

**Raytheon**  
**Blackbird Technologies**

**WMI Persistence Proof of Concept  
Supplemental Report**

**For  
SIRIUS Task Order PIQUE**

**Submitted to:  
U.S. Government**

**Submitted by:  
Raytheon Blackbird Technologies, Inc.  
13900 Lincoln Park Drive  
Suite 400  
Herndon, VA 20171**

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**Analysis Report**  
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## **(U) Analysis**

(U) PIQUE report 189 describes a persistence technique using Windows Management Instrumentation (WMI). Accessing WMI in C++ requires the use of Component Object Model (COM) APIs. In essence, the technique requires the registration of a permanent event filter, the registration of a consumer, and the binding of the two together. In other words, when an event meets the criteria set forth by an event filter, the event consumer that it is bound to executes the specified functionality. Because permanent WMI objects are stored in a special database that is automatically loaded during startup and are not easily modified, this represents an ideal persistence technique.

(U) After carefully searching the API documentation, Blackbird believes that it is not possible to implement the entirety of the Proof of Concept (PoC) in C++. Additionally, Blackbird searched the HKEY\_CLASSES\_ROOT registry hive to determine if an undocumented Class ID (CLSID) exists that may provide the necessary functionality; unfortunately, none were found.

(U) Nevertheless, we did test a variety of techniques, but we were not able to implement a permanent event provider or consumer in C++; only temporary ones. The difference between the two can be summarized with two distinct points:

1. (U) A temporary event filter is created for the duration of the application that is requesting it and is not registered in the WMI database.
2. (U) A temporary event consumer is created for the duration of the application and is also not registered in the WMI database. Unlike a temporary provider, a temporary consumer captures events by either polling or using blocking function calls.

(U) When both limitations are taken into account, the use of a temporary event provider and consumer should be considered insufficient for a startup persistence technique. Due to these limitations, Blackbird performed additional research to determine if a similar implementation was possible that still enabled the desired functionality.

(U) After the additional research, Blackbird determined that the best solution was to generate a Managed Object Format (MOF) file. An MOF file is a C-Style syntax file that defines a series of WMI classes and objects to be installed.

(U) Typically, an MOF file is compiled using mofcomp.exe – an executable included with all standard Windows builds. Mofcomp.exe can be used to generate a Binary MOF (BMOF) file or it can be used to compile and install the MOF file into the WMI database. Fortunately, the C++ COM API contains the IMofCompiler interface which implements three methods that enable all of the functionality typically found in mofcomp.exe.

(U) Unfortunately, Microsoft's documentation is inconsistent and, ultimately, incorrect. For example, consider **Figure 1** (below):

Method	Description
<b>CompileBuffer</b>	Takes the information in a buffer and stores it in Windows Management. The buffer must contain binary MOF data.
<b>CompileFile</b>	Compiles a particular MOF file.
<b>CreateBMOF</b>	Reads a MOF file and outputs binary MOF data to another file.

**Figure : IMofCompiler Interface Documentation**

(U) Note that the **CompileBuffer** method states that it can take a buffer of BMOF data and compile /install it. Although the file cannot easily be generated at runtime, the small size of the BMOF data allows it to be included in a variety of ways and, therefore, make this a viable option. With this in mind, we still performed additional research to verify that no method exists that would allow a text MOF buffer to be generated at runtime and subsequently installed. Further investigation into the **IMofCompiler::CompileBuffer** method above revealed the text in **Figure 2** (below):

The **IMofCompiler::CompileBuffer** method compiles either a buffer containing binary MOF data or a text buffer in ASCII format. Binary MOF files contain parsed data and must be stored in the database. The **CompileBuffer** method only accepts multi-byte character arrays (string buffers) that are not NULL-terminated.

**Figure : IMofCompiler::CompileBuffer Documentation**

(U) Because the description of the method varies from one webpage to the next, we performed significant testing before determining that the ASCII text support is either incorrect or bugged to the point that it does not work. For example, the exact same file that succeeds with mofcomp.exe and IMofCompiler::CompileFile inexplicably fails with IMofCompiler::CompileBuffer. Various methods were attempted in an effort to get IMofCompiler:CompileBuffer working; however, none succeeded. Adding to the confusion, the error messages returned in this process did not provide line numbers and were generally completely undescriptive.

(U) The problems described above lead to the PoC being implemented in a way that accepts an ASCII (B)MOF file and installs it into the WMI database. With this in mind, we believe that embedding a BMOF file as a resource and unpacking it to a buffer to feed IMofCompiler::CompileBuffer constitutes the best functionality for future implementations. Furthermore, we believe future implementations should also contain the option of specifying a file to compile and / or install.

(U) During testing, Blackbird found that all tasks performed by the event consumer were run as the SYSTEM user and were executed on the SYSTEM desktop. For instance, when calc.exe was the command performed by the event consumer, calc.exe would not be drawn on the user's desktop and could only be seen if the desktop context was switched to the SYSTEM desktop.

(U) Also during testing, Blackbird found that the IMofCompiler interface methods appear to require Administrator rights in order to run successfully. We did test different security levels during COM initialization, but were ultimately unable to bypass this step. Despite that, Blackbird believes that a security context may yet exist that bypasses the need for elevated credentials.

(U) During research, Blackbird would also like to highlight the Microsoft WMI Tools utility that we believe is essential to future development and testing for any programs with similar implementations to this one.