The Military Ranks Ontology

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**Abstract**

The Military Ranks Ontology (MRO) provides a taxonomy of military ranks that is designed to support the integration and comparison of data pertaining to the hierarchical organization and command structures used by different armed forces around the globe. The ontology also provides coverage of other entities associated with military ranks, including authority roles, duties and responsibilities, acts of promotion, promotion requirements, and military rank titles. It uses U.S. and British Commonwealth derived rank structures as its starting point, but is designed in such a way as to be applicable to rank structures in general. After presenting the content of MRO as it exists today, we discuss potential applications for future work, including the analysis of *order of battle* data, formalized historical study of rank system evolution, as well as a strategy for dealing with rank systems which deviate in significant ways from more widely adopted canonical approaches.

**Keywords**

**1. Introduction**

*1.1. Military Ranks Ontology: Foundations and Design Goals*

When intelligence analysts collect or analyse information pertaining to the order of battle of an armed force, two central features upon which they focus are *hierarchical organization* and *command structure*. All such information incorporates data pertaining to military ranks, including their associated command roles, duties and responsibilities, since it is primarily through military ranks that armed force hierarchical organization is articulated. We present in what follows the Military Ranks Ontology (MRO), which provides a controlled vocabulary that is designed to support interoperability of military and intelligence data systems dealing with order of battle and related information.

MRO extends from the Common Core Ontologies (CCO), a suite of interoperable mid-level ontologies (CUBRC 2020a, 2020b) which grew out of IARPA’s Knowledge, Discovery and Dissemination project (Office of the Director of National Intelligence, 2014) and is now used in a variety of defense and intelligence related data initiatives. The CCO itself extends from the Basic Formal Ontology (BFO), a top-level ontology comprised of highly general terms such as ‘material entity’, ‘site’, ‘spatial region’, and ‘process’ (Arp, et al., 2015), which is used in over 400 ontology projects and is now published as international standard ISO/IEC 21838–2 (International Organization for Standardization, 2021).

In this first release, MRO is oriented primarily towards the rank structures of the U.S. Armed Forces and their associated promotion systems. That said, MRO is designed to enable the modelling of comparable rank structures, such as those employed by other member states of the North Atlantic Treaty Organization (NATO) (2021), as well as by those non-NATO states that emulate U.S.- and British Commonwealth-derived rank structures. In later iterations, the ontology will be extended also to other rank structures, including those used by the former Warsaw Pact and Chinese armed forces. One feature of the approach is that it can facilitate rigorous formulating and testing of the results of comparative rank structures, and also enable a more formal approach to the historical study of how rank structures evolved.

*1.2. The MRO backbone hierarchy*

Starting from the core class *Military Rank* (see section 2.1.), MRO introduces broad subclasses as illustrated in Figure 1. The terms used to represent these classes are defined in a highly generic manner in order to encompass the specific rank structures used by different services. The modelling of the latter is then enabled by introducing more specific subclasses, some examples of which are also given in Figure 1.

***Figure 1***

Graphical user interface, text

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*1.3. Overview of MRO’s Coverage*

MRO also covers a variety of entities related to the implementation and deployment of rank structures, including:

* *roles* associated with military ranks (for example, a service member holding the rank of general thereby acquires the role of general, with all the duties and powers which that role entails)
* *acts* of military rank promotion
* eligibility requirements for advancement in rank (for example, time in grade and time in service requirements, civil and military education requirements, physical fitness requirements)
* documents such as military commissions, promotion recommended lists, and promotion orders
* codes used to classify military ranks, such as NATO rank scale codes and U.S. uniformed service pay grade codes.

In what follows, terms representing ontology classes are written in italics, and unless otherwise specified, all such terms are taken from MRO. The most recent version of MRO can be found here: <https://github.com/PhiBabs935/Military-Ranks-Ontology>.

**2. Core MRO Classes**

*2.1. Military Rank*

The core class in MRO is represented by the term *Military Rank*, which is defined as follows:

*Military Rank* =def. Information Content Entity which: i) specifies a position in the order of precedence among members of an Armed Force, as well as any Authority Roles or responsibilities associated with that position; ii) is bestowed upon some Service Member through enlistment, appointment, or promotion.

The term *Information Content Entity* (*ICE*) is imported from the CCO Information Entity Ontology (CUBRC, 2021), where it is defined as follows:

*Information Content Entity* =def. Generically Dependent Continuant that generically depends on some Information Bearing Entity and stands in relation of aboutness to some Entity.

Examples include the information contents of a newspaper article, the data in a database, or a person’s name. Such entities manifest two features: they are copyable (and thus can serve as vehicles of communication) and they are about something.

*2.2. Rank and Title*

A *Military Rank* can be thought of as a title of a certain type. Examples of titles include: Mr., Ms., Professor, Princess, Reverend and so forth. A common feature of all such titles is that they are *partial* linguistic entities in the sense that they are typically used in conjunction with other linguistic entities which complete them. A title is then a part of an extended proper name which provides class or sortal information about the person named. ‘Mr. Babcock’, for instance, is an extended proper name, where the title ‘Mr.’ provides the sortal information that this article’s corresponding author is an adult man. The extended name ‘Professor Babcock’ provides information to the effect that the person named has the role of professor.

Information content entities possess aboutness always in virtue of the context in which they are used. (This paper, and its title and author information provide the relevant context for our use of ‘Babcock’ in the previous paragraph.) The extended proper name ‘General Mark Milley’ provides the information that Mark Milley has the rank of general. When used in the context of a U.S. Army document this would carry the additional information that the person in question is a U.S. Army General.

The view of ranks as titles should not be confused with the use of the phrase ‘title of address’ as used, for instance, for active duty members of the U.S. Armed Forces. In the Army, generals, lieutenant generals, major generals and brigadier generals are all addressed using an extended proper name including ‘general’. On an official publication or form, however, they would be referred to using an extended proper name that includes their specific rank (of major general, and so forth).

*2.3. Rank and Authority*

The definition of *Military Rank* relies on two terms imported from the CCO Agent Ontology (CUBRC, 2021), namely *Armed Force* and *Authority Role*. Here the term *Role* is taken over from BFO as a means of dealing with what are called ‘phase sortals’, such as ‘lawyer’, ‘student’, and so forth. A lawyer is a person who, for a certain period of time, has the lawyer role.

In the present context we are interested specifically with authority roles. An *Authority Role* is a role that is realized by acts which create, modify, transfer, or eliminate *Action Regulations*, and inheres in an *Agent* in virtue of collective acceptance of that *Agent*’s ability to issue binding directives. A CCO *Action Regulation* is a directive *ICE* that prescribes an Act as required, prohibited, or permitted (CUBRC, 2021). Examples include: an order issued to a subordinate by a commanding officer, or an Army policy prescribed within some official Department of the Army publication.

In order for an *Agent* to bear an *Authority Role*, their authority must be accepted, either directly or indirectly, by those over whom it is intended to prevail. This is typically achieved through a procedure for bestowing authority, and this procedure, too, must be authorized (CUBRC, 2021). Directives issued by the authority would otherwise have no binding force. But each chain of authority bestowal must at some point come to an end. In the U.S., for example, Presidential authority is legitimized by an election process.

In the U.S. Armed Forces privilege to exercise command is granted only to those Service Members who hold a grade of military rank above a certain level (Department of the Army, 2020a). For example, appointment to the officer ranks of second lieutenant, first lieutenant and captain in the Army, Marines, Air Force, and Space Force, or to ensign, lieutenant junior grade and lieutenant in the Navy and Coast Guard, must be approved by the President. In the case of appointments to major and above in the former and to lieutenant commander and above in the latter appointments must be approved also by the Senate (Office of the Law Revision Council, 1996).

*2.4. Order of precedence and chain of command*

The reference to order of precedence in clause i) of the definition of *Military Rank* reflects the characterization of rank found in the glossaries associated with official U.S. Army regulations (Department of the Army, 2020b). An order of precedence is a sequential hierarchy which can be applied to persons, groups, and organizations. For instance, a soldier holding the *U.S. Army General Rank* thereby has precedence over all soldiers of lower rank in the Army Chain of Command. In the case of officers, both commissioned and non-commissioned, precedence of rank is linked to a higher degree of authority, and consequently, greater responsibilities (Table 1) (Department of Defense, 2022).

Table 1 U.S. Army General Officers, ranked from highest to lowest

| **U.S. Army General Officers** | **Typical command roles** |
| --- | --- |
| *U.S. Army General* | Commander of a Field Army of 2 or more Army Corps, or of an Army Group consisting of 4 to 5 Field Armies |
| *U.S. Army Lieutenant General* | Commander of an Army Corps of 2 to 5 Army Divisions |
| *U.S. Army Major General* | Commander of an Army Division |
| *U.S Army Brigadier* | Deputy Commander of an Army Division |

Precedence of rank paradigmatically indicates a higher degree of authority exercised through military command. Indeed, the term ‘rank’ in the sense at issue here occurs in the *DOD Dictionary of Military and Associated Terms* only once*,* namely in the first of the three entries associated with the term ‘command’:

command — 1. The authority that a commander in the armed forces lawfully exercises over subordinates by virtue of rank or assignment (Joint Chiefs of Staff, 2021).

However, the link between precedence of rank and degree of authority does not hold in every case. A *U.S. Army Private First Class* obeying an order from the platoon commander (a Lieutenant)—which has been relayed to him by his immediate supervisor (a Sergeant)—is not part of the chain of command. Indeed, while the Private First Class has precedence of rank in relation to the Private Second Class, he/she has no *Authority Role* in relation to privates of lower rank, but only duties or responsibilities. Hence the use of ‘or’, rather than ‘and’, in clause i) of the MRO definition of *Military Rank*.

*2.5.* *Upper-level Military Rank terms*

*Military Rank* is the parent class to *Commissioned Officer Rank*, *Enlisted Rank*, and *U.S. Armed Forces Warrant Officer Rank* as in Figure 1.[[1]](#footnote-1) Two important children of *Enlisted Rank* are: *Junior Enlisted Rank* and *Non-Commissioned Officer Rank.* Consider first *Enlisted Rank*, which we define as follows:

*Enlisted Rank* =def. Military Rank that signifies a position in the order of precedence below that of the Commissioned Officer Ranks and is bestowed on a Service Member either when enrolling into an Armed Force, or on completion of basic training, or via a subsequent promotion.[[2]](#footnote-2)

Upon enlistment into an Armed Force, Service Members are typically assigned to its lowest *Junior* *Enlisted Rank*. Examples include the *U.S. Army Private Rank*, *U.S. Airman Basic Rank*, and *U.S. Navy Seaman Recruit Rank*. We define *Junior Enlisted Rank* as follows:

*Junior Enlisted Rank* =def. Enlisted Rank which signifies a position in the order of precedence below that of the Non-Commissioned Officer Ranks.

Typically, Service Members holding a *Junior Enlisted Rank* lack an *Authority Role*. Their primary role is to carry out orders issued to them by their higher ranked supervisors.

After initial entry into service, enlisted personnel advance to higher *Enlisted* *Ranks* through promotion. At each *Enlisted Rank*, Service Members spend a good deal of time undergoing training and education to gain the capabilities (knowledge, skills and attributes of moral character and the like[[3]](#footnote-3)) required to take on higher levels of responsibility at successively higher ranks (Department of the Air Force, 2021; Department of the Army, 2019b; Office of the Chief of Naval Operations, 2018). As a result, eligibility criteria for enlisted promotions typically encompass a variety of training and education requirements, and sometimes requirements involving the swearing of oaths which are designed to consolidate unit cohesion and go hand in hand with the ethical dimensions of military training.

*2.6. Non-Commissioned Officer Rank*

Typically, it is only when an enlisted service member advances beyond the *Junior Enlisted Ranks* to a *Non-Commissioned Officer Rank* that he or she acquires an *Authority Role*, for example when a U.S. Navy Sailor is promoted from the *U.S. Navy Seaman Rank* to the *U.S. Navy Petty Officer Third Class Rank*.

We define *Non-Commissioned Officer Rank* as follows:

*Non-Commissioned Officer Rank* =def. Enlisted Rank which specifies an Authority Role that is realized in the leadership and training of lower ranked enlisted Service Members, or service in a military staff position, and which is acquired via promotion through the enlisted ranks.

When holding a *Non-Commissioned Officer Rank*, one’s primary role is to observe and direct lower ranked Service Members—including lower ranked non-commissioned officers (NCOs)—in the execution of their duties and responsibilities. We define *U.S. Army Staff Sergeant Rank*:

*U.S. Army Staff Sergeant Rank* =def. U.S. Army Non-Commissioned Officer Rank that is directly above the U.S. Army Sergeant Rank and directly below the U.S. Army Sergeant First Class Rank, and which signifies that the rank holder bears an Authority Role that primarily involves leadership of a squad of 8 to 16 Soldiers (Department of the Army, 2020c; U.S. Army, 2022).

*U.S. Army Staff Sergeants* are also permitted to serve in other capacities. The role of Platoon Sergeant—primary assistant and advisor to the Platoon Commander—is typically reserved for the next higher rank, the *U.S. Army Sergeant First Class Rank*. But in the absence of a Sergeant First Class, the Staff Sergeant may acquire that role.[[4]](#footnote-4)

The first clause of the definition of *U.S. Army Staff Sergeant Rank* reflects a recurring feature of *Military Rank* terms, namely that they represent a place within a hierarchy (namely: the hierarchy of ranks of a given Armed Force). This feature is also captured in the logical axiomatization of MRO (see section 3 below).

*2.7. Commissioned Officer Rank*

We define a *Commissioned Officer Rank* as follows:

*Commissioned Officer Rank* =def. Military Rank that signifies an Authority Role derived from a Military Commission from the head of state, and is typically appointed following training as a leadership and management generalist.

The training of NCOs in contrast is more focused on specialization in a certain occupational field. The command authority of commissioned officers is defined in relation to command units, detachments, vessels, and aircraft. Following completion of officer training, they are appointed to the most junior of the *Commissioned Officer Ranks* of the relevant service via a *Military Commission*, a legally binding directive – issued in the name of or signed by the head of state – that bestows on those officers the powers associated with commissioned rank.

*2.8.* *Warrant Officers*

Warrant officers were first employed by the English Royal Navy in the 13th century to fill an authority position above that of NCOs, but below that of commissioned officers. Unlike commissioned officers, naval warrant officers were appointed to and held their rank by virtue of a warrant issued by the Navy’s Board of Admirality, rather than a formal commission issued by the sovereign. To this day, appointment via warrant is still the standard for militaries that employ warrant officer ranks.

Note (Figure 1) that MRO has no generic class for the rank of warrant officer, as the warrant officer ranks used by different militaries do not form a homogenous class. The U.S. Armed Forces are like the British and Canadian Armed Forces in that each classifies warrant officers into a separate category of ranks between the *Commissioned* and *Non-Commissioned Officer Ranks* (Department of National Defence, 2019; Ministry of Defence, 1999, 2017, 2019). But there are also many military rank structures which classify warrant officer ranks as the most senior of the NCO ranks. Notice also (as in Figure 1) that, unlike the British and Canadian Armed Forces, the U.S. Armed Forces do not classify warrant officers as enlisted, even though U.S. warrant officers usually attain their rank only after enlisting and then accruing years of specialized technical experience while advancing through the *Enlisted Ranks*.

*U.S. Armed Forces Warrant Ranks* are not comparable to those of the British and Canadian warrant officer ranks. While part of a separate category from the NCO ranks, British and Canadian warrant officer ranks are NATO equivalent to the most senior NCO ranks of the U.S. Armed Forces (NATO, 2021), with British and Canadian warrant officers filling leadership roles comparable to those of their American equivalents. The U.S. Armed Forces warrant ranks, on the other hand, have no equivalents in the services of other NATO member countries. We define the class *U.S. Armed Forces Warrant Officer Rank* as follows:

*U.S. Armed Forces Warrant Officer Rank* =def. Military Rank of the U.S. Armed Forces that is above the Enlisted Ranks but below the Commissioned Officer Ranks, is appointed by warrant or Military Commission, and possession of which signifies that the rank holder is a technical specialist serving in a position requiring greater authority and responsibility than that of a senior Non-Commissioned Officer (Congressional Budget Office, 2002; Department of the Army, 2019c; Department of the Navy, 1992, 2006).

A U.S. warrant officer’s primary role is to provide technical expertise and guidance to their superior commanders. The most junior warrant officers are appointed via a warrant from their respective service secretaries, where more senior warrant officer ranks are appointed via Presidential commission in the same manner as commissioned officers. By virtue of the warrant or Presidential commission on whose basis they hold their rank, they are also authorized to command units, detachments, vessels, and aircraft, thereby exercising the same powers as officers of the *Commissioned Officer Ranks*. Warrant officers fill positions that require both the authority of more broadly trained commissioned officers, and the sort of extensive knowledge and specialization gained through progression through the *Enlisted Ranks*.

**3** **Relations between rank terms**

*3.1. Precedence between ranks*

MRO defines a number of important relations to represent links between *Military Rank* terms. First, we define the relation *is higher military rank than* and its inverse as follows:

A Military Rank MR1 *is higher military rank than* Military RankMR2iff

1. MR1 and MR2 are ranks of the same Armed Force, and MR1specifies a higher position in the order of precedence among the members of that Armed Force than does MR2; or
2. MR1 and MR2 are ranks of two separate Armed Forces, and MR1 specifies a higher position in the order of precedence among the members of those Armed Forces than does MR2.

The converse, whereby one military rank is lowerthan another, is then defined in the obvious manner.These definitions allow us to say, for instance, that *U.S. Army General Rank is higher military rank than* *U.S. Army Colonel Rank* and that *U.S. Army Specialist Rank is lower military rank than U.S. Army Corporal Rank*. The second clause of each definition allows us to say, for instance, that *U.S. Army General Rank is higher military rank than U.S. Marine Corps Colonel Rank*. It also allows us to say, for instance, that *British Army Brigadier Rank is lower military rank than U.S. Army Major General Rank*.

In MRO, these relations have the sub-properties *is one military rank higher than* and *is one military rank lower than*, which are used to link ranks separated by only a degree of one in order of precedence. These in turn have the sub-properties *is military rank directly above* and *is military rank directly below*, which hold only between ranks of the same Armed Force. These relations are used to provide each *MRO* term representing a U.S. military rank with logical axioms that link it to other such terms in the manner illustrated in Figure 2.

***Figure 2***: Military Rank order of precedence axioms

Table

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*3.2. NATO Rank Codes*

As we can also see from Figure 2, *Military Rank* terms are provided with axioms linking them to the classification codes assigned by NATO to the corresponding ranks of the Armed Forces of its member states. We define *NATO Rank Code* as follows:

*NATO Rank Code* =def. Information Content Entity that classifies the Military Ranks used by member countries of the North Atlantic Treaty Organization according to a standardized rank scale which matches the Military Ranks of each member country to the equivalent Military Ranks used by the other members.

NATO's standardized rank scale establishes the order of precedence among military personnel of different member countries, first to support NATO joint operations, secondly when assigning positions within NATO itself. The codes are used also in the preparation of establishment tables, personnel statistics, strength returns, personnel requisitions, and personnel reporting in general (NATO, 2021). In MRO the specific codes used by NATOare classified under the following subclasses of *NATO Rank Code*:

*Commissioned Officer NATO Rank Code* =def. NATO Rank Code that classifies the Commissioned Officer Ranks used by member countries of NATO according to a standardized rank scale which matches the Commissioned Officer Ranks of each member country to the equivalent Commissioned Officer Ranks used by the other members.

*Other Ranks NATO Rank Code* =def. NATO Rank Code that classifies the Enlisted Ranks used by member countries of NATO according to a standardized rank scale which matches the Enlisted Ranks of each member country to the equivalent Enlisted Ranks used by the other members.

*Warrant Officer NATO Rank Code* =def. NATO Rank Code that is assigned to U.S. Armed Forces Warrant Officer Ranks of different branches of the U.S. Armed Forces that are equivalent in grade.

Under *Commissioned Officer NATO Rank Code*, we have the codes *OF-1* through *OF-10*, where *OF-10* is the code used for those *Commissioned Officer Ranks* in any given force which rank highest on the NATO scale, and *OF-1* for ranks at the most junior end of the Commissioned Officer scale. Under *Other Ranks NATO Rank Code*,we have the codes *OR-1* through *OR-9*, where *OR-9* is used for the most senior Enlisted Ranks on the NATO scale, and *OR-1* for the most junior of those ranks. Under *Warrant Officer NATO Rank Code*, we have the codes *WO-1* through *WO-5*. Falling between the *Commissioned Officer Ranks* and the *Enlisted Ranks*, the *U.S. Armed Forces Warrant Ranks* have no equivalents in the Armed Forces of other NATO member countries, as noted in *2.8*.

Related, in addition to the rank systems of the U.S. Armed Forces, the rank structures of the British, Canadian, German, and French Armed Forces (all NATO members) have also already been incorporated into MRO’s *is-a* hierarchy. All of these ranks are linked to each other via the relations *is military rank directly above* and *is military rank directly below* and linked to *NATO Rank Codes*. MRO will eventually provide coverage of all NATO armed forces rank systems and of rank systems of peer adversaries.

**4 Acts of Promotion and Promotion Eligibility Requirements**

*4.1. Acts of Promotion*

The promotion system is a key aspect of military rank structures. While serving in an Armed Force, one is typically expected to advance through the ranks. Those who repeatedly fail in this respect are typically discharged from service. Thus a Service Member’s time in their current rank is spent not only fulfilling the responsibilities of that rank but spent developing the knowledge, skills and other attributes required to be eligible for promotion to the next rank.

Military promotions are a subclass of promotion more broadly conceived. In MRO, we define promotion as follows:

*Act of Promotion* =def. Act of Declarative Communication in which an Agent, realizing an Authority Role derived from that Agent’s rank or position within some Organization, advances a Person within that Organization, or related Organization, to a higher rank or position.

*Act of Declarative Communication*, whichis imported from CCO, is an act in which someone makes a declaration that is designed to bring about a change in reality in accordance with that declaration. Examples include baptisms, declaring war, and pronouncing a couple husband and wife (Searle, 1969).

Promotions always involve some person with authority. For instance, an employee’s immediate supervisor within an *Organization* typically has the power not only to assign the employee various tasks, but also to determine whether the employee is qualified for advancement. We say that the promotion authority is an *Agent*.The term *Agent*, also imported from CCO, is a defined class. An *Agent* is someone, or something, that is capable of intentional acts. An agent can be either an individual person or a group of persons such as an *Organization*. While an act of promotion can often be carried out by an individual person, promotions are also carried out by *Organizations*. The decision to advance an employee may for example be made by a board, rather than one person. In this case, the board has the relevant authority role.

Notice also that the definition allows for cases where the *Agent* carrying out the promotion is not part of the same *Organization* as the person being promoted. This is particularly important in the military case, as *Agents* who carry out promotions are not exclusively members of the Armed Forces. This is reflected in the following definition:

*Act of Military Rank Promotion* =def. Act of Promotion in which an Agent, realizing an Authority Role derived from that Agent’s position within some Government, Military Department, or Armed Force, advances another Agent, who holds a Military Rank within some Armed Force, to a higher Military Rank.

An *Agent* within a Government can be an agent in an *Act of Military Rank Promotion*, as when the U.S. President approves promotions to the *Commissioned Officer Ranks* of Major and above, ‘by and with the advice and consent of the Senate’ (Office of the Law Revision Council, 1996). Various civilian-led U.S. Military Departments participate as *Agents* in promotions that are centralized, or semi-centralized, at the headquarters of the respective military department. For instance, Headquarters, Department of the Army, including its civilian staff, take part in promotions for the *U.S. Army Sergeant Rank* and *U.S. Army Staff Sergeant Rank*. But other U.S. Armed Forces promotions are also made by members of the Armed Forces themselves, for instance those decentralized promotions that occur at the unit level and are made by the unit’s commanding officer.

The MRO provides a taxonomy of different types of *Acts of Military Rank Promotion*, with a current focus on promotion systems of the U.S. Armed Forces. It distinguishes between the promotion systems of the different Services, as well as sub-branches of each Service (for example, the Regular Army, Army Reserve, and Army National Guard). A snapshot of portions of the current taxonomy, with examples, is presented in Figure 3:

***Figure 3*** Acts of Military Rank Promotion

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*4.2. Promotion Eligibility Requirements*

There is a variety of requirements one must meet to be eligible for promotion through the ranks: requirements pertaining to physical fitness, education, technical skill, ethics, as well as time served. The MRO classifies these requirements, and then links them axiomatically to the associated subclasses of *Act of Military Rank Promotion*. This enables one to query the ontology for each of the requirements that must be satisfied to be eligible to participate in an *Act of Military Rank Promotion*. The main types of eligibility requirement are represented in Figure 4:

***Figure 4*** MRO’s Promotion Eligibility Requirement Taxonomy

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The various requirements are classified under the MRO term, *Action Requirement for Promotion in Military Rank*, which is defined as follows:

*Action Requirement for Promotion in Military Rank* =def. Action Requirement that requires an Agent, who holds a Military Rank within some Armed Force, to complete some Act in order to be eligible for promotion to the next higher Military Rank.

This represents a subclass of *Action Requirement*, another term imported from the CCO Agent Ontology, which is defined as “An Action Regulation that requires some Act”.

Examples of *Action Requirement for Promotion in Military Rank* are usually recorded in official military publications. In the U.S. Army, the relevant publications are referred to as Army Regulations, which are documents published by the Headquarters, Department of the Army, which prescribes Army policy. In this case, the relevant authority is the Department of the Army, and the directives found in Army Regulations are the outputs of actions taken by this organization in such a way as to realize its Authority Role.

Many military rank promotion systems include eligibility requirements pertaining to time served in the military, including time served at current rank. In the U.S. Armed Forces, these are called Time in Service and Time in Grade Requirements. The MRO provides a taxonomy of such requirements prescribed by the different branches of the U.S. Armed Forces, including their subbranches (e.g., Regular Army and Army Reserve) (Figures 5 and 6).

**Figure 5** Time in Service Requirements. Abbreviations are as follows. ARNG = Army National Guard; RA = Regular Army; USAR = U.S. Army Reserve.

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**Figure 6** Time in Grade Requirements. ARNG = Army National Guard; RA =

Reserve Army; USAR = U.S. Army Reserve.

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A *Time in Service Requirement for Promotion in Military Rank* is an *Action Requirement* that requires a Service Member to have served a minimum length of time from their initial date of entry into military service, to be promoted to the next rank. A *Time in Grade Requirement for Promotion in Military Rank* requires a Service Member to have served a minimum length of time in their current rank to be promoted to the next rank. In MRO, each subclass of *Time in Service* and *Time in Grade Requirement for Promotion in Military Rank* is associated with an axiom that links the class via CCO’s *requires* relation to some MRO subclass of CCO’s *Act of Military Service*, where the latter is defined as “An Act of Employment wherein a Person serves as a member of a Military Force, whether voluntarily or by conscription.” Examples of such subclasses, with associated axioms, are presented inFigure 7:

***Figure 7*** MRO Examples of Time in Service and Time in Grade Requirements

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The complexity of the axioms for the MRO terms in Figure 7 requires some unpacking. They rely on the following terms and relational expressions imported from CCO (Table 2):

**Table 2**

|  |  |
| --- | --- |
| Term | *Day*, *Multi-Month Temporal Interval*, and *Information Bearing Entity* |
| Individual Term | *Month Measurement Unit* |
| Relational Expression | *requires*, *occurs on*, *designates*, *interval started by*, *is measured by*, and *uses measurement unit* |
| Data Property | *has integer value* |

But first a clarification regarding *Act of Military Service*. Consider the MRO term *Act of U.S. Army Service*, defined as an “An Act of Military Service wherein some Person serves as a member of the U.S. Army.” Instances of this class include the training a Soldier receives on a given day, or the tour of duty a Soldier completed in a foreign country. Importantly, an *Act of U.S. Army Service* can include other such acts as parts. The totality of a Soldier’s service, from time of enlistment to time of discharge, is itself an *Act of U.S. Army Service*.

*4.3. Axiomatization for Promotion Requirement Terms*

Let us focus on *Time in Service Requirement for Promotion to U.S. Army Specialist Rank (RA)* and the axiom by which it is linked via the *requires* relation to an *Act of U.S. Army Service*. This axiom specifies that the required *Act of U.S. Army Service* must be such that the measurement of its duration—which is represented by the MRO term *Time in Service Measurement Information Content Entity* (where ICE abbreviates)—meets or exceeds a certain minimum value.

The complexity of the axiom reflects the CCO semantics for representing information. The CCO is designed to be realism-based. This means that its ontologies draw a distinction between information entities, and the entities which *carry* that information (CUBRC 2020a, 2020b; Smith et al., 2010; Smith et al., 2013). For instance, it distinguishes between the enlistment date of a Private First Class (PFC), and the material entities which carry that information such as documents or servers. Entities of the latter sort are instances of the class *Information Bearing Entity*.

CCO data properties, such as *has integer value*, have as their range OWL:*datatypes* such astext values, integer values, and date values, and have *Information Bearing Entity* as their domain (CUBRC, 2020b). Furthermore, instances of the class *Measurement Unit*, such as the CCO individuals *Pound Measurement Unit* and *Month Measurement Unit*, are linked only to instances of *Information Bearing Entity*. For example, a certain patient’s weight measurement of 200 pounds is carried by the hospital scale the doctor uses to take the measurement. The scale *uses measurement unit* some *Pound* *Measurement Unit*, and *has integer value* a value of 200. In our example from Figure 7, an *Information Bearing Entity*—such as the record of the time in service measurement entered into a document field on a Department of the Army form—*uses measurement unit* some *Month Measurement Unit* and *has integer value* a value of at least 24.

In BFO terms, a process’s duration is the BFO:*temporal region* on which it occurs or unfolds. In our case, the required *Act of U.S. Army Service* *occurs on* some CCO *Multi-Month Temporal Interval*, whichis a “one-dimensional temporal region that is measured in months and spans at least one month.” The latter *is measured by* some *Time in Service Measurement ICE*. In the U.S. Armed Forces, time in service is computed using a Service Member’s ‘date of initial entry into military service’, with the U.S. Army in particular using the term ‘basic active service date’. To represent this, MRO introduces the class *Basic Active Service Date Identifier*, a *Designative ICE* that designates the calendar *Day* on which some person officially entered the U.S. Army. It is a subclass of CCO’s *Calendar Date Identifier*.

The CCO relation *interval started by* is used to link one temporal interval to a shorter temporal intervalthat it contains and marks the start of the former. For example, any month or week is an *interval started by* the first *Day* of that month or week.Our axiom says that the *Multi-Month Temporal Interval* on which an *Act of U.S. Army Service* occurs is an *interval started by* a *Day* that is *designated* by some *Basic Active Service Date Identifier*. Thus, we can represent that the *Time in Service Measurement ICE* measures the multi-month duration of an *Act of U.S. Army Service* which started the *Day* the PFC initially entered the Army (as opposed to an intervening *Act of U.S Army Service*, such as his or her service at the *U.S. Army Private Second Class Rank*).

*4.4. Measurement Information Content Entities*

The same logical representation is used for the terms *Time in Service Measurement ICE* and *Time in Grade Measurement ICE* as shown in Figure 8.

**Figure 8** Time in Service and Time in Grade Measurement ICE’s. CCO’s *is a measurement of* and *is temporal region of* are, respectively, the inverse properties of *is measured by* and *occurs on*.

Graphical user interface, text, application, chat or text message

Description automatically generated

The logical definition for *Time in Service Measurement ICE* relies on MRO’s *Date of Initial Entry into Military Service Identifier*, which is defined as a “Calendar Date Identifier that designates the Calendar Day on which some Person first entered into service in some branch of the U.S. Armed Forces.” The definition thus expresses that a *Time in Service Measurement ICE* measures the BFO *one-dimensional temporal region* of some person’s *Act of Military Service* which started on the *Day* that person first entered into service.

The logical definition for *Time in Grade Measurement ICE* relies on MRO’s *Date of Rank Identifier*, a *Calendar Date Identifier* that designates the day on which a Service Member’s appointment to a particular *Military Rank* took effect.[[5]](#footnote-5) The definition also relies on MRO’s *Act of U.S. Military Service at Current Department of Defense Pay Grade*, defined as an “Act of U.S. Military Service which is composed of those Acts of U.S. Military Service that a Person is an agent in over the duration of their time at their current Department of Defense Paygrade.”

When a U.S. Army corporal’s time in grade is calculated in order to determine eligibility for promotion to sergeant, it is a measure of the time they have served since first attaining paygrade E-4. E-4 is one of several U.S. military paygrades that comprehends more than one rank, including in addition to corporal the next lower rank of specialist. Where an E-4 specialist is laterally appointed to the rank of corporal, the Soldier’s date of rank remains unchanged (Department of the Army, 2019a, 2019b). It is the *Date of Rank Identifier* designating the day on which the Soldier was promoted to specialist that is used to calculate their time served at E-4.

*4.5.* *Querying MRO for Promotion Requirements*

As shown in Figure 7, both time in service and time and grade requirements are linked to a required act by the followingrelation:

*x* *is a requirement condition for* *y* at *t* iff *x* is an instance of Action Regulation at time *t*, *y* is an instance of Act at a later time *u*, and there is some *z* such that *z* is an instance of Act at *t*, and *x* prescribes that some Agent must be agent in *z* in order for that Agent, or another Agent, to be a participant in *y*[[6]](#footnote-6) at *u*.

To illustrate how this works imagine that Bob, a Regular Army PFC, is being considered for promotion to Specialist. The *Time in Service Requirement for Promotion to U.S. Army Specialist Rank (RA)* *is a requirement condition for* promotion to Specialist which prescribes that Bob must have served for at least 24 months since entering the Army in order to be promoted to Specialist.

Within MRO, each *Action Requirement* *for Promotion in Military Rank* that must be satisfied for a person to participate in an *Act of Military Rank Promotion* is linked to the latter class by *is a requirement condition for*. For any *Act of Military Rank Promotion*, this enables one to query the ontology for the corresponding promotion eligibility requirements. A few examples are provided inFigure 9.

***Figure 9*** *MRO Promotion Requirements Queries*. APFT = Army Physical Fitness Test; REGAF = Regular Air Force; WAPS = Weighted Airman Promotion System

Graphical user interface, text, application, email

Description automatically generated

**5 Ranks, Roles and Persons**

*5.1. Military Rank-Associated Roles*

The MRO distinguishes between *Military Ranks*, the BFO *Roles* that are associated with *Military Ranks*, and the persons that hold those ranks (Figure 10).

***Figure 10***

Timeline

Description automatically generated

By virtue of holding a given military rank, the rank holder acquires the corresponding roles that are specified by that rank. This is reflected in the definition of such roles. For example:

*U.S. Army Sergeant First Class Role* =def. U.S. Army Non-Commissioned Officer Role that inheres in an Agent in virtue of that Agent holding the U.S. Army Sergeant First Class Rank, and which the Agent typically realizes by serving as a Platoon Sergeant, assisting, and advising the platoon leader, while also training and caring for the unit’s subordinate Soldiers (Department of the Army, 2020c; U.S. Army, 2022).

Bearing the *U.S. Army Sergeant First Class Role* involves having certain other roles, including the primary role of Platoon Sergeant. But in the absence of a Sergeant First Class in a given unit, the role of Platoon Sergeant may also be taken on by the NCO of the next lower rank, namely Staff Sergeant. This is a common feature of roles. Thus, while the role of Vice-Chair of a committee is realized in various primary tasks, secondarily it involves taking on the roles of the Chair in her or his absence.

The above definitionreflects the fact that Platoon Sergeant is the role prescribed for the *U.S. Army Sergeant First Class* by the Army’s Tables of Organization and Equipment (TO&Es). The latter prescribes also distinctive positions for Soldiers of other ranks, such as the *U.S. Army Sergeant Rank*. The primary role which the TO&E prescribes for that rank is that of leader of a 4 Soldier team. In practice though, U.S. Army Sergeants often take on the role of squad leader, the role prescribed primarily for NCOs of the next higher rank, namely Staff Sergeant. This is due to the high rate at which Soldiers tend to be promoted to Sergeant from the *Junior Enlisted Ranks*.

*5.2. Classes for Persons holding Military Ranks*

Given ranks and roles, we define classes for persons holding those ranks and roles. For instance, we define a *U.S. Army Sergeant First Class* as follows:

*U.S. Army Sergeant First Class* =def. U.S. Army Senior Non-Commissioned Officer who has U.S. Army Sergeant First Class Rank and is the bearer of a U.S. Army Sergeant First Class Role.

The same definition pattern, namely, ‘*x* =def. A *y* who has some rank *r* and is the bearer of some role *p*’, is used for all the person classes in the ontology.

*5.3. Virtues of our account of rank-related roles and Persons bearing those roles*

Consider the case of Joe a *U.S. Army Sergeant First Class*, who acquires the role of Platoon Leader after his commanding officer, a *U.S. Army First Lieutenant*, perishes on the battlefield. By taking on this role, Joe does not thereby acquire a *First Lieutenant Role*, for there are two distinct roles at issue here. Exercising the latter role primarily involves exercising the former role, but they are not the same roles. Having the *U.S. Army First Lieutenant Role* involves acquiring and realizing other roles as well, as reflected in our definition:

*U.S. Army First Lieutenant Role* =def. U.S. Army Commissioned Officer Role that inheres in an Agent in virtue of that Agent holding the U.S. Army First Lieutenant Rank, which primarily involves the command of more specialized weapons platoons and indirect fire computation centers, but often also involves service as the executive officer of a company-sized unit (U.S. Army, 2022).

The executive officer in a company (which is composed of platoons) is the second-in-command, serving directly under the company commander. When, however, Joe replaces the lieutenant as Platoon Leader, then unlike the lieutenant, he would not be expected to serve at the company level as an executive officer. Thus it would be incorrect to say that Joe acquires the *U.S. Army First Lieutenant Role*. He acquires that role only by advancing to the *U.S. Army Lieutenant Rank*.

Other cases are different. Consider, for instance, the case where Jim, a First Lieutenant, is given a battlefield promotion to the next higher officer rank in order to fill an emergency position vacancy. There is a shortage of available *U.S. Army Captains* in the battle zone, and the vacant position is a command role that is officially authorized for the *U.S. Army Captain Rank*. A battlefield promotion to this rank temporarily advances Jim to this rank precisely in order that he can take on a command role that is designated for officers of that rank (Department of the Army, 2020b). This case is represented in the ontology as follows:

*Act of Battlefield Promotion to U.S. Army Captain Rank* =def. Act of Promotion to U.S. Army Captain Rank, executed during wartime, in which some U.S. Army Lieutenant Colonel appoints a Soldier within their command to a vacant position authorized for the U.S. Army Captain Rank, and advances the Soldier to that rank, but only for the duration of their service in the qualifying position (Department of the Army, 2020b).

Such promotions are terminated at the termination of the Soldier’s service in the qualifying position. The Soldier is given the rank, and in virtue of this acquires the *U.S. Army Captain Role*, authorizing him or her to fill the vacant command position. Here, therefore, the Soldier is at least temporarily an instance of *U.S. Army Captain*.

**Discussion and Future Work**

In the future we will add coverage to MRO of the military rank insignia which Service Members typically wear on their uniforms. For example, one can identify *U.S. Army Generals* by the 4 silver star insignia which they wear above the shoulder of their uniforms. Military rank insignia will be introduced in MRO as *Information Bearing Entities*, where one’s rank then serves as the relevant ICE.

Definitions of MRO terms such as *Commissioned Officer Rank and Non-Commissioned Officer Rank* reflect a common pattern implemented by military command structures: commissioned officers are trained as military management generalists, while NCOs assist officers in the command and control of their respective units through the training, discipline, and care of the junior enlisted ranks. But there are bound to be deviations from the norm.

In the present-day Russian Armed Forces what are called “contract NCOs” fill a markedly different niche from their Western (including U.S.) counterparts. Russian NCOs are primarily trained as technical experts, and usually serve their whole career in a single vocation. A career path for small unit leadership personnel exists, but requires the NCO to graduate from an academy program lasting 2 years and 9 months (Grau et al., 2016; Bartles, 2019). As a result, Russian commissioned officers must fill many of the roles filled by NCOs in Western forces. For instance, in addition to serving as the platoon commander, a Russian lieutenant typically serves as the platoon’s primary trainer and disciplinarian. Furthermore, the academy training of Russian commissioned officers focuses upon developing expertise in the officer’s particular specialty (Bartles, 2019), which implies a deviation of Russian practice from the definition of *Commissioned Officer Rank* in MRO.

MRO will deal with this issue using the methodology developed for the modelling of human anatomy within the Foundational Model of Anatomy (FMA) (Rosse et al., 1998; Rosse et al., 2003). The FMA ontology is a representation of *canonical anatomy*, which “comprises the synthesis of generalizations based on anatomical observations that describe idealized anatomy” (Rosse et al., 2003). But it also provides a framework for representing what are called anatomical variants. In FMA, anatomical variants are assigned to a *Variant* subclass of certain FMA terms (Rosse et al., 1998). For instance, *Cervical Rib* is a child of *Variant Rib*, which is a child of *Rib*.

Similarly, we can define MRO terms such as *Variant Commissioned Officer Rank* and *Variant Non-Commissioned Officer Rank*. As Russian NCOs are primarily intended to be technical experts, terms for Russian NCO ranks would be assigned as children of *Variant Non-Commissioned Officer Rank*, which is a type of NCO rank that deviates from its canonical signification in MRO.

Chain of command is vital to the functioning of highly complex group structures such as we find in the military, particularly in the context of war where immediate response is vital. To ensure the timely execution of military operations, those of lower ranks have to know who they are to take orders from; superior officers need to know those to whom their orders are to be directed. Chain of command provides the line of authority and responsibility along which such orders are correctly passed. An ontology of military ranks might thus help in the analysis of military organizational behavior, for example by allowing analysts to identify different types of degradation of rank structure, and of the chain of command that depends thereon, and how such degradation affects the realizability of missions.

An ontology of *ranks* goes hand in hand with an ontology of the *units* people of given ranks can have command over. The latter would include terms such as *team*, *platoon*, *company, regiment, division, corps, squadron, fleet,* and so on, as well as subclasses, such as *rifle team* and *field artillery regiment*. As discussed in Table 1, each general officer rank in the U.S. Army is associated with command of a different level of Army unit, and so with increasing levels of responsibility. Indeed, this is a common feature of military ranks, at least for those that confer an *Authority Role*.

Likewise, an ontology of ranks goes hand in hand with an ontology of the military installations that people of given ranks can be given command of, but also with an ontology of military vehicles and their parts, for example gunnery, navigation, engineering, construction and repair (hull), medical, supply, and communications departments on a Navy ship. Future work will accordingly involve linking *Military Rank* terms to associated terms for military units, military installations, and the like. We can, for instance, link commissioned naval ranks to the different types of ships, units, formations (e.g., carrier battle group), and shore installations over which naval officers exercise command and control.

MRO can also be applied to *order of battle* analysis.An order of battle is a representation of the hierarchical organization, command structure, strength, disposition, equipment, training, tactics, and logistics of the units and formations of an Armed Force. In the context of a military operation, the predicted order of battle of the enemy force provides an analyst with information about what his or her own force can expect to encounter from the enemy while deployed in the field and is crucial to operations planning. The features of hierarchical organization and command structure will then incorporate data pertaining to military ranks and their associated command roles, duties and responsibilities.

The MRO can also be used to facilitate a formal framework for describing the evolution of rank systems. First, this would involve the creation of sister ontologies representing historical precursors of modern-day rank systems. Secondly, we could then apply to these ontologies the sort of Formal Concept Analysis (FCA) described in (Ganter et al., 2005), drawing on the way in which (Ceusters et al., 2016) used FCA to analyze content changes within subsequent releases of the SNOMED-CT medical terminology. In this way we can analyze the ways in which rank systems have changed over time and investigate how changes were brought about for example by changes in military technology or by political developments. The MRO would thereby allow a new sort of military history, providing the formal means to study the different sorts of changes in rank and authority structures which have occurred over time.

**Conclusion**

When monitoring enemy armed forces for the purpose of operation planning, as well as defense, two key features intelligence analysts need to consider are *hierarchical organization* and *command structure*. The MRO provides the analyst with a useful tool with which to harvest such data. A plethora of military-related domain ontologies, many extending from BFO and the CCO suite (CUBRC, 2020a), have been developed to support a variety of defense and intelligence related data initiatives. These include ontologies pertaining to military occupations, planning, operations, command and control, intelligence, joint doctrine, as well as domains such as aircraft and watercraft. The MRO is designed to be interoperable with such efforts, and so can facilitate the integration of information pertaining to the above domains with data concerning the hierarchical organization and command structures of different armed forces from around the globe.

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1. Note that a temporary military rank is not a subtype of *Military Rank*. Rather, to speak of a temporary rank is to speak of a rank under one or other of the headings in Figure 1, with all the authority that goes together therewith, but which is conferred upon a person only for the duration of their appointment to a specific position or of their assignment to a specific task or mission. [↑](#footnote-ref-1)
2. Enlistment can either be voluntary or compulsory (as in conscription). It should be noted that NATO, and the British and other Commonwealth Armed Forces, use the term ‘Other Ranks’ to denote ranks falling below commissioned officer. That said, ‘Enlisted Rank’ is commonly used to encompass this usage. The choice of ‘Enlisted Rank’ adheres to the principle of using singular nouns for ontology terms (Arp, et al., 2015). Each ontology term is intended to refer to a universal, whereas the term ‘Other Ranks’ clearly refers to a plural entity. [↑](#footnote-ref-2)
3. See the Figure at (Department of the Army, 2018, p. 4). [↑](#footnote-ref-3)
4. The *Platoon Commander* and *Platoon Sergeant Roles* are not currently terms in MRO. We plan on developing a sister ontology for MRO as the home for such role terms, from which they will be imported into MRO. [↑](#footnote-ref-4)
5. This includes promotions made retroactively, as when a Soldier’s promotion is delayed, and the promotion authorities later determine that the Soldier was in fact qualified for promotion during all or part of the delay. [↑](#footnote-ref-5)
6. We say 'participant in *y*' because in many cases, the agent in *Act z* is not causally active in *Act y*, but rather a passive participant in *Act* *y*. A student is agent in the *Acts* by which she earns the A grade, but only the teacher is an agent in the act of giving the student the A grade. The same point applies to *Acts of Promotion*. Thus, a PFC is an agent in the *Acts* by which he earns a promotion, but it is his commander who is an agent in the *Act of Promotion*. [↑](#footnote-ref-6)