption decision due to the tendency of a single RSD reading leading to a large number of false passes. EPA is still analyzing the use of RSD in clean screening and welcomes input. Clean screening should improve the cost effectiveness of a periodic I/M program by eliminating unnecessary inspections and should increase public awareness and acceptance of the I/M program.

EPA and CARB El Monte studies show that using a single RSD reading allows a large number of RSD passing vehicles to be exempted that in fact would fail an IM240 or equivalent I/M test. Requiring multiple (e.g., possibly three or even four) passing RSD readings on a vehicle will greatly lessen the chances of false passing. Also, a state could implement clean screening (at least in its initial phases) on certain specific model years (e.g., newer model years) not expected to have many I/M failures. Even though EPA and CARB El Monte studies cannot be used to assess how useful a clean-screening program might be since they do not have multiple RSD readings on vehicles, the initial Arizona RSD results on actual in-use vehicles can be used. EPA is analyzing the Arizona RSD database comparing RSD readings to the IM240 results to determine specifics on how many RSD tests are useful for optimal clean-screening results minimizing false RSD passes. Results from other programs (e.g., California, Colorado, and the Toronto study) will also be useful.

The specifics of clean screening (e.g., cutpoints, fraction of the fleet measured, how close to a scheduled I/M test the vehicles must be measured) would be determined by the state; though EPA will give advice as needed. While clean screening does not in itself increase credits, it can improve the cost effectiveness of a periodic I/M program by eliminating unnecessary inspections and increase public acceptance of the I/M program.

In addition, RSD can be used in areas not otherwise needing a full I/M program for the entire vehicle fleet. RSD can flag high emitters and only those high emitters would then be sent for a regular I/M test. Use of RSD in this fashion greatly limits the test-only or test-and-repair I/M facilities needed. However, high emitting vehicles not flagged by RSD in such areas would have no emission reductions.

3.0 REMOTE SENSING CREDITS

The EPA MOBILE5 model stores the credits for all I/M programs in separate data files that are read during MOBILE runs. EPA can modify or supplement these files to add new data and/or options that were not included in the original release of the model, without the need for a new version of the MOBILE model itself. The credits in the I/M credit files can thus be adjusted, as needed, in the coming year to reflect the experience from an in-use remote sensing program. The numbers in the separate data files for determining RSD credits are based on presently available information (discussed in the references) for emission benefits (using IM240/FTP data coupled with RSD readings) and fleet coverage. However, as discussed below, EPA RSD credits allow local areas to use their own specific programs to project fleet coverage (commitments to percent fleet coverage or number of failures). It is critical to emphasize that after RSD programs have been in place for a certain time period (e.g., a year or so), information will be available to update the emission benefits of RSD from those in the reference documents. Also, more information will be available on fleet coverage. The MOBILE5 RSD credit programs will be revised at that point (if not sooner) to use the updated information. Of course, EPA and the states will have much more experience with RSD programs in general, including strong and weak points, not fully realized now, and perhaps some information will be available on deterrence effects.

3.1 Basic Remote Sensing Methodology

It is assumed that vehicles targeted by remote sensing are required to submit to an "off-cycle" I/M inspection in addition to the mandatory periodic inspection. These off-cycle inspections in effect increase the inspection frequency for portions of the fleet. To experience the increase in testing frequency, a high-emitting vehicle must be seen by the remote sensing units, fail the remote sensing cutpoint, and be called in for an "off-cycle" confirmatory I/M inspection.

For biennial I/M programs, it is assumed that on average vehicles tested by remote sensing which fail the RSD cutpoints get one extra inspection at an I/M station due to remote sensing, and that this inspection occurs halfway between the on-cycle biennial inspections. Some vehicles though may fail RSD and receive the extra inspection before the half-way point; other vehicles may have an RSD failure with the extra inspection after the half-way point. Increased emission benefits result from these increased numbers of inspections between "on-cycle" inspections.

Currently, the MOBILE5 model does not calculate inspection frequencies that are greater than annual frequencies, i.e., there are no semi-annual I/M credits to use for the "A" case mentioned below. Thus, with the current MOBILE5 structure, remote sensing benefits attributable to more frequent inspections for programs with annual inspections cannot be generated at least for a test-only I/M program. For an annual test-and-repair program with a discounted effectiveness, RSD benefits can be determined (at least up to the point of an annual test-only program) if the RSD failures are subject to a test-only confirmatory I/M test. However, in the future, if warranted by user interest, EPA could develop credits that reflect the possibility of failing vehicles using remote sensing more frequently than annually.

In a test-and-repair I/M program, a remote sensing failure can force a vehicle to get a test-only confirmatory test. Remote sensing in this case also has the effect of making some vehicles, those seen and failed by remote sensing units, behave as though they were in a test-only program. To model this scenario, the "A" credit is the credit for a test-only program, and the "B" program is the test-and-repair program. The benefit attributed to remote sensing is a portion of the difference in benefits of the test-only and test-and-repair programs. Conceptually, this type of program would produce the largest benefit attributable to remote sensing because of whatever differences exist between test-only I/M benefits on as frequent as an annual basis and test-and-repair benefits from a biennial program affecting the result.

Similarly, a hybrid I/M program requires only some vehicles to obtain a test-only on-cycle inspection, based on age and/or retest status. Since test-only stations exist, remote sensing failures can be sent to them for confirmatory testing. In this case, the "A" program is test-only and the "B" program is hybrid. If the on-cycle program is biennial, remote sensing could create incremental benefits based on both more frequent inspections and test-only inspections for more vehicles.

It is also possible for a state with a test-and-repair I/M program to allow vehicles failed by remote sensing to be confirmatory tested at a test-and-repair station, in which case both "A" and "B" credits are test-and-repair and the only effect of remote sensing is the increase in testing frequency for part of the fleet. This avoids the need for setting up any test-only stations for purposes of confirmatory testing. However, in a test-and-repair program with the RSD failures going to a test-and-repair I/M station, the additional benefits from remote sensing would have to adjusted considering the interaction from whatever discount is determined for test-and-repair programs.

The remote sensing credits are thus a function of four design choices. These choices are: 1) the structure of the periodic I/M program; 2) whether the test which is used to confirm the remote sensing failures is performed at test-only or test-and-repair programs (if the periodic I/M program is test-only, the confirmatory test must be test-only); 3) the fraction of the fleet, by model year, measured by remote sensing; and 4) the effectiveness of the remote sensor at identifying high emitters including the influence of the remote sensing cutpoints or emission standards.

Mathematically, the process to generate the additional remote sensing program credits is as follows:

$$\text{RS Credit}_{m,p} = (A_{m,p} - B_{m,p}) * F_m * E_{m,p}$$

Where:

B = I/M credit for the on-cycle biennial program

A = I/M credit for an annual inspection (test-only or test & repair)

F = Adjusted fraction of the inspected fleet scanned at remote sensing sites

E = Effectiveness of remote sensing identification and repair of high emitters.

m Quantity is a function of vehicle model year; and

p Quantity is a function of pollutant (i.e., HC, CO or NOx).

In the equation, the influence of the underlying I/M program is represented by the variables $A_{m,p}$ and $B_{m,p}$ which are chosen from the already-released I/M credits used with the MOBILE5 model. The variables F_m and $E_{m,p}$ in the equation represent the remote sensing fleet coverage and the
remote sensing effectiveness. The fleet coverage is determined as explained below. The effectiveness is also discussed below and is based on the EPA and California studies. This additional RSD benefit can be added directly to the base program I/M credit ($B_{m,p}$) to give the overall inspection program benefit.

3.2 Inspection Program Designs

The remote sensing I/M credit utility allows the user to describe the remote sensing inspection used either in combination with a periodic I/M program or as a separate inspection program in a non-I/M area. There are five basic I/M program designs that can be selected.

Program l: Basic Remote Sensing Program Design

High-emitting vehicles identified by remote sensing are sent to the periodic I/M inspection stations. This includes the case of test-only I/M programs with test-only confirmation and test-and-repair I/M programs with test-and-repair confirmation of RSD failures.

Since this (and any other) scenario is modeled by increasing the inspection frequency and presently MOBILE5 allows a maximum frequency of I/M as annual, the methods in this document do not calculate a supplemental benefit for RSD with annual inspection programs using this approach.

Program 2: Test-and-Repair Remote Sensing Program

In a test-and-repair I/M area, high-emitting vehicles identified by remote sensing are sent to special test-only inspection stations. As mentioned earlier, credits can be calculated for an annual test-and-repair program with a discounted effectiveness using RSD with the RSD failures being sent to a test-only I/M station.

Program 3: Retest Hybrid Remote Sensing Program

In a retest hybrid I/M area, high-emitting vehicles identified by remote sensing are sent only to the test-only inspection stations.

Program 4: Remote Sensing Only Program

In a "non-I/M" area, high-emitting vehicles identified by remote sensing are sent only to the test-only inspection stations.

Program 5: Clean Screen Remote Sensing Program

In any I/M area, remote sensing is used to identify some low-emitting vehicles which are exempted from the periodic I/M inspection. The databases available for EPA analysis for these credits included only single RSD readings on any given vehicles. Use of a single RSD reading for clean screening, as mentioned previously, should be avoided and instead a state should use multiple RSD readings. Clean screening does not increase the RSD credits, but can help improve the cost/effectiveness and public acceptance of the I/M program. More specific guidance on clean screening with multiple tests will be provided later based largely on the AZ RSD program results which will be analyzed.

3.3 Options for Fleet Coverage

There are three user options for indicating remote sensing program vehicle coverage listed briefly below and discussed in more detail further in Sections 3.3.1, 3.3.2, and 3.3.3. Fleet coverage is the fraction "F" in the equation given earlier.

Option l: Commitment to a Level of Effort

The user specifies the number of valid remote sensing measurements done. The utility estimates vehicle coverage from this information using coverage information derived from a Poisson distribution. The method used to make this estimate is described in a later section.

Option 2: Commitment to a Specific Fleet Coverage

The user specifies the fraction of the fleet in each model year that is seen using remote sensing. This fraction should be only the fraction of the fleet which has had sufficient valid remote sensing measurements to be identified as remote sensing failures for purposes of further I/M inspection. For example, if a state decides (to minimize false confirmatory I/M failures for vehicles failing RSD) that three RSD failures are needed to have a vehicle sent for off-cycle I/M, this fraction should represent the portion of the fleet that has received three RSD readings. The decision on how many RSD failures are needed to send a vehicle for confirmatory I/M testing is left up to the state.

Option 3: Commitment to a Number of Failures

The user specifies the fraction of additional confirmatory I/M failures (beyond those failing the regular periodic I/M test) that are presented for and fail inspection as a result of remote sensing identification. Only vehicles identified for inspection by remote sensing and which fail the I/M inspection count towards this additional fraction of failures. Vehicles failing RSD but that are repaired before the confirmatory I/M test are discussed below.

3.3.1 Option 1: Commitment to a Level of Effort

This is the simplest of the three options in which a state looks at its resources and commits to obtaining a specific number of RSD readings annually. In this option, a modified Poisson algorithm is used to estimate the number of vehicles seen by remote sensing in order to calculate the fraction of the fleet tested by remote sensing (factor F). This is necessary, since the fraction of all vehicles in the fleet which are measured by remote sensing is a function of the total number of remote sensing measurements, but is less than obtained by looking at the number of RSD readings since some vehicles are seen multiple times by RSD. A Poisson algorithm is a standard method to model such a situation. This phenomenon was demonstrated in the Sacramento Study [1] where some individual vehicles were measured several times over the course of the study. This fraction is a function of the annual average VMT of a vehicle model year at a given age compared to its VMT when new. In addition, the fraction of excess emissions identified by remote sensing in the vehicles seen must be estimated (factor E) which the utility does based on excess emissions found in the California and EPA studies as a function of RSD cutpoint. [2, 3, 4, 5, 6] This modified Poisson distribution was discussed as the second option for fleet coverage at the Technical Experts Workshop held on September 12, 1995.[8]

The algorithm used to calculate remote sensing coverage involves a modification to Lambda in the Poisson series using the ratio of the VMT of the youngest model year (age) to the VMT of the model year (age) being estimated. This adjustment uses national average VMT information, but the VMT information can be modified by the user to reflect local, rather than national default, information. The form of the equation is as follows:

$$P = 1.0 - \exp(k * -\text{Lambda})$$

where k is the ratio of VMTs,

$$k = \text{VMT(current age)}/\text{VMT(age=1)}.$$

This algorithm is calculated for each model year and gives the probability of measuring emissions from vehicles of a given model year. One sums the probabilities for each model year to obtain an overall probability for all vehicles. Also, as mentioned later, this option permits the user to specify only vehicles with more than one RSD reading as being flagged for RSD failures. Such a specification will lower the fraction of the fleet seen. However, the fraction of excess emissions discussed in the next section is a function of what was found in EPA and CARB studies which utilized a single RSD reading; thus, while the fraction of the fleet seen will change with multiple RSD readings, the fraction of excess emission found for a given fraction of the fleet inspected will not change with multiple RSD readings due to the databases used. Multiple RSD readings would alter this fraction of excess emissions found. Multiple readings mean fewer vehicles fail RSD which may increase the vehicles falsely passing RSD thus decreasing RSD benefits; on the other hand, those vehicles failing RSD would more likely be true I/M failures increasing the per vehicle benefit for RSD. Unfortunately, there is inadequate data in these studies to get a good estimate of the RSD excess emission benefits with multiple RSD readings; more data are needed and should be available as states (such as Arizona) conduct RSD programs.

3.3.2 Option 2: Commitment to a Specific Fleet Coverage

In this option, the user inputs related to remote sensing effort are replaced by a commitment to obtain valid remote sensing readings on a fraction of the fleet as determined by the state. These readings are used to direct remote sensing failures to I/M stations for inspection. This commitment is for sufficient RSD readings for each vehicle age category (i.e., by model year) separately to meet
the commitment of vehicles for RSD targeting. This requires the user to supply the number of vehicles currently of each age and the number of those vehicles which are committed to be seen by remote sensing in the next year.

Other user inputs related to the remote sensing cutpoints remain and are used to calculate the fraction of excess emissions identified by remote sensing in the vehicles seen (factor E). The fraction of vehicles sent to an I/M station is calculated directly from the user input. It is assumed that this fraction of vehicles replaces the calculation of vehicle coverage that is done in Option 1 using the Poisson distribution (factor F). All other calculations for remote sensing credits remain the same.

As previously noted, the fraction of excess emissions found is not altered in this present credit utility with multiple RSD readings. Data from RSD programs with multiple readings such as the AZ program must be analyzed to provide additional credits when a state decides to have a certain fraction of its fleet measured multiple times by RSD. EPA will address the effect of multiple readings in the future.

3.3.3 Option 3: Commitment to a Number of Failures

In this option, the user provides an estimate of the expected number of I/M failures provided by remote sensing, again by model year/age. If there is an existing periodic I/M program, the actual failure rate for the overall I/M can be used as input in determining what level of additional I/M failures is found by RSD would be reasonable. Beyond the first year of an RSD program, of course, actual numbers of additional I/M failures found by RSD can be used. New I/M areas need to estimate the expected failures found by RSD, perhaps from other operating periodic I/M programs. The user enters the number of additional I/M program failures, by model year/age, that are provided by remote sensing targeting in the next year. The user also needs to know the number of I/M failures from its base I/M program which is also entered. Other user inputs related to the remote sensing cutpoints remain.

For example, a state with 10,000 regular periodic I/M program failures last year for 5-year-old vehicles might specify that an additional 500, 5-year-old vehicles would be failed by using remote sensing to identify vehicles for out-of-sequence testing. The state would then be committing to adequate vehicle coverage and effort to supply sufficient number of vehicles for out-of-sequence testing to result in the additional 500 failures.

Although this option provides the clearest connection between remote sensing activity and confirmed emission repairs, it, like the other options, may underestimate the remote sensing benefits. Some or possibly most vehicle owners, confronted with a requirement to appear for a confirmatory emission test, will have their vehicle repaired before submitting their vehicle for testing. If such vehicles pass the confirmatory test, they could mistakenly be thought to not count toward the commitment of failures by the program, even though the repairs were done. States can use special studies to correct their vehicle count. Analysis of operating remote sensing programs may provide new information on the impact of this behavior in the future.

In this option, the ratio of the additional remote sensing failures to the expected failures represents the fraction of the fleet tested by remote sensing (factor F) used to calculate remote sensing benefits.

F = (Additional remote sensing failures/expected failures)

Although the number of remote sensing failures available to be found will be decreased by the use of higher cutpoints (and the ease with which these failures are found will be decreased since more vehicles will have to be screened to find a given number of failures using higher RSD cutpoints), higher remote sensing cutpoints increase the benefits per failure, since marginal failures are not targeted. Higher cutpoints also help minimize vehicles failing RSD that will pass the confirmatory I/M test (false RSD failures). Therefore, the remote sensing effectiveness (factor E) determined from the user input of remote sensing cutpoints must be adjusted in this option so that it increases as the cutpoints are loosened.

E = function (cutpoint)

This function is determined by examining the emission identification and failure rate of remote sensing samples. A functional relationship array is added into the remote sensing utility which depends on the user input of remote sensing cutpoint. That is, RSD failures with higher cutpoints are assumed to have higher excess emissions found by the confirmatory I/M test that are lowered on vehicle repair. Users are allowed to change this array in the external data file if a user has actual information on the excess emissions found in these failures; such information would be available after an RSD program is in operation. Before the RSD program is in operation (e.g., when making projections for the first year), a state should document its rationale for changing the emission level of the RSD failures; such levels could come from available RSD studies which also measure IM240 or FTP emission levels. All other calculations for remote sensing credits remain the same.

Note in this option that a state commits to a certain number of I/M failures found by RSD. The number of RSD readings per vehicle, single or multiple, does not affect the credit assigned in this option. All that matters is that the vehicles are found to be I/M failures on the confirmatory I/M test after failing RSD.

3.4 Remote Sensing Effectiveness

Remote sensing effectiveness refers to the ability of remote sensing to correctly identify vehicles which fail an I/M inspection. Assuming that all vehicles in a fleet were tested using remote sensing, and if, using remote sensing, it were possible to identify every vehicle in that fleet that fails an I/M inspection, then the effectiveness of remote sensing is 100 percent. In practice, even if vehicle coverage were complete, not all I/M failures are identified by remote sensing. The shortfall in identification depends primarily on the remote sensing CO measurement cutpoint chosen by the program.

For purposes of determination of remote sensing effectiveness, the emissions of individual vehicles were defined as their IM240 scores measured in grams per mile. Excess emissions were defined as any IM240 emissions in excess of IM240 emission levels selected to identify emission that can be reduced by repairs. This approach is used by California and was discussed at the EPA Technical Experts Workshop held September 15, 1995.[1] These IM240 emission levels are shown in Tables 1a and 1b for California standards and Federal standards data. Therefore, by definition, vehicles with emissions lower than these IM240 levels have no excess emissions that can be identified and reduced by vehicle repairs. The excess emissions are assumed to be the only potential benefit of identification of a vehicle by remote sensing for repairs, since the vehicle must fail an IM240 type inspection in order to be required to have repairs performed. Repaired vehicles are assumed to pass the IM240-type test procedure after repairs.

Table 1a

IM240 Excess Emission Thresholds
(for California Emission Standards)

Model Year	HC (g/mi)	CO (g/mi)	NOx (g/mi)
1975-76	2.70	18.0	2.00
1977-79	1.23	18.0	1.50

1980	1.23	18.0	1.00
1981-86	0.59	10.5	1.05
1987-88	0.39	7.0	0.70
1989+	0.39	7.0	0.40

Table 1b

IM240 Excess Emission Thresholds (for Federal Emission Standards)

Model Year	**HC (g/mi)**	**CO (g/mi)**	**NOx (g/mi)**
1975-76	4.50	30.0	3.1
1977-79	4.50	30.0	2.0
1980	1.23	14.0	2.0
1981-86	0.62	5.1	1.5
1987-88	0.41	3.4	1.0
1989+	0.41	3.4	1.0

The identification rate is the fraction of all excess emissions for each pollutant (HC, CO and NOx) from vehicles identified by remote sensing. The identification rate is determined for three technology groupings of vehicles as below (generally the first two categories are combined).

Pre-1975 model years (non-catalyst)
1975 through 1980 model year (oxidation catalyst)
1981 and newer model years (3-way catalyst)

The identification rate was based solely on the CO emission measurement from remote sensing (use of the CO reading is also a reasonably accurate surrogate for exhaust HC). An identification rate was determined for each case, from 0.5 through 7.5 percent CO, in increments of 0.5 percent CO. For the default values, the data from the El Monte Parking Lot Study by the California Air Resources Board was combined with EPA testing in Arizona. [2, 3, 4, 5] The results are summarized in Table 2 below.

Table 2

Fraction of IM240 Excess Emissions Identified Using Remote Sensing CO Cutpoints (Combined CARB El Monte/EPA Studies)

Remote Sensing	1980 and Older Model Years			1981 and Newer Model Years		
CO Cutpoint	HC	CO	NOx	HC	CO	NOx
0.5%	0.543	0.945	0.436	0.570	0.596	0.283
1.0%	0.487	0.899	0.423	0.433	0.499	0.178
1.5%	0.487	0.758	0.335	0.387	0.442	0.122
2.0%	0.487	0.751	0.295	0.348	0.396	0.091
2.5%	0.272	0.676	0.232	0.319	0.352	0.059
3.0%	0.272	0.662	0.146	0.262	0.278	0.054
3.5%	0.262	0.584	0.118	0.217	0.213	0.042
4.0%	0.184	0.489	0.067	0.182	0.178	0.018
4.5%	0.110	0.467	0.067	0.150	0.133	0.015
5.0%	0.110	0.420	0.063	0.109	0.107	0.009
5.5%	0.095	0.398	0.052	0.071	0.072	0.006
6.0%	0.095	0.398	0.000	0.060	0.053	0.003
6.5%	0.095	0.398	0.000	0.046	0.044	0.003
7.0%	0.088	0.308	0.000	0.039	0.034	0.003
7.5%	0.022	0.205	0.000	0.028	0.017	0.003

In addition, the average excess emissions of remote sensing failures for each cutpoint was needed for each technology grouping for programs that commit to a number of failures. The average excess emissions as a ratio of the average IM240 excess emissions identified per vehicle at various RSD cutpoints compared to the average excess emissions per vehicle in the fleet as a whole were determined using the same combined data sets and cutpoints used for determination ofidentification rates. For an RSD cutpoint of 0 percent for CO, all (100 percent) of the excess emissions are obviously identified. The results are summarized in Table 3 below.

Table 3

Ratio of Average IM240 Excess Identified Emissions per Vehicle to Average Excess Emissions per Vehicle in Fleet Using Remote Sensing CO Cutpoints (Combined CARB El Monte/EPA Studies) (0% CO Cutpoint Gives Ratio of l)

Remote Sensing	1980 and Older Model Years			1981 and Newer Model Years		
CO Cutpoint	**HC**	**CO**	**NOx**	**HC**	**CO**	**NOx**
0.5%	0.84	1.86	0.98	1.51	2.47	0.95
1.0%	0.85	2.13	1.06	1.57	3.11	0.97
1.5%	0.85	2.34	1.01	1.87	3.54	0.93
2.0%	0.85	2.67	1.10	2.05	4.05	0.91
2.5%	0.54	3.20	1.05	2.28	4.73	0.88
3.0%	0.54	3.61	0.82	2.70	5.42	0.92
3.5%	0.61	3.77	0.76	2.88	6.30	1.01
4.0%	0.52	4.34	0.76	3.07	7.08	0.69
4.5%	0.38	5.53	1.00	3.08	6.54	0.72
5.0%	0.38	5.96	1.42	2.88	6.49	0.49
5.5%	0.44	7.06	2.34	3.28	8.31	1.00
6.0%	0.44	7.06	0.00	4.43	9.13	0.90
6.5%	0.44	7.06	0.00	4.27	11.38	0.90
7.0%	0.62	7.28	0.00	4.82	11.63	0.90
7.5%	0.30	7.29	0.00	5.25	8.71	0.90

These results are similar to those presented at the EPA Technical Experts Workshop. [6] The major differences is that only the data from the EPA and CARB El Monte studies [2,3,4,5] are used with the data from the California Sacramento pilot study [1] not being included. Excluding the California Sacramento study for the effectiveness calculations increases the RSD benefits somewhat.

3.5 Estimating Remote Sensing Benefits

As described in Section 3.1, the effect of remote sensing on I/M credits are determined by one of the following methods:

Interpolating between existing annual and biennial I/M credits;.
Interpolating between test-and-repair or retest-based hybrid I/M credits and test-only I/M credits; or
Interpolating between zero credit and the applicable annual I/M credits

If the existing periodic I/M program (either test-and-repair, retest-based hybrid or test-only) is biennial and vehicles are directed to standard I/M stations used in that program, the addition of remote sensing is modeled as an increase in the inspection frequency. This is done solely by interpolating between the annual and biennial program credits of the same type.

If the existing periodic I/M program is either test-and-repair or retest-based hybrid, and vehicles are directed only to test-only stations, then not only is the frequency of inspection increased, but the effectiveness of the inspection is enhanced. This is done by interpolating between the base program credits (either test-and-repair or retest-based hybrid, either annual or biennial) and test-only annual credits.

If there is no existing I/M program and RSD is used to flag high emitters for inspection and repair, the benefits are calculated directly from the applicable annual I/M credits interpolating as necessary accounting for the vehicle coverage and remote sensing effectiveness.

For purposes of determination of I/M credits, effectiveness is defined as the ability of remote sensing to properly identify I/M failures. Vehicles which fail I/M but do not fail remote sensing (false RSD passes) cannot contribute to additional I/M benefits from remote sensing. Vehicles which fail remote sensing but do not fail I/M are not required to be repaired and are assumed not to contribute to additional I/M benefits. Therefore, it is the fraction of emissions represented by vehicles identified by remote sensing which fail the I/M test which can contribute to additional I/M benefits.

The calculation of the effects depends on the inspection program type. The benefit is calculated from the existing I/M credits for the inspection program type in combination with similar I/M credits that represent the effect of the additional failures targeted by remote sensing. The following definitions are used in the formulas giving RSD credits:

A(TO): Annual test-only I/M credit

A(T&R): Annual test-and-repair I/M credit

A(RH): Annual retest-based hybrid I/M credit

B(TO): Biennial test-only I/M credit

B(T&R): Biennial test-and-repair I/M credit

B(RH): Biennial retest-based hybrid I/M credit

F: Fraction of the fleet tested by remote sensing:
Remote sensing program effectiveness
(identification and repair of high emitters)

C: Overall I/M credit with remote sensing added

The IM credit for the following inspection program types are included in the remote sensing utility:

1. Remote sensing failures are inspected at standard periodic I/M program stations (either test-only or test-and-repair).

C = B(TO) + (A(TO)-B(TO)) * F * E

or

C = B(T&R) + (A(T&R)-B(T&R)) * F * E

The test-and-repair case is simply the test-only case with a test-and-repair discount of 50 percent
applied within MOBILE5; for different test-and-repair discounts, one uses the MOBILE5 case with 50 percent and the corresponding test-only no discount case and interpolates. Future versions of the MOBILE model will apply the user supplied test-and-repair discount. Therefore, for MOBILE5, separate test-and-repair I/M credit files are not needed. If a test-and-repair discount of other than 50% is used, then an interpolation is necessary.

2. Periodic test-and-repair I/M program with remote sensing failures inspected at special test-only stations.

C = A(T&R) + (A(TO)-A(T&R)) * F * E

C = B(T&R) + (A(TO)-B(T&R)) * F * E

Test-and-repair situations are handled as in case 1. above.

3. .Periodic retest-based hybrid I/M program with remote sensing failures inspected only at test-only stations.

C = A(RH) + (A(TO)-A(RH)) * F * E

C = B(RH) + (A(TO)-B(RH)) * F * E

4. Non-I/M area with remote sensing failures inspected at special stations.

C = A(TO) * F * E

or

C = A(T&R) * F * E

The test-and-repair case is, again, simply the test-only case with the test-and-repair discount applied. Therefore, for MOBILE5, separate test-and-repair I/M credit files are not needed.

When using the RSD utility and for MOBILE modeling in general, one should note that I/M credits are based on different aspects of the I/M program. For example, anti-tampering benefits are assigned for the program as a whole on top of which a per-vehicle benefit is assigned for I/M failures. Thus, increasing the number of I/M failures by, for example, a factor of two will not increase the I/M program benefits by a factor of 2.

4.0 REMOTE SENSING UTILITY

4.1 Remote Sensing Utility Input Structure

The remote sensing utility is designed to be used once for a scenario selected by the user. It is assumed that the number of scenarios that a user might consider is small enough so that batch run options are not necessary. Each run requires a single input file which contains all of the information required by the utility and supplied by the user. The user is prompted for the name (including path, if not in the local directory) of the input file.

Enter the name of the remote sensing input file: (default RSD.D)

Note that all inputs have default values. Here, if the user does not enter a name instead using the EPA files (which the user is generally expected to use lacking any specific local data), the utility will look for the "RSD.D" file in the local directory.

The input file contains all of the remaining information needed to calculate the remote sensing effects, including the location of the original I/M credit data files and the names and location of the output remote sensing credit files.

The input file is structured so that each line (record) begins with an identification number. This number indicates what information is contained on that record and allows the records to be entered in any order. Although some records are mandatory, any records missing from the input file revert to default values stored in the utility. In this way, only the information that the user wishes to supply need be included in the input file. Any records with a record number of 000 are considered comment records and are not processed. In addition, text may be added to records beyond the last formatted data entry on any card to clarify the contents of that record. This additional text is not read or processed by the utility.

Control Section of Input File

Records 001 and 002 are mandatory records.

Record 001 contains the user selection of the fleet coverage option. The format of this record is (I3,11X,I1), meaning the first three characters contain the record number, followed by 11 blank characters, followed by the user selection of Option. Any characters following the user selection are ignored by the utility, but can be used to annotate the input file. The available option levels as described in Section 3.3 on fleet coverage are as follows.

1: Commitment to a Level of Effort

2: Commitment to a Specific Fleet Coverage

3: Commitment to a Number of Failures

Record 002 contains the user selection of I/M program design. The format of this record is identical to Record 001. The available program design levels (described in Section 3.2) are as follows.

1: Basic Remote Sensing Program Design

2: Test-and-Repair Remote Sensing Program

3: Retest Hybrid Remote Sensing Program

4: Remote Sensing Only Program

5: Clean Screening Remote Sensing Program

A complete description of these user options is located in the previous section regarding the basic utility description. The user must always enter both Record 001 and 002 in order to use the remote sensing utility. The following is an example input of the control section, including some added comments to add clarity.

```
000 Control Section
000 ---------------
001        2 Option (may be 1, 2, or 3)
002        1 Program Type (may be 1, 2, 3, 4, or 5)
```

Filenames Section

In this section, Records 005 through 008 indicate the name and location of the standard I/M credit data files and Records 015 through 018 determine the location and name of the resulting remote sensing adjusted I/M credit data files. Normally, the resulting I/M credit data will be written to the filenames in Records 015-018. The indicated I/M credit input files are not altered by the utility. Instead, new replacement credit files are created with the appropriate adjustment of the I/M credits to reflect the effects of the user specified remote sensing program.

The format of each record is (I3,1X,A40), meaning the first three characters contain the record number, the next character is blank, followed by up to 40 characters which indicate the file name, including any necessary path information. If no path is specified, the data files must reside in the same (local) directory from which the utility is run. The record number for each file are as follows.

Input Files

Record Description

005: 1981 and newer model year credits
006: 1981 and newer model year Retest-Hybrid credits
007: Pre-1981 model year credits
008: Pre-1981 model year Retest-Hybrid credits

Output Files

Record Description

015: Adjusted 1981 and newer model year credits
016: Adjusted 1981 and newer model year Retest-Hybrid
017: Adjusted Pre-1981 model year credits
018: Adjusted Pre-1981 model year Retest-Hybrid credits

Since there are default filenames for the standard I/M credit files and the output files, the user may skip all of these input records and the default names are used. All of the files, however, then must be in the local directory. The following is an example input of the filename section, using files other than the default filenames, including some added comments to add clarity.

```
000 Input and Output Filenames
000 ---------------------------------------- Default
005 C:\DATA\IM1.D                IMDATA.D
006 C:\DATA\IMH.D                HYBRID.IMC
007 TC1.D                        TECH12.D
008 TCH.D                        TECH12.D
015 RSDDAT11.D                   RSDDATA.D
016 RSDDATA.H                    RSDDATA.H
017 TECDAT11.D                   TECDATA.D
018 TECDATA.H                    TECDATA.H
```

For maximum flexibility, separate input has been allowed for Retest-Hybrid I/M credits for the pre-1981 model year vehicles, even though EPA has not calculated separate credits for that case. For this reason, the default input for that case is identical to the standard input file.

One-Time Data Section

Some remote sensing program information applies to all options. This information includes the following which are described in more detail afterwards.

Record Description

024: The age at which vehicles first become eligible for targeting by remote sensing
031: The CO cutpoints to be applied to remote sensing measurements for 1974 and older model year vehicles
032: The CO cutpoints to be applied to remote sensing measurements for 1975 through 1980 model year vehicles
033: The CO cutpoints to be applied to remote sensing measurements for 1981 and newer model year vehicles
041: The test and repair effectiveness for HC emissions
042: The test and repair effectiveness for CO emissions
043: The test and repair effectiveness for NOx emissions

The age at which vehicles first become eligible for targeting by remote sensing allows the user to exempt newer vehicles in the fleet from targeting. Newer vehicles tend to produce fewer benefits and more false failures than older vehicles. Exempting vehicles from targeting does not reduce their I/M benefits, but does not provide additional benefits from remote sensing. The age that vehicles are first eligible for RSD targeting is entered on Record 024. The format for this record is (I3,1X,I11).

The CO cutpoint to be applied to remote sensing measurements for targeting must be provided for each of three model year groupings of vehicles.

1974 and older model year vehicles (Record 031)
1975 through 1980 model year vehicles (Record 032)
1981 and newer model year vehicles (Record 033)

This cutpoint is used to select the effectiveness of the remote sensing measurement in determining whether vehicles pass or fail an I/M inspection. It is assumed that all vehicles which are subject to the inspection program, are measured the specified number of times, and exceed the CO cutpoint for their model year, are required to undergo an additional, out-of-sequence I/M inspection.

If the user enters 99.9 for a CO cutpoint, vehicles in those model years are assumed to be exempted from the remote sensing program and the I/M credits for those model years are not adjusted. If a more complicated scheme for use remote sensing measurements to identify vehicles for I/M testing is proposed, the user should consult with EPA. The cutpoints (or 99.9 for exempted) are entered on Record 031 (for 1974 and older vehicles), Record 032 (for 1975 through 1980 vehicles) and Record 033 (for 1981 and newer vehicles). The format for this record is (I3,1X,F11.3).

The current version of the model, MOBILE5a, adjusts the I/M credits for test and repair I/M program designs to be 50 percent of the benefits of test-only program designs. Future versions of the model will allow for user input of test-and-repair effectiveness values as established by data from the states in accord with the National Highway System Designation Act. The remote sensing I/M credit utility, therefore, allows the user to specify the value for the effectiveness of test and repair I/M program designs to be used in determining the effects of remote sensing. One option is, for now, to interpolate between the 50 percent discount provided by MOBILE5a for test-and-repair and the benefit for a test-only program with no discount. One then interpolates to estimate what a credit would be for a particular test-and-repair program with a discount between 50-100 percent. The provisions of the National Highway System Designation Act set up criteria by which to determine the proper test-and-repair discount. There are three records (Records 041, 042 and 043) for HC, CO and NOx effectiveness values. The format for these records are (I3,1X,F11.2).

The following is an example input of the one-time data section, using the default age, cutpoint and effectiveness values, including some added comments to add clarity:

```
000 One-Time Data Section
000------------------------------
024       1  Age when first eligible (1-24), default 1
```

031 3.0 CO cutpoint, '74 & older model years, default 3.0
032 3.0 CO cutpoint, '75 - '80 model years, default 3.0
033 3.0 CO cutpoint, '81 & newer model years, default 3.0
041 0.50 Test and repair effectiveness for HC, default .50
042 0.50 Test and repair effectiveness for CO, default .50
043 0.50 Test and repair effectiveness for NOx, default .50
The default values above are what is assumed if not input is provided.

The calculations of benefits require the use of an estimate of the effectiveness of remote sensing in identification of excess emissions for the remote sensing CO cutpoint chosen by the user. The default values for this ratio may be overridden by the user by entering Records 401 through 415 for HC, Records 501 through 515 for CO and Records 601 through 615 for NOx emissions. Each of the fifteen records contain three ratios for each CO cutpoint from 0.5% through 7.5% for three model year groupings.

1974 and older model years
1975 through 1980 model years
1981 and newer model years

The format for the record is (I3,1X,F11.3,F11.3,F11.3). This means that the first 3 characters contain the record number, the next character is a blank followed by a number (including a decimal) within the next 11 spaces, indicating the effectiveness that are used for 1974 and older model year vehicles, followed by another number (including a decimal) within the next 11 spaces, indicating the effectiveness that are used for 1975 through 1980 model year vehicles, followed by another number (including a decimal) within the next 11 spaces, indicating the effectiveness that are used for 1981 and newer model year vehicles.

Option 1: Data Section

The first vehicle coverage input option requires that the user supply information on the level of effort which is applied to make a given number of valid vehicle measurements using remote sensing. This information includes:

Record Description

021: The number of vehicles in the fleet
022: The number of valid measurements per month that are made using remote sensing devices
023: The number of times that a vehicle must be failed by RSD before it can be targeted for I/M inspection.

In addition, the user may supply the average vehicle miles traveled per year by vehicle age to override the MOBILE5 default values normally used in the calculations.

The number of vehicles in the fleet represents the population of vehicles which are subject to the inspection program in the area. This number excludes out-of-area vehicles and vehicles exempted from the inspection. The number of vehicles in the fleet is entered on Record 021. The format for this record is (I3,1X,I11).

The number of valid measurements per month that are made using remote sensing devices is the primary measure of the level of effort related to vehicle coverage. The number of valid measurements that can be made with remote sensing devices depends on a great variety of factors including the number of practical remote sensing locations (as mentioned before, optimal RSD sites for vehicle speed and acceleration to assure most vehicles are not under high loads and thus in enrichment operation may not always have high-traffic flow), the number of devices provided, the amount of staff required and available to operate the remote sensing devices, the density of vehicles subject to the inspection program at the remote sensing sites, the number of hours and days that the remote sensing devices are operated, the staff allocated to remote sensing data processing and the quality of the remote sensing readings. The number entered by the user represents the commitment by the program to expend sufficient effort to make that number of valid measurements in each month. This number is entered on Record 022. The format for this record is (I3,1X,I11).

The input of the number of times that a state determines a vehicle must be failed using remote sensing before it can be targeted for I/M inspection allows for the use of multiple measurements to reduce the number of false failures. The utility allows the user to specify up to 11 measurements; although, again, the present EPA credit data are based on a single measurement and give no additional credit for multiple measurements. This means that vehicles which are measured less than the user specified number of times cannot be used for targeting. Increasing the number of times a vehicle must be measured noticeably reduces the vehicle coverage, since for a fixed number of measurements, the same vehicles must be measured multiple times. This number is entered on Record 023. The format for this record is (I3,1X,I11).

The following is an example input of the Option 1 data section, using values other than the default values, including some added comments to add clarity.

```
000 Option 1 Data Section
000 ---------------------
021  810498  No. of veh. in inspection area default 1000000
022  110808  Valid veh. measurements per month default 50000
023  3  No. times a veh. must be measured default 1 (1-11)
```

In addition, the user may supply the average vehicle miles traveled per year by vehicle age to override the MOBILE5 default values normally used in the calculations. This requires the entry of 25 separate records (Records 101 through 125). Record 101 contains the mileage accumulation of vehicles from 0 to 1 year of age. Record 102 contains the mileage accumulation of vehicles from 1 to 2 years of age, and so forth. Since vehicles are more likely to be measured if they drive more, a higher mileage accumulation in proportion to other vehicles increases the expected number of vehicles of that age that are measured. The default values assume that all vehicles travel the roadways which are monitored using remote sensing. If remote sensing is to be restricted to only some roadways (such as limited access freeways), the distribution of mileages should be adjusted to reflect the actual distribution of ages expected on those roadways. The format for these records is

(I3,1X,I11).

Option 2: Data Section

The second vehicle coverage input option requires that the user supply information on the fraction of the fleet in each model year which have sufficient valid vehicle measurements using remote sensing to be targeted each year. For example, if it takes three RSD failures to have a vehicle be sent for an I/M test, this is the fraction of the fleet which will be measured three times by RSD. Again, our present data base allows no extra credit in excess emission found for such multiple measurements simply because this type of information is not available in the studies used. This is a commitment on the part of the program to apply sufficient resources to find and measure a fraction of each model year using remote sensing. The fraction of the fleet measured can vary from model year to model year, reflecting the difficulty in finding and measuring older model years, which drive less and tend to avoid some roadway types, such as limited access freeways.

A separate record must be entered for each of 25 vehicle ages (Records 201 through 225). There are no default values for these inputs. Each record contains the record number, the number of vehicles which are eligible for targeting each year (i.e., the total number of vehicles on which remote sensing readings are taken), and the total number of vehicles of that age in the vehicle fleet subject to inspection (i.e., the total number of vehicles in the fleet on which a state commits to obtain remote sensing readings). The entry of both the number of vehicles subject to inspection and the number expected to be eligible, instead of a single fractional estimate, for each vehicle age allows for an explicit count of the number of vehicles which must be measured and eligible for targeting.

The format for the record is (I3,1X,2I11). This means that the first 3 characters contain the record number, the next character is a blank followed by an integer number in the next 11 spaces, indicating the total number of eligible vehicles of that age, followed by another integer number in the next 11 spaces, indicating the number of vehicles in that age which have sufficient valid vehicle measurements using remote sensing to be targeted each year.

The following is an example input of the Option 2 data section. The example assumes a MOBILE5 default distribution of 1 million vehicles and assuming, using remote sensing, that 1% of each model year are eligible for targeting. The records include some added comments to add clarity.

```
000 Option 2 Data Section
000       Total   Eligible
000 ----------------------
201       49000        490  Option 2 : Age  0 -  1
202       79000        790  Option 2 : Age  1 -  2
203       83000        830  Option 2 : Age  2 -  3
204       82000        820  Option 2 : Age  3 -  4
205       84000        840  Option 2 : Age  4 -  5
206       81000        810  Option 2 : Age  5 -  6
```

207	77000	770 Option 2 : Age 6 - 7
208	56000	560 Option 2 : Age 7 - 8
209	50000	500 Option 2 : Age 8 - 9
210	51000	510 Option 2 : Age 9 - 10
211	50000	500 Option 2 : Age 10 - 11
212	54000	540 Option 2 : Age 11 - 12
213	47000	470 Option 2 : Age 12 - 13
214	37000	370 Option 2 : Age 13 - 14
215	24000	240 Option 2 : Age 14 - 15
216	19000	190 Option 2 : Age 15 - 16
217	14000	140 Option 2 : Age 16 - 17
218	15000	150 Option 2 : Age 17 - 18
219	11000	110 Option 2 : Age 18 - 19
220	8000	80 Option 2 : Age 19 - 20
221	6000	60 Option 2 : Age 20 - 21
222	5000	50 Option 2 : Age 21 - 22
223	4000	40 Option 2 : Age 22 - 23
224	3000	30 Option 2 : Age 23 - 24
225	10000	100 Option 2 : Age 24 - 25

Option 3: Data Section

The third vehicle coverage input option allows the user to specify an estimate of the expected number of I/M failures provided by remote sensing, by age, in the current year. In this way, the number of vehicles in the fleet which are measured or how many times each vehicle is seen are not needed. The user only need indicate the CO cutpoints used for remote sensing and a commitment to the number of failures in each age that are provided.

A separate record must be entered for each of 25 vehicle ages (Records 301 through 325). There are no default values for these inputs. Each record contains the record number, the number of vehicles of that age which normally fail this year in the periodic inspection program, and the number of additional vehicles of that age which are referred to the I/M inspection by remote sensing targeting and fail the inspection this year (i.e., remote sensing failures which also fail the confirmatory I/M test). The format for the record is (I3,1X,2I11). This means that the first 3 characters contain the record number, the next character is a blank followed by an integer number in the next 11 spaces, indicating the number of vehicles of that age which normally fail this year in the periodic inspection program, followed by another integer number in the next 11 spaces, indicating the number of additional vehicles of that age which are referred to the I/M inspection by remote sensing targeting and fail the inspection this year.

The following is an example input of the Option 3 data section. The example assumes an equal number of failures in each age and assuming that, using remote sensing, that an additional 1% are failed by the I/M inspection. The records include some added comments to provide clarity.

000 **Option 3 Data Section**

```
000    Failures Additional
000 ----------------------
201      9000      90  Option 3 : Age  0 -  1
202      9000      90  Option 3 : Age  1 -  2
203      9000      90  Option 3 : Age  2 -  3
204      9000      90  Option 3 : Age  3 -  4
205      9000      90  Option 3 : Age  4 -  5
206      9000      90  Option 3 : Age  5 -  6
207      9000      90  Option 3 : Age  6 -  7
208      9000      90  Option 3 : Age  7 -  8
209      9000      90  Option 3 : Age  8 -  9
210      9000      90  Option 3 : Age  9 - 10
211      9000      90  Option 3 : Age 10 - 11
212      9000      90  Option 3 : Age 11 - 12
213      9000      90  Option 3 : Age 12 - 13
214      9000      90  Option 3 : Age 13 - 14
215      9000      90  Option 3 : Age 14 - 15
216      9000      90  Option 3 : Age 15 - 16
217      9000      90  Option 3 : Age 16 - 17
218      9000      90  Option 3 : Age 17 - 18
219      9000      90  Option 3 : Age 18 - 19
220      9000      90  Option 3 : Age 19 - 20
221      9000      90  Option 3 : Age 20 - 21
222      9000      90  Option 3 : Age 21 - 22
223      9000      90  Option 3 : Age 22 - 23
224      9000      90  Option 3 : Age 23 - 24
225      9000      90  Option 3 : Age 24 - 25
```

The calculation of benefits used in this option uses a measure of the average excess emission levels of vehicles failing the remote sensing cutpoint chosen by the user. This measure is the ratio of the average excess emissions of vehicles identified by the remote sensing cutpoint divided by the average emissions of all vehicles with excess emissions. In this way, the fact that remote sensing may be used to target only the highest emitting vehicles can be used in determination of the benefits of identification of these vehicles.

The default values for this ratio may be overridden by the user by entering Records 701 through 715 for HC, Records 801 through 815 for CO and Records 901 through 915 for NOx emissions. Overriding the default values which come from the California/EPA studies would require data from an actual in-use RSD program showing the actual emissions of the remote sensing failures. Each of the fifteen records contain three ratios corresponding to a cutpoint from 0.5% through 7.5% for three model year groupings:

1974 and older model years
1975 through 1980 model years
1981 and newer model years

The format for the record is (I3,1X,F11.3,F11.3,F11.3). This means that the first 3 characters contain the record number, the next character is a blank followed by a number (including a decimal) within the next 11 spaces, indicating the ratio that are used for 1974 and older model year vehicles, followed by another number (including a decimal) within the next 11 spaces, indicating the ratios that are used for 1975 through 1980 model year vehicles, followed by another number (including a decimal) within the next 11 spaces, indicating the ratios that are used for 1981 and newer model year vehicles.

Appendix A contains a more concise narrative listing of the records for the RSD utility.

4.2 Using Remote Sensing I/M Credits with MOBILE5

MOBILE5 uses two external data files which contain the I/M credits whenever an I/M program is specified in the user input. The benefit of I/M program options can be adjusted by altering the numbers contained in those data files. The remote sensing I/M credit utility takes advantage of that fact by adjusting the default I/M credit files to reflect the user supplied information about the use of remote sensing in the inspection programs. In this way, the current version of MOBILE5 (MOBILE5, March 26, 1993 or MOB5a_H, February 1995) can be used to evaluate remote sensing options.

The first step is to describe the remote sensing program to be modeled in sufficient detail to create an input file for the remote sensing I/M credit utility. For some proposed programs, it may be necessary to estimate or assume some of the necessary input data. However, the inputs should reflect, as near as possible, the actual expected performance of the remote sensing program element.

Once the remote sensing program design has been determined, the necessary input data must be collected together in the input data file. An example input data file is provided with the remote sensing I/M credit utility which shows the format for all of the necessary input parameters. The user should carefully read the User Guide to identify the necessary data and to properly locate the data in the input file. The input data file is a simple ASCII text file that can be changed using any standard editor or word processor. However, the user must save any changes in a text format. The Remote Sensing I/M Credit Utility cannot read input files which are saved in a word processing format.

The next step is to create an alternative set of I/M credit data files using the remote sensing I/M credit utility. The input file designates the names of the default I/M credit files to be used and the names of the altered I/M credit files output by the remote sensing utility. These filenames can include "path" information if the I/M credit files are not located in the local directory. If a path is not specified, the default I/M credit files must be in the local directory when the remote sensing utility is run.

The remote sensing utility is run by simply invoking its name (RSDUTIL.EXE) at the DOS prompt. There are no interactive features to the remote sensing utility, and so no further user input is required. The processing is quite lengthy, and some time will pass. There will be some diagnostic information on the screen during processing. When completed without errors, the remote sensing utility will display a completion message on the screen.

Once the processing has been completed, the new I/M credits, adjusted for remote sensing, will be in the filenames indicated by the user in the input file. Although these files can be renamed to the MOBILE5 default I/M credit filenames, there will be no output in MOBILE5 which indicates that alternate I/M credits were used. It may be less confusing to require that these alternate I/M credits be accessed using the alternate credit option in MOBILE5 described in the MOBILE5 User Guide Section 2.2.5.4. In this case, the input file for MOBILE5 would indicate which set of alternate credits were used.

Since the effect of remote sensing is contained in the alternate I/M credit files, there should be no need to change any of the normal MOBILE5 input parameters (other than those to access the use of alternate I/M credits) to reflect the use of remote sensing. It is very important, therefore, to carefully choose the right combination of factors in the remote sensing I/M credit utility that properly reflect the features of the remote sensing program elements.

5.0 REFERENCES

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7. "Approaches to Integrating Remote Sensing Benefits into the MOBILE5 Structure," Draft EPA Paper, August 1995.

8. "Methods to Assess Fleet Coverage," Draft EPA Paper, August 31, 1995.

9. "Remote Sensing Program Scenarios," Draft EPA paper, August 31, 1995.

10. "Description of Remote Sensing and Regulatory Requirements," Draft EPA Paper, August 31, 1995.

11. "Potential Remote Sensing Device Specifications," Draft EPA paper, August 31, 1995.

12. "Final Statement on Remote Sensing Policy," Memo from Steve Gerritson to Candy Garrett, Chris Kite, Celia Shih, Doug Surpitski, Jon Heuss, Bob Stevens, Lois Platte, Joe Somers, and Dave Brzezinski, February 23, 1996.

13. "Review of Draft EPA RSD Paper," Memo from Randy Guensler and Lois A. Platte to Members of the Mobile Source Technical Advisory Subcommittee, June 12, 1996.

14. Letter from Lois A. Platte to Gerry Gallagher, Colorado Department of Health, June 11, 1996.

15. "Laboratory Assessment of the Remote Sensing Device Program," Arizona Department of Environmental Quality Draft Report, Cox, Frank W., John R. Walls, Mark W. Carrel, Andy G. Clifton, Jimmy D. Lewis, and Warren C. Mason, 1996.

16. "Remote Sensing: A Supplemental Tool for Vehicle Emission Control," EPA Office of Mobile Sources Fact Sheet, August 15, 1993.

17. "The Potential Use of Remote Sensing Devices in Inspection and Maintenance Programs," Morgan, Julie K., EPA - Region 9, August 1995.

APPENDIX A

List of Records for RSD Utility

000 control section
001 fleet coverage

1 commitment to level of effort RSD program
2 commitment to specific fleet coverage RSD program
3 commitment to a number of failures RSD program

002 I/M program design

1 basic remote sensing program
2 test-and-repair remote sensing program
3 retest hybrid remote sensing
4 remote sensing only program
5 clean screening remote sensing program

005-008 - no user input; indicates name & location of standard I/m credit data input files

015-018 - no user input; indicates location and name of the resulting remote sensing adjusted I/M credit data output files

Input Files

005 1981 & newer model year credits
006 1981 & newer model year retest-hybrid credits
007 pre-1981 model year credits
008 pre-1981 model year retest-hybrid credits

Output Files

015 adjusted 1981 & newer model year credits
016 adjusted 1981 and newer model year only for retest-hybrid credits
017 adjusted pre-1981 model year credits
018 adjusted pre-1981 model year only for retest-hybrid credits
024 the age at which vehicles first become eligible for targeting by remote sensing, 1 to 24 (default = 1 year)
031 the CO cutpoints to be applied to remote sensing measurements for 1974 and older model year vehicles, default = 3%
032 the CO cutpoints to be applied to remote sensing measurements for 1975 through 1980 model year vehicles, default = 3%
033 the CO cutpoints to be applied to remote sensing measurements for 1981 and newer model year vehicles, default = 3%

041 the test and repair effectiveness for HC emissions, default = 0.5
042 the test and repair effectiveness for CO emissions, default = 0.5
043 the test and repair effectiveness for NOx emissions, default = 0.5

Option 1: Data Section (level of effort)

021 the # of vehicles in the fleet (in inspection area)
022 the # of valid measurements per month that are made using RSD
023 the # of times a vehicle must be failed by RSD before it can be targeted for I/M inspection; default 1, range 1-11

Option 2: Data Section (specific fleet coverage)

201-
225 the # of vehicles for each of last 25 model years that are eligible for RSD targeting and the # of vehicles of that age that actually receive RSD; the ratio of the two #s is the fleet coverage by model year

Option 3: Data Section (# of failures)

301-325 The # of vehicles which normally fail I/M annually for each of the past 25 model years and the # of additional vehicles which are targeted by RSD and also fail the confirmatory I/M test

The program contains default benefits for RSD. However, the user also has the option of specifying benefits for option 3 based on a measure of the average excess emission levels of vehicles failing the remote sensing cutpoint chosen. Such values would presumably come from an operating I/M program using RSD. This measure is the ratio of the average excess emissions of vehicles found at that remote sensing cutpoint divided by the average emissions of all vehicles with excess emissions. There are 15 records for each of the three pollutants (HC, CO, and NOx) corresponding to RSD cutpoints from 0.5% to 7.5%. These records are the ratio of the average IM240 excess emissions identified per vehicle to the average excess emissions per vehicle in the fleet as a whole for a particular CO RSD cutpoint. Each of the 15 records has three model year groupings (1974 and older, 1975-80, and 1981 and newer).

701-715 values for HC
801-815 values for CO
901-915 values for NOx