Broward MPO
Metropolitan Planning Organization

Road Safety Analysis Framework

January 2022

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1.0 Overview

The Broward Metropolitan Planning Organization (MPO) is committed to eliminating traffic fatalities and severe injuries while promoting a safe and equitable transportation system for its residents and visitors. The Broward MPO's 2045 Metropolitan Transportation Plan (MTP) established a Transportation Systems Management & Operations (TSM&O)/Safety Program with an emphasis on addressing safety concerns at key intersections and corridor segments on Broward's roadway network. The intent of this program is to fund safety studies and capital improvements both on and off the state highway system in coordination with the Broward MPO's state, county, and local planning partners. As part of the MTP development process, the MPO conducted a countywide analysis of high crash intersections and corridor segments and prioritized locations for further study and project implementation.

The Broward MPO continues to work with the Florida Department of Transportation (FDOT) to program on-system roadway improvement projects through FDOT's safety office. In order to remain consistent with FDOT's roadway safety audit process for on-system locations, the Broward MPO plans to develop a modified process for high-crash off-system locations identified through MTP network screen. Since a significant portion of serious injury and fatal crashes occur on off-system roadways, it's important to identify, design and fund safety projects for these streets in a collaborative process with FDOT and local municipalities.

Through this effort, the Broward MPO is developing a programmatic framework for a road safety analysis (RSA) process to expedite the identification of engineering countermeasures at high crash locations and identify discrete projects for programming through the MTP's TSM&O/Safety program. The Broward MPO also plans to pilot the modified RSA framework using a sample of high crash, off-system locations from the MTP network screen to test this new process. The development of the modified RSA framework will be collaborative, involving an interdisciplinary group of planners, engineers, and other stakeholders. The outcome of this effort will be used to inform and implement future safety studies and projects off the state system in support of broader safety efforts by FDOT and other planning partners.

This document presents a framework to conduct RSAs for off-system transportation facilities (i.e., facilities that are not part of the State or National Highway System) that will achieve the following objectives:

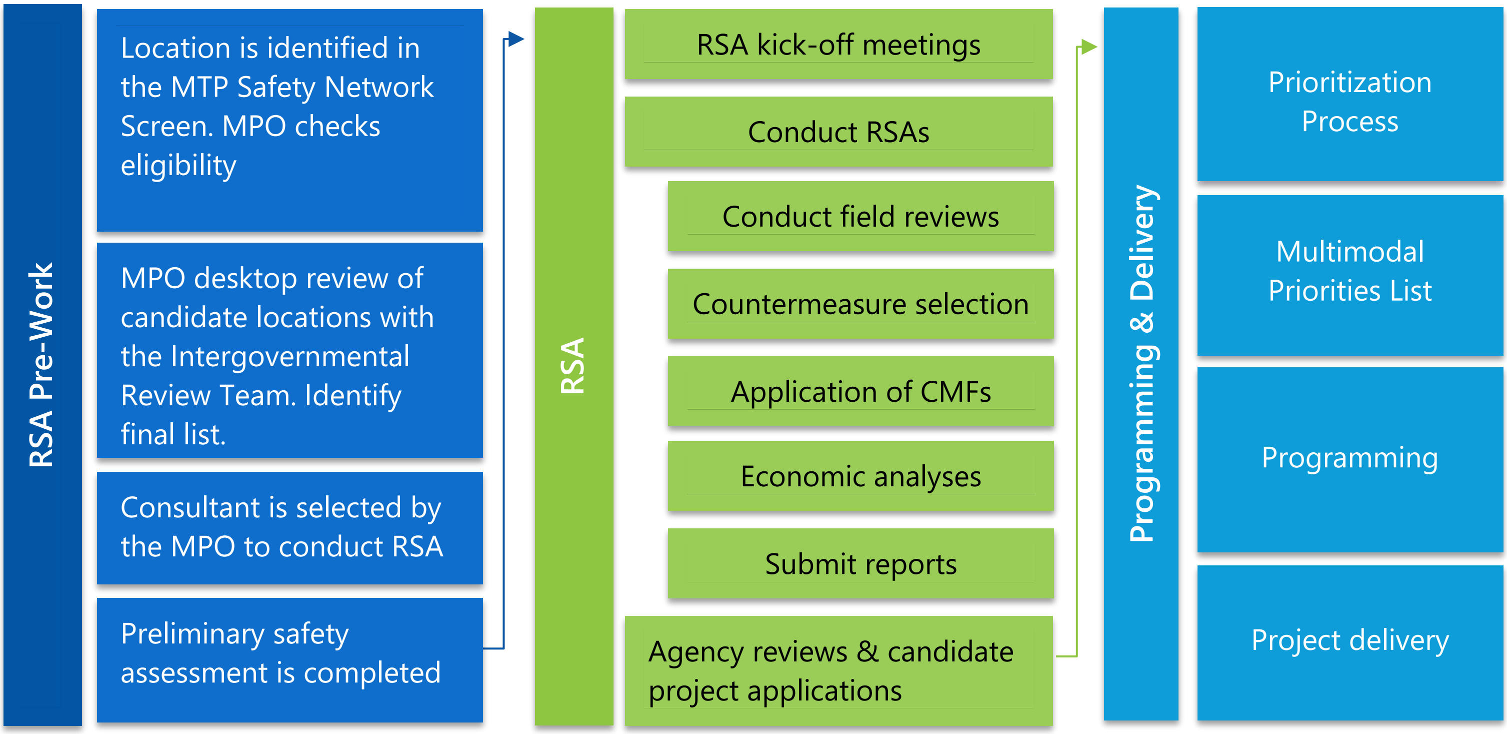
- Create a programmatic framework to expedite the identification of effective countermeasures at high crash locations;
- Create a study methodology that makes efficient use of funds and results in a plan to utilize available funding for construction of safety projects;
- Ensure program ready criteria is met for programming of safety projects in the Broward MPO's Multimodal Priorities List (MMPL) by identifying countermeasures, cost estimates, and agency collaboration/support;

- Create a backlog of safety projects ready for design and construction;
- Result in measurable improvement in transportation safety within the Broward MPO planning area.

The Broward MPO safety study framework is scalable and repeatable. The process can be applied to any roadway facility type including signalized intersections, unsignalized intersections, and roadway segments. Figure 1.1 shows the general steps within the framework to conduct a safety study for the purposes of programming projects through the MPO's MMPL. The process is detailed in **Section 4.0 – Annual Road Safety Analysis Process.**

Section 2.0 and Section 3.0 provide additional context on the administration and analysis tools related to the process.

Figure 1.1 – Annual Roadway Safety Analysis Cycle



2.0 Off-System RSA Program Administration

As this framework is applied broadly across the MPO planning area, it is important to understand the general administration of the program, including the leadership responsible for establishing and implementing the guidance. The leadership includes MPO staff, and an RSA development team as described in the following sections. These groups will continue to provide guidance to the member agencies and practitioners that execute the process outlined in this guide.

2.1 MPO Staff

The Broward MPO staff are responsible for the vision and management of the off-system RSA program. Table 2.1 lists the primary MPO contacts for administration of the off-system RSA framework and project programming through the MMPL process.

Table 2.1 – Primary Broward MPO Contacts for Safety

Name **Position**	**Phone Number**	**E-mail**
William Cross Deputy Executive Director, Planning & Programming	(954) 876-0056	crossw@browardmpo.org
Peter Gies Strategic Planning Manager	(954) 876-0048	giesp@browardmpo.org
Mark R. Brown Planning and Programming Senior Planner	(954) 876-0036	brownm@browardmpo.org

2.2 RSA Development Team

The Broward MPO, as the lead agency, has engaged stakeholders to guide development of the RSA framework and review the pilot application of the framework at three locations. The RSA Development Team was thoughtfully assembled to provide the feedback necessary to create and refine the process. The group comprises eight individuals representing diverse technical backgrounds and agency interests, all with the common goal of significantly improving safety. Table 2.2 lists the RSA Development Team members.

Table 2.2 – RSA Development Team Members

Name Position Organization	Phone Number	E-mail
Adolfo Prieto Pedestrian and Bicycle Safety Analyst III FDOT District 4 Traffic Operations		Adolfo.prieto@dot.state.fl.us
Katherine Kehres District Four Safety Administrator FDOT District 4		Katherine.Kehres@dot.state.fl.us
Tracy Xie District Traffic Safety Program Engineer		yujing.xie@dot.state.fl.us
Carmelo Caratozzolo Traffic Operations Engineer Broward County Traffic Engineering		ccaratozzolo@broward.org
Scott Brunner Director of Traffic Engineering Broward County Traffic Engineering		sbrunner@broward.org
Colin Mulloy Broward County Transit		cmulloy@broward.org
Carolina Vargas Engineer II Broward County Highway Construction & Engineering		cmulloy@broward.org
Peter Gies Strategic Planning Manager Broward MPO Planning & Programming	(954) 876-0048	giesp@browardmpo.org
Mark R. Brown Planning and Programming Senior Planner Broward MPO Planning & Programming	(954) 876-0036	brownm@browardmpo.org
Benjamin Restrepo Transportation Engineer MPO Mobility Team		restrepob@browardmpo.org
Priscilla Cygielnik, P.E. City Engineer Deerfield Beach		PCygielnik@deerfield-beach.com

2.3 Intergovernmental Review Panel

An intergovernmental review panel will be established by the MPO staff with the purpose of reviewing candidate RSA projects from the MTP crash severity list. The intergovernmental review panel will also help prioritize project locations before RSAs are initiated. Finally, the panel will review the results of RSAs and help prioritize implementation of the recommendations. The members of the panel may change on an annual basis.

2.4 Off-System RSA Program Delivery Overview

The 2045 MTP System Management/Safety program proposes to use 10% of the available "Other Arterial Funding" in the 2045 FDOT Revenue Forecast to fund safety studies and projects off the state highway system. The 2025 – 2045 MTP Cost Feasible Plan forecasted approximately $81M of available funding for off-system safety studies and projects. The total 20-year revenue equates to an average of $4M per year. Further subdividing the safety and TSM&O dedicated funding into on-system and off-system allocations would limit the flexibility of the MPO to program the funding in the most effective way.

2.5 Eligibility Criteria

To ensure the safety investments create the greatest benefit and to ensure equitable distribution of funds amongst member agencies, the following project eligibility guidelines are established to ensure project could be programmed in the MMPL:

- The location must be on the Federal Aid System and eligible for Federal Funds.
- The location must be on the MTP's list of Top Signalized or Unsignalized Intersections for Future Safety Studies (Non-State Roadways) – Map 5-4, or Top Corridors for Future Safety Studies (Non-State Roadways) – Map 5-6, as periodically updated.
- The project has been selected by the Intergovernmental Review Panel.
- The project must address existing safety issues through viable infrastructure countermeasures.
- The project must meet the Broward MPO's program ready criteria.

Non-eligible activities include education, public outreach, and enforcement. These activities are vital components of an effective safety program; however, they do not meet the intent of the Off-System RSA Program which is to deliver cost-effective infrastructure improvements with quantifiable benefits.

2.6 Supplementing Project Funding with Systems Management/Safety Funds

Safety improvements or features routinely included in broader Federal-aid projects (such as guardrail) should be funded from the same source of funds as the broader project whenever possible. Systems Management/Safety funds are primarily intended for standalone safety projects targeting serious safety problems as cost-effectively as possible.

In some cases, it may yield efficiencies to use Systems Management/Safety funds to pay for safety enhancements within other projects. This scenario will be handled on a case-by-case basis by the MPO.

3.0 Safety Data and Analysis Tools

Given the fixed funding available for safety projects and the ever-increasing need to improve safety, this framework requires a data-driven approach. Safety data is the basis for safety analysis and safety improvements. There is a direct correlation between the quality and extensiveness of data available to make safety decisions and the effectiveness of the projects.

The state, county, and local agencies maintain and continually improve safety data sets consisting of crash, roadway, and traffic characteristics. Various tools and software have been developed to better inform safety issue identification, countermeasure selection, design considerations, resource allocation, and effectiveness evaluations. Many of the tools are necessary to facilitate the calculations in advanced safety analysis and are described in greater detail later in this chapter.

3.1 Crash Data

Crash data are the basis of safety analysis. Quantitative safety performance is based on the expected frequency, severity, and type of crashes. This includes both the observed crash history of a site as well as the predicted crashes for other similar sites. Crashes are reported by law enforcement or self-reported by drivers to the Department of Highway Safety and Motor Vehicles (DHSMV). Any crash with over $500 in damage is considered reportable. In Florida, crashes are reported with a long-form or short-form version of the crash report. Long-form reports are required for injury crashes, commercial vehicle crashes, towaway crashes, and some other scenarios. All others may be reported with the short-form, which contains the same information except the narrative and diagram portions.

The Florida Department of Transportation (FDOT) maintains the Crash Analysis and Reporting (CAR) database, which includes long-form crashes from DHSMV geolocated manually to the Roadway Characteristics Inventory (RCI). CAR system crash data is available on the FDOT Traffic Safety Web Portal SSOGis application website (https://fdotewp1.dot.state.fl.us/TrafficSafetyWebPortal/). At least three to five years of crash data should be used under consistent site conditions in safety analysis.

Many reportable property-damage-only (PDO) crashes recorded via short-form (or not reported at all) do not make it into the DHSMV database or CAR, which affects safety analysis and should be accounted for to the maximum extent possible. Another limitation of CAR is that since it is geolocated manually to FDOT's RCI, CAR does not contain a large portion of crashes that occur off-system. Off-system crash data is necessary to implement this framework.

Florida supports another crash data system, Signal Four Analytics, that should be used as the primary reference for crash data. Signal Four Analytics is maintained by the University of Florida and includes extensive crash data sets for off-system facilities. Because this system uses a web-based GIS framework, it shows all long-form and short-form crash locations from DHSMV (rather than just those in RCI), which can help verify crash patterns. However, the geolocation process is automated and only supplemented by CAR for failed geolocations, which means it is not as reliable as CAR for injury crash data. The safety analyst must review the crash reports to verify that the locations are plotted correctly and that crash types are represented correctly. These two data elements are critical to conducting more reliable safety analysis and developing appropriate countermeasures.

3.2 Roadway and Traffic Data

Roadway and traffic data are available on the off-system sections required for the FHWA Highway Performance Monitoring System (HPMS) within FDOT's RCI database. FDOT's linear referencing system (LRS) in the RCI is a route-milepost based system. FDOT maintains roughly 10% of public roadway mileage in Florida, but more than 10% within Broward County given its urban form. HPMS data are required for roads above local functional classification. Some local roads are also in HPMS as sample sections. Altogether, the data in the RCI account for approximately 30% of public road mileage and the locations of over 60% of fatalities. The all-roads base map (ARBM) includes RCI and HPMS data combined with supplemental HERE data (vendor source probe data), which provides basic inventory data for off-system roads. FDOT's roadway characteristic data is available in the FDOT GIS Data Directory.

The Broward MPO maintains an extensive roadway capacity and level of service spreadsheet that contains 2019 annual average daily traffic (AADT), capacity, level of service, and volume/capacity ratio for over 1,000 roadway segments within the planning area. The spreadsheet also includes the length of each roadway segment which allows analysts to calculate the vehicle-miles of travel. This is an important metric for safety analysis since roadway segment crash rates are based on number of crashes per million vehicle-miles of travel and intersection crash rates are based on number of crashes per million entering vehicles.

There are often multiple contributing factors in a given crash. As such, it is often useful to review and consider many pieces of data to identify crash contributing factors. Table 3.1 lists several common geometric conditions that can impact safety.

Table 3.1 – Roadway Conditions Contributing to Safety Trends

Horizontal alignment	Roadside conditions
Vertical alignment	Sight distance
Intersection skew	Deceleration lane presence
Deceleration lane length	Pedestrian crossing distance
Bicycle lane buffer width	Pedestrian/bicycle facility offset distance
Lane width	Number of lanes
Speed limit	

3.3 Other Data and Sources

Data is becoming a commodity. The challenge is no longer having data available. We are faced with challenges relating to synthesizing the data for decision-making, storing the data, and standardizing data for a repeatable process. The following sections describe additional data that can be obtained and used for safety analysis.

3.3.1 Probe Data

Probe data describes information gleaned from 3rd party vendors that partner with mobile applications and use location base services (LBS) enabled on a mobile phone. For example, a user may enable LBS on their Facebook application. The users' phone then reports speed and trajectory data to a 3rd party vendor who anonymizes the data and provides it to the industry. There are several vendors that provide this information to transportation and safety practitioners, including, but not limited to, StreetLight Data, STRAVA, HERE, and INRIX. Probe data that can support safety studies includes average speeds, traffic volumes, pedestrian and bicycle activity, and origin-destination information.

3.3.2 Traffic Signal Controller and Advanced Traffic Management System (ATMS) Data

Modern traffic signal controllers have the capability to log every discreet change in their operation. This includes number of pedestrian actuations, number of vehicles that cross a detector during the yellow clearance interval, number of vehicles that arrive during a red light, and many other items. Safety analysts can use this data to correlate trends with signal operations to identify the most effective countermeasures.

3.4 Crash Reduction Analysis System Hub

FDOT's Crash Reduction Analysis System Hub (CRASH) is a web-based application developed mainly for the selection and evaluation of highway safety improvement projects. Specifically, it has the following five functions:

- Perform benefit-cost analysis of safety improvement projects.
- Perform before-and-after analysis to evaluate the effectiveness of safety programs.
- Serve as a central storage location for safety improvement projects.
- Update crash reduction factors (CRFs) using implemented safety improvement projects and crash records.
- Generate standard reports for annual reporting.

Access to the CRASH system is restricted to authorized personnel only. FDOT's State Safety Office can be contacted for more information.

3.5 Overview of Predictive and Performance-Based Safety Analysis

The Highway Safety Manual (HSM) provides methods for predictive and performance-based safety analysis. The number of historical crashes over a recent time period has been a traditional safety indicator of a site. However, by solely looking at the crash history of one location (i.e., frequency, type, and severity), it is difficult to determine if that site is performing relatively well or relatively poorly. Performance-based analyses compare a site to many others with similar geometric and operational characteristics to determine how it is performing relatively, and to indicate factors contributing to differences in performance.

The simplest way to conduct performance-based analysis is to compare a site's crash frequency or rate to the average for similar sites. A more reliable, predictive method is to use safety performance functions (SPF). SPFs are statistical models that better account for the randomness of crash occurrence, changes in traffic volumes, and other biases to estimate a long-term average predicted crash frequency performance threshold. The empirical Bayes (EB) method incorporates both the observed crash history of a site and the predicted crashes from an SPF to produce a more reliable estimate of a site's expected safety performance.

Crash modification factors (CMF) are another predictive tool to estimate the effectiveness of countermeasures in changing a location's crash frequency, type, and severity. CMFs are an important tool in estimating the expected benefits of proposed safety projects and determining funding eligibility. The FDOT HSM User's Guide and the FHWA CMF Clearinghouse are good resources for finding and selecting appropriate CMFs for analysis. This is discussed in detail later in this document.

3.6 Pedestrian and Bicycle Crash Analysis Tool

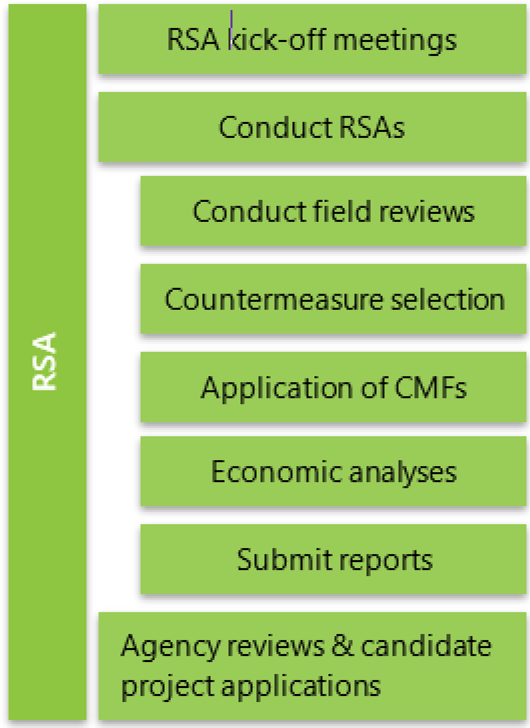
The Pedestrian and Bicycle Crash Analysis Tool (PBCAT) is a software tool that assists users with crash-typing pedestrian and bicycle crashes. Crash-typing is a method of categorizing crashes of similar circumstances and collision types. PBCAT helps assign accurate crash types that reflect the nature of the collision, rather than just noting that the crash involved a pedestrian or bicyclist. Characterizing crash types helps to understand the underlying crash contributing factors, which is key to selecting targeted countermeasures. Lists, images, and codes of PBCAT's crash types can be found on the PBCAT website.

PBCAT users enter crash report data, and the software produces the crash typology. PBCAT also provides a list of multidisciplinary countermeasures that relate to each crash type and provides recommendations for when the countermeasures may be appropriate. Users can conduct crash-typing, relate crashes to roadway locations, and identify appropriate countermeasures to address overrepresented crash types. University of Florida's Signal Four Analytics includes PBCAT crash type data.

The data and tools used to develop safety countermeasures and conduct supporting analysis is at the discretion of the consultant performing the study. At a minimum, the practitioner must obtain at least three years of crash data, review roadway characteristics, conduct a field review to compare trends against field conditions, and prepare a benefit-cost analysis (BCA).

4.0 Annual Roadway Safety Analysis Process

The Broward MPO will retain consultant services to conduct RSAs for the locations identified in the MTP. When given a task to study a particular location, the consultant will provide a scope and fee estimate in accordance with the template provided in **Appendix A** of this framework document. As noted in **Section 1.0** and **Figure 1.1**, the RSA consists of the steps in the excerpt to the right, which are detailed in this section.



4.1 Kick-Off Meeting

Upon receipt of notice to proceed, the consultant will schedule a study kick-off meeting with the owning agency(ies) and Broward MPO staff to review the data needs and establish expectations. The owning agency(ies) is/are encouraged to invite participants that can offer insight into the issues at the study location. This can include representatives from law enforcement, schools, transit agencies, bicycle and pedestrian advocacy groups, public health agencies, neighborhood groups, and other stakeholder groups.

Prior to the kick-off meeting, the consultant will complete a preliminary safety assessment (PSA) and share it with the meeting attendees at least three business days prior to the kick-off meeting. The PSA must contain a summary of the crash data, crash diagrams, prevailing crash trends, and roadway characteristics. The consultant will prepare an agenda and meeting minutes.

4.2 Field Review

Following the kick-off meeting, the consultant will schedule a field review to compare the crash trends with the field conditions and observe road user behaviors that could be contributing to the crashes. The field review should be conducted on an average weekday during the AM, mid-day, and PM peak hours. Crash trends from the PSA should be used to inform the field review conditions. For example, an overrepresentation of nighttime or wet weather crashes may indicate that the field review should be conducted concurrent with those conditions.

Federal Highway Administration's (FHWA) traditional road safety audit process includes a collaborative field review with many project stakeholders. This framework is intended to streamline the traditional process. The sheer nature of scheduling heavily attended field reviews can sometimes slow a schedule. However, it is recognized that stakeholder engagement early in the process, such as during the field review, can help to streamline latter steps and achieve stakeholder buy-in. Stakeholder participation in the field review should be evaluated on a case-by-case basis.

4.3 Countermeasure Selection

The objective of countermeasure selection is to choose countermeasures that will target the crash contributing factors and address the concerns identified in the qualitative assessment. Rather than selecting a preferred countermeasure at this point, analysts should compile a list of potentially applicable countermeasures for economic appraisal and prioritization (unless there is only one clear or acceptable solution).

The best practice is to start by considering low-cost countermeasures and then move to higher-cost options when lower-cost countermeasures are not desirable or appropriate for the candidate project. Further, if low-cost countermeasures are selected and implemented, the agency can monitor the crash trends over time and implement higher-cost options if the low-cost countermeasures do not achieve the desired result.

There are a variety of resources available to analysts to help select appropriate countermeasures. A sample of these resources include:

- National Cooperative Highway Research Program (NCHRP) Report 500 Series
- FHWA's Proven Safety Countermeasures
- ITE's Unsignalized Intersection Improvement Guide
- Pedestrian Safety Guide and Countermeasure Selection System
- Bicycle Safety Guide and Countermeasure Selection System
- FHWA's Reliability of Safety Management Methods: Countermeasure Selection
- FHWA RSA Guidelines

Crash Modification Factors (CMFs) can also assist in countermeasure selection. CMFs may be available for all or specific crashes types and severities. It's important to consider the range of researched crash implications for all suggested countermeasures. For instance, a traffic signal may help to reduce the frequency and severity of left-turn angle crashes but may increase lower severity rear-end crashes. The CMF Clearinghouse can also be accessed for further information. The CMF Clearinghouse is a comprehensive and searchable database of CMFs from published and unpublished reports and professional journals. More information on CMFs is provided in the following section.

If these tools are not applicable to a candidate project, then professional judgment and experience as well as other stakeholder input can be valuable tools to recommend and select applicable countermeasures. Inexpensive, “off-the-shelf" countermeasures which may not need extensive data collection should be considered for all RSAs. Examples of off-the shelf countermeasures may include:

- Leading pedestrian intervals/Ped signal timing improvements
- Special emphasis crosswalks
- Traffic signal backplates with retroreflective borders
- Internally illuminated/high visibility street name signs
- Advance Street Name Signs
- Refurbishing worn pavement markings
- ADA pedestrian ramp upgrades
- Pedestrian refuge Island opportunities
- Sight triangle visibility improvements
- Turn/corner radii modifications
- Lane narrowing of excessively wide traffic lanes
- Various speed management strategies

FHWA provides a list of proven safety countermeasures (PSC) that can also be referenced to find the most effective countermeasures to incorporate on all roadways. PSCs can be found at https://safety.fhwa.dot.gov/provencountermeasures/. Additionally, FDOT and FHWA independently maintain Crash Modification Factors and Countermeasure Lists with suggested CMFs. FDOT’s list can be found at https://www.fdot.gov/roadway/qa/tools.shtm.

4.4 Application of CMFs

Based on the information gathered from the field review and the desktop data analysis, the consultant will formulate safety countermeasure recommendations. The benefit of the countermeasures will be quantified using one of the following approved methodologies.

- Apply HSM predictive method to estimate the expected average crash frequency of the existing and proposed conditions over the service life of the project. The project benefit is the difference in estimated crash frequency between the existing and proposed conditions multiplied by crash costs.
- Apply HSM predictive method to estimate the expected average crash frequency of the existing condition and apply an appropriate CMF to estimate the safety performance under proposed conditions. The project benefit is the difference in estimated crash frequency between the existing and proposed conditions multiplied by crash costs.
- Estimate the average crash frequency of the existing condition using three to five years of observed crash frequency. Apply an appropriate CMF to estimate the safety performance under proposed conditions. The project benefit is the

difference in estimated crash frequency between the existing and proposed conditions multiplied by crash costs.

A CMF is a multiplicative factor used to estimate the effectiveness of a countermeasure implemented at a specific site. Examples of countermeasures include installing a traffic signal at an intersection and installing a median barrier. A CMF value less than 1.0 indicates an expected reduction in crash frequency at a specific site due to the implementation of a countermeasure. A CMF value greater than 1.0 indicates an expected increase in crash frequency at a specific site due to the implementation of a countermeasure. A CMF of 0.70 would imply an expected crash reduction of 30 percent, while a CMF of 1.3 would imply an expected crash increase of 30 percent. It should be noted that some CMFs can apply to all crash types for all locations, while the applicability of others can vary based on crash type, crash severity, and site condition.

The CMF Clearinghouse provides a star rating system, a CMF rating score, and standard error (where available) to indicate the quality of CMFs. CMFs with a star rating of three stars or better should be selected whenever possible. The standard error is a measure of certainty in the CMF. A CMF with a relatively small standard error (in comparison to the magnitude of the CMF estimate) indicates greater certainty in the CMF estimate, whereas a relatively large standard error indicates less certainty in the CMF estimate. The standard error values can be used to calculate the confidence interval of the CMF using the formula shown below:

$$Confidence\ Interval = CMF \pm [Cumulative\ Probability\ Factor * Standard\ Error]$$

The Cumulative Probability factor is based on the desired Confidence Level. The Cumulative Probability factors for common confidence levels are shown in Table 4.1

Table 4.1. Cumulative Probability Factors for Common Confidence Levels

Confidence Level	Cumulative Probability Factor
99%	2.576
95%	1.980
90%	1.645

The confidence interval is another measure of certainty of a CMF. Based on the standard error, the confidence interval provides a range of potential values of the CMF. A wider confidence interval indicates less certainty in the estimate of the CMF and a narrower confidence interval indicates greater certainty in the estimate of the CMF.

The CMF for a given countermeasure is 0.75 with a standard error of 0.17. An analyst would like to calculate the 95 percent confidence interval for this CMF.

The first step is to determine the appropriate factor from Table 4.1. The factor for a 95 percent confidence interval is 1.96. The 95 percent confidence interval is calculated by adding and subtracting 1.96 times the standard error of 0.17 from the CMF estimate of 0.75 as shown below:

95 % Confidence Interval=0.75 ±1.96*0.17

This gives a confidence interval of 0.42 to 1.08. Note the value of 1.0 is within the confidence interval, indicating the countermeasure may result in a reduction in crashes, no change, or an increase in crashes. If the upper bound of the confidence interval is less than 1.0, the analyst can be more certain that the countermeasure will be expected to reduce crashes.

In addition to measuring the effectiveness of a countermeasure, CMFs are also useful for identifying cost-effective strategies and locations for crash reduction, comparing safety benefits among various countermeasures and locations, and gauging the reliability of new evaluations against existing CMFs.

Expected project benefits are estimated by multiplying the change in annual average crash frequency over the expected service life of the countermeasures by crash costs, and then converting the annual results to a present value. The 2022 FDOT Design Manual (FDM) lists the applicable crash costs, which are replicated below in Table 4.2. When using HSM analysis methods, crash costs by severity are appropriate. When using observed crash frequency methods, or when the severity of past or future crashes is not reliable or well-known, weighted crash costs are appropriate. These values are updated annually.

Table 4.2 – Crash Costs by Severity

Crash Severity	Cash Cost
Fatal (K)	$10,890,000
Severe Injury (A)	$888,030
Moderate Injury (B)	$180,180
Minor Injury (C)	$103,950
Property Damage Only – PDO (O)	$7,700

4.5 Economic Analysis of Proposed Projects

Economic analysis helps to identify the most cost-effective and efficient projects. It can also help to assure that the MPO does not invest more funds into safety projects than the anticipated benefits those projects will bring to road users. Each project in the Safety/TSM&O program should be economically justified, such that the BCR is greater than 1.0 and the net present value (NPV) is positive, as explained below.

BCR – The ratio of present value benefits (PVB) to present value costs (PVC). A BCR greater than 1.0 indicates that benefits exceed costs, and therefore a project is economically justified. Generally, higher BCRs are desirable. BCR is unitless.

$$BCR = \frac{PVB}{PVC}$$

NPV – The difference between PVB and PVC. NPV is also sometimes called net benefits or net present worth. A positive NPV indicates that benefits exceed costs, and the project is economically justified. Generally, higher NPVs are desirable. NPV is in units of dollars.

$$NPV = PVB - PVC$$

When a project is not economically justified, the following options are available.

1. Consider whether the cost could be reduced (e.g., by eliminating non-essential safety project components or identifying cheaper construction methods) or the benefits could be increased (e.g., by adding more cost-efficient supplemental countermeasures).

2. Consider whether other countermeasures of higher or lower cost could be justified instead of the proposed unjustified alternative. Higher or lower cost countermeasures could be justified if they provide more crash reduction per dollar spent than the unjustified alternative. Confirm whether the newly considered countermeasures are acceptable to stakeholders.

4.6 Estimating Project Costs

Project costs should include preliminary engineering, right of way, and construction and should be estimated in present value. Often, project features or design aspects that do not directly improve safety (e.g., utility adjustments) are required to facilitate safety countermeasure implementation. These aspects should also be accounted for in project costs.

When the MPO's Safety/TSM&O funding allocation is used to supplement other projects, only the safety portion of project costs should be accounted for in the safety-related economic analysis. Economic analysis should indicate whether the additional safety features will meet the requirements and advance the goals of the MPO's safety program.

To support an accurate cost estimate, a concept plan should be prepared. The concept plan must be prepared in accordance with all applicable design criteria. The vast majority of projects delivered by the MPO's Safety/TSM&O funding program will be delivered using FDOT's Local Agency Program (LAP) or a Join Project Agreement (JPA). Therefore, the concept plans must be prepared to meet FDOT LAP standards.

The concept plans support unit quantity take-offs for the purposes of estimating project costs. FDOT's Basis of Estimates Manual and pay items will serve as the source for describing the work to be completed and units needed to complete the project. Once the quantity estimates are complete, unit costs will be selected. FDOT provides several databases of historical unit costs. The databases include 6-Month Moving Statewide Average, 12-Month Moving Statewide Average, 12-Month Moving Market Area Average, and Annual (calendar year), Statewide Average. The databases should be used in the following hierarchy:

1. 12-Month Moving Market Area Average (area 12)
2. 6-Month Moving Statewide Average
3. 12-Month Moving Statewide Average
4. Annual Statewide Average

If particular pay items are not used on construction projects in Area 12 within the last 12 months, or the number of contracts contributing to the average is two or fewer, the next list of unit prices should be used until a statistically supported cost is found.

"Soft costs" should be included as a proportion of the construction cost estimate. Table 4.3 lists the percentages that may be applied to the construction cost to develop the total project costs. These estimates are meant to be used as preliminary values that can be modified using professional judgement when preparing an opinion of probable cost.

Table 4.3 – Soft Costs for Cost Estimates

Description	Percentage	Applied To
Mobilization (MOB)	10%	Construction Cost
Maintenance of Traffic (MOT)	10%	Construction Cost + MOB
Project Unknowns (PU)	15%	Construction Cost + MOB + MOT
Contingency (C)	5%	Construction Cost + MOB + MOT + PU
Preliminary Engineering (PE)	30%	Total Construction Cost
Right of Way	N/A	Right of way cost must be estimated by a qualified appraiser

The project cost estimating approach is designed to provide contingencies that will account for bids that exceed the budget or other overruns during construction. If the project costs exceed the programmed costs, the agency having ownership of the roadway will be required to cover the cost of the overrun.

4.7 Draft Report and Reviews

The draft RSA report can be prepared when all components are complete. The reports should include the following sections, at a minimum:

- 1.0 Introduction
- 2.0 Existing Condition
  - 2.1 Condition Diagram
- 3.0 Collision Analysis
  - 3.1 Crash Diagram
- 4.0 Field Observations
- 5.0 Recommendations
- 6.0 Feasibility Review
- 7.0 Implementation Plan
  - Appendix A – Crash Summary
  - Appendix B – Field Photographs
  - Appendix C – Conceptual Improvement Diagram
  - Appendix D – Construction Cost Estimate
  - Appendix E – Benefit Cost Analysis
  - Appendix F – Net Present Value
  - Appendix G - Candidate Project Feasibility Checklist for TSM&O/Safety Program Funds

The RSA report template is attached as **Appendix B**. The draft reports will be submitted to the agency with ownership of the facility. The agency will have the opportunity to review the report, provide comments within 14 days, and provide approval of the information contained therein. Upon approval, the draft report will be finalized, and the owning agency will complete the Systems Management/Safety Candidate Project Application form contained in **Appendix C**. The form can be completed with information contained in the RSA report and includes a commitment for the owning agency to cover any cost overruns.

Once the project has a concept, cost estimate, BCR, NPV, agency support, and candidate project application from the owning agency, the candidate project is ready for programming in the Broward MPO's MMPL.

4.8 Prioritizing Candidate Projects

The Broward MPO is committed to creating a safety prioritization process that delivers effective projects to member agencies in a timely, equitable, and cost-efficient manner. Projects will be selected on an annual basis by the intergovernmental review panel and the MPO before moving forward to the MMPL. The MPO will ultimately be responsible for prioritizing projects.

The effectiveness of the Systems Management/Safety Program is assessed by the benefits it achieves per dollar spent and in terms of reduced fatalities and serious injuries. The objective of project prioritization is to maximize the net benefits of the program, such that the maximum possible reduction in fatalities and serious injuries within available budget is realized.

With a fixed program budget (i.e., total costs), the most cost-effective program will also be the most efficient and effective overall, having the highest possible BCR and NPV. The intergovernmental review panel and the MPO will consider BCR as one of many selection factors and adjust the rankings as necessary to deliver a successful program. It is recognized that in some cases, prioritization by BCR may not be acceptable in practice when stakeholders demand a more effective project or intangible factors impact prioritization.

To summarize, project prioritization criteria will include:

- The project must meet the Broward MPO's MMPL program ready criteria.
- Project prioritization should consider benefit-cost ratio (BCR)
- Project prioritization should consider project costs

4.9 Project Delivery

Once an off-system RSA is complete, the concept plan can be used to advance the project through planning, preliminary engineering, final design, and construction. Project needs, such as right of way, utility adjustments, or National Environmental Policy Act (NEPA) compliance will dictate the remaining schedule and delivery methods. Governmental agencies playing a role in delivery include the MPO, the owning agency, and FDOT as the steward of federal funds. Any of these agencies may lead design through in-house staff or retain a consultant to support development of construction plans. Depending on the approach, a Local Agency Program (LAP) agreement or Joint Project Agreement (JPA) will need to be in place, unless FDOT is the lead agency. Contract documents consisting of plans and specifications establish the basis for contractor bids and construction. Awarding the bid and executing construction engineering and inspection (CEI) are the final steps for agency completion of project delivery.

Appendix A - Sample Scope

I. TASK DESCRIPTION

A. Expedited Road Safety Analysis (RSA)

The Broward Metropolitan Planning Organization (BMPO) strives to eliminate fatal and severe injury crashes and reduce all crashes through the implementation safety countermeasures. Therefore, the study's goal is to develop traffic operational strategies to enhance safety while minimizing negative impact, if any, on traffic flow.

In general, RSAs aim to answer the following two questions:

1. What elements of the road may present a safety concern: to what extent, to which road users, and under what circumstances?
2. What opportunities exist to eliminate or mitigate identified safety concerns?

The goal of an RSA is to develop recommendations that enhance safety, while minimizing negative impact on traffic flow. As part of this assignment, the Consultant shall complete the following steps consistent with the procedures and guidelines outlined in the FDOT MUTS Manual, MUTCD, HSIP, AASHTO, and FHWA RSA guidelines:

1. **Identify project or existing road to be audited. (By the MPO)**
2. **Select RSA team.** The consultant team must provide a qualified and multidisciplinary team of experts suitable for the specific RSA to be conducted – each RSA will likely require the participation of different areas of expertise. While in the ideal RSA some of the expertise is provided by the local agency and/or the Department, there may be occasions in which these agencies are unable to provide the necessary expertise. For these cases, the consultant team shall have access to experts within the necessary fields of expertise. Typical fields of expertise necessary to conduct an RSA are:
    a. Road safety specialist. The road safe specialist shall act as the leader of all RSAs. As the RSA team leader, the road safety specialist shall sign and seal the final RSA document – the road safety specialist shall be a licensed engineer in the State of Florida
    b. Traffic operations engineer
    c. Road design engineer
    d. Local contact person
    e. Other areas of expertise. Some of the areas of expertise that may be required in some RSAs may include (this is not intended to be a comprehensive list):
        i. Human factors
        ii. Maintenance
        iii. Enforcement
        iv. First response
        v. Pedestrian & bicycle treatment
        vi. Transit operations
        vii. ITS
3. **Conduct a preliminary meeting to review project information.** This meeting shall bring together the project owner, the design team (if any) and the audit team to discuss the context and scope of the RSA and to review all project information available.
4. **Office review of crash data and other available information**. This step aims to help identify areas of safety concerns. The RSA team should restrict its comments to those

issues having a bearing on the safety of road users. Comments may be either specific to a particular location or broad-based. Issues related to aesthetics, amenities, or congestion should also be commented upon if they lead to less-safe conditions.

5. **Perform field reviews under various conditions.** For typical RSAs, at least 3 field reviews ought to be performed: one during night time, one during the daytime peak period, and one during day-time off-peak period. The number/time of field reviews may be modified if the RSA study location justifies it. The objectives of the field reviews are:
   a. Gain insight into the project or existing road
   b. Verify/identify areas of safety concerns
6. **Conduct audit analysis and prepare report findings.** As a result, the safety issues are identified and suggestions are made for reducing the degree of safety risk. The RSA results are then succinctly summarized in the formal RSA report.
7. **Present audit findings to project owner, design team, RSA steering committee, or Safety Review Committee.** The audit team will orally report the key RSA findings to the project owner, design team, RSA steering committee, or Safety Review Committee in order to facilitate the understanding of the RSA.

1. Task products

As part of this assignment, the Consultant shall complete the following tasks consistent with the procedures and guidelines outlined in the FDOT MUTS Manual, FDOT Traffic Engineering Manual, MUTCD, HSIP, AASHTO and any other technical publications approved by the BMPO:

1. Collect data relevant to the study location, example:
   a. Crash data
   b. Hard copies of police reports
   c. High crash listing
   d. Aerial photographs
   e. Field inventory
   f. Lighting levels (if night time crashes are the object of the study)
   g. Other relevant data
2. Summarize the latest 5-year crash data by preparing crash summary tables
3. Review hard copies and:
   a. Prepare collision diagrams
   b. Ensure that there are no discrepancies between the police reports, the crash data, and the summary tables
4. Identify crash patterns
5. Conduct field reviews during appropriate times to assess the existing safety and operational conditions
6. Develop countermeasures to reduce the number of crashes and the severity of the crash patterns identified while attempting to minimize any negative impact on operations
7. Assess the feasibility of the proposed improvements
8. Prepare an existing condition diagram based on the MUTS Manual
9. When impacts on operations are unavoidable, conduct an operational analysis of the existing and proposed conditions. The operational analysis shall be made using the most recent version of a traffic analysis software package approved by the project manager.

10. Prepare a conceptual improvement drawing depicting proposed improvements
11. Coordinate with the owning and maintaining agencies regarding the proposed improvements
12. Prepare a preliminary estimate of construction costs
13. Calculate the benefit to cost ratio of the proposed improvements
14. Calculate the net present value of the proposed improvements
15. Prepare a technical memorandum to document the findings and recommendations of the study
16. Revise recommendations, if necessary, based on input from the BMPO and review agencies
17. Finalize the study

Appendix B - RSA Report Template

Draft or Final Report

Placeholder for cover photo

Road Safety Analysis Report

For

[Name of Location]

Broward County

Month Year

Move People & Goods | Create Jobs | Strengthen Communities

1.0 INTRODUCTION

The [Project Location] was identified as a high-crash location in the 2045 Metropolitan Transportation Plan (MTP) and chosen for study by the Broward Metropolitan Planning Organization (BMPO). The location is in [municipality or county] and under the maintenance jurisdiction of [agency]. The study [intersection or corridor] in relation to the surrounding roadways is graphically depicted on the Location Map below.

Placeholder for Location Map

2.0 EXISTING CONDITION

The characteristics of the study [intersection/corridor] located in the [City/County], Broward County, Florida are summarized below. A condition diagram is provided in the following pages.

Table for intersection studies

Features	Description
Main Street	Describe cardinal direction and functional classification
Minor Street	Describe cardinal direction and functional classification
Number of Intersection Approach Lanes	Describe each approach and lanes
Traffic Control	Describe traffic control here
Context Classification	Context classification and target speeds
Posted Speeds	Posted speeds or corridor or approaches
Sidewalks	Describe sidewalks here
Bicycle Lanes	Describe bicycle lanes here

Features	Description
Pedestrian/Bicycle Generators	Describe pedestrian and bicycle generators here
Nearest Signalized Intersections	Indicated distance and location of adjacent intersections.
Roadway Lighting	Describe roadway lighting here.
Surrounding Development	Describe surrounding development here.
Pavement, Signing & Marking Condition	Describe the signing and pavement marking condition here.
Transit	Describe transit routes and stop locations here.

Table for corridor studies

Features	Description
Main Street	Describe the cross section, cardinal orientation, and functional classification
Context Classification	Describe context class and target speed

Posted Speeds	Posted speed(s)
Sidewalks	Describe sidewalks here
Bicycle Lane	Describe bicycle lanes here
Pedestrian/Bicycle Generators	Describe pedestrian and bicycle generators here
Signalized Cross Streets	List signalized cross streets here.
Roadway Lighting	Describe roadway lighting here.
Surrounding Development	Describe surrounding development here.
Pavement, Signing & Marking Condition	Describe the signing and pavement marking condition here.
Transit	Describe transit routes and stop locations here.

Insert Condition Diagram

3.0 COLLISION ANALYSIS

Include narrative regarding limits of crash data dates, total number of crashes, crash types, severity, pedestrian and bicycle crashes, etc. The crash summary is attached as **Appendix A**.

The number of crashes by types are as follows:

Crash Type	Number	Percentage

The number of crashes by contributing cause is as follows:

Contributing Cause	Number	Percentage

The number of crashes by lighting condition are as follows:

Lighting Condition	Number	Percentage

The number of crashes by analysis year are as follows:

Year	Number	Percentage

Describe crash types and trends. Identify severe crashes and fatalities. Include narrative of any noteworthy observations.

Insert Crash Diagram

4.0 Field Observations

A qualitative assessment based on field observations was performed by a team of stakeholders on [Date] at the study location of [Location]. The team consisted of the following representatives:

Name	Agency

Prior to the field observations, the RSA team was provided with corridor existing conditions data related to crash history, geometrics, and surrounding land use patterns. The crash trends were compared to traffic and physical conditions to identify field factors potentially contributing to increased crash risk. In addition, maintenance issues were identified and are detailed later in this report.

The purpose of the qualitative assessment was to evaluate safety of the [intersection/ corridor] while taking into consideration prevailing operating traffic conditions to identify areas where improvements would be potentially beneficial for safety and efficiency. Specific attention was paid to the interaction between vehicular and non-vehicular roadway users. Field photographs are attached in **Appendix B**.

Mobility and Safety:

1. Provide bulleted list of observations related to mobility and safety of the study location.

Maintenance:

1. Provide bulleted list of items related to maintenance of the study location.

5.0 Recommendations

Based on the crash records, field observations of the intersection operation, and input from the multi-disciplinary RSA team, this study recommends the improvements identified below. The recommendations are categorized as maintenance, near-term, or long-term. Maintenance can be implemented in the next two years, near-term improvements can be implemented in the next three to five years, and long-term improvements can be implemented beyond the next five years.

1. Recommendation #1
   Justification: Justification for recommendation

2. Recommendation #2
   Justification: Justification for recommendation

A conceptual improvement diagram is attached as **Appendix C.** A construction cost estimate, benefit-cost (B-C) analysis, and net present value (NPV) analysis are attached as **Appendices D, E, and F**, respectively.

The project cost, benefit-cost ratio, and NPV are summarized in the following table.

Project Cost Estimate	$00,000.00
B-C Ratio (Benefit $/Cost $)	00.00
NPV	$00,000,000

The B-C ratio is the present value of benefits over the present value of costs. A B-C ratio greater than 1.0 indicates that benefits exceed the costs and the project is economically justified. Generally, higher B-C ratios are more desirable.

The NPV is the difference between the present value of benefits and present value of costs over the life of the improvements. NPV is sometimes called net benefits or net present worth. A positive NPV indicates that benefits exceed costs and the project is economically justified. Generally, higher NPVs are desirable.

6.0 Feasibility Review

Discuss feasibility of each recommendation in a bulleted list by improvement.

The Candidate Project Feasibility Checklist for TSM&O/Safety Program Funds is provided in **Appendix G**.

7.0 Implementation Plan

The implementation plan presented below identifies the agency responsible for the implementation, the nature of the improvement with respect to maintenance, near-term, or long-term and the associated cost.

Improvement	Responsible Agency	Agency with Roadway Jurisdiction	Maint., Near-, or Long-Term	Cost

Appendix A – Crash Summary

Insert Crash Summary Table

Appendix B – Field Photographs

Appendix C – Conceptual Improvement Diagram

Insert Conceptual Improvement Diagram

Appendix D – Construction Cost Estimate

Appendix E – Benefit Cost Analysis

Appendix F – Net Present Value

Appendix G – Candidate Project Feasibility Checklist for TSM&O/Safety Program Funds

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Appendix C - Project Application

Broward MPO
Metropolitan Planning Organization

Systems Management/Safety Candidate Project Application

1. Location of improvements: Click or tap here to enter text.

2. Applying agency: Click or tap here to enter text.

3. Owning agency: Click or tap here to enter text.

4. Maintaining agency: Click or tap here to enter text.

5. Agency representative:
Name: Click or tap here to enter text.
Title: Click or tap here to enter text.
Phone: Click or tap here to enter text.
E-mail: Click or tap here to enter text.

6. Summary of improvements: Click or tap here to enter text.

7. Anticipated present-day costs:
Construction + mobilization + maintenance of traffic: Click or tap here to enter text.
Preliminary Engineering: Click or tap here to enter text.
Contingency: Click or tap here to enter text.
Right of way: Click or tap here to enter text.
Total: Click or tap here to enter text.

8. Benefit-cost ratio: Click or tap here to enter text.

9. Net present value: Click or tap here to enter text.

10. Agency commitment to cover cost overruns ☐ Yes ☐ No

11. Attach Resolution of Support documentation

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